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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

Indexed in MEDLINE

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Western Journal of *Emergency Medicine*:

Integrating Emergency Care with Population Health

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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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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Western Journal **of** *Emergency Medicine*:
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Impact Factor for *WestJEM*

Mark I. Langdorf, MD, MHPE University of California, Irvine School of Medicine, Department of Emergency Medicine, Orange, California

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I want to take this opportunity to update our readers, reviewers, and supporters regarding the growth and stature of the *Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health* (*West*JEM). We continue to grow and thrive, extending our scope and reach throughout the nation and the world.

One of the measures of a successful journal is its ability to make its published research available to other researchers, policy makers and thought leaders through robust indexing. *West*JEM is indexed in all the world's sources, including MEDLINE/Index Medicus, PubMed, PubMed Central, Europe PubMed Central, Embase, EBSCO/CINAHL, SCOPUS, HINARI (World Health Organization journal list) and Clarivate (formerly Thomson-Reuters) Emerging Sources Index. As an open access journal, we are members of the Directory of Open Access Journals, which indexes our abstracts.

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The trend for impact factor can be found at: http://www.scimagojr.com/journalsearch.php?q=19900193277&tip=sid&clean=0 (Image 1).

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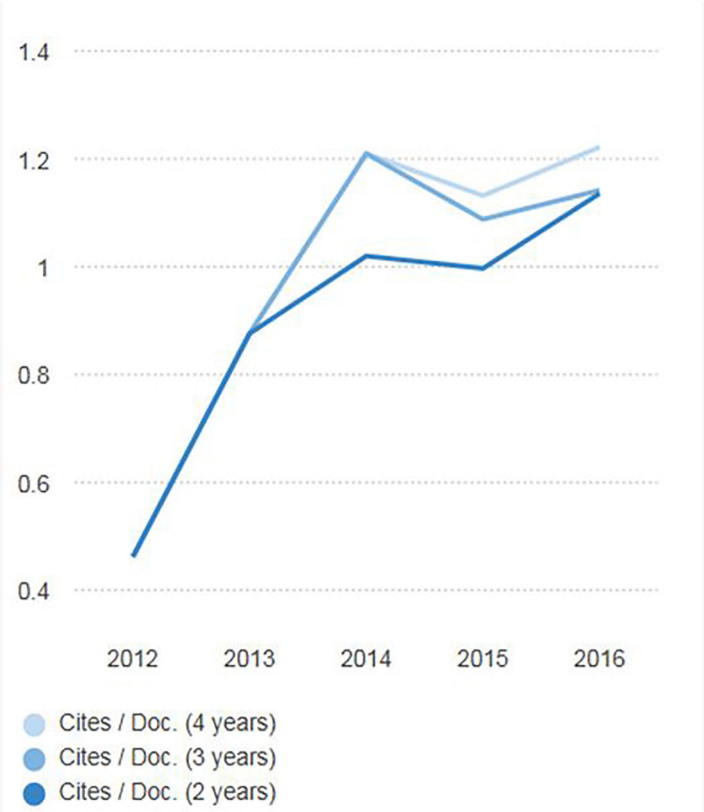

Figure 1. Trend of two- , three- , and four-year impact factor for *Western Journal of Emergency Medicine*. These are citations in index year of journal documents in previous two, three and four calendar years. Two-year impact factor is the same as Clarivate (formerly Thomson-Reuters) two-year impact factor.

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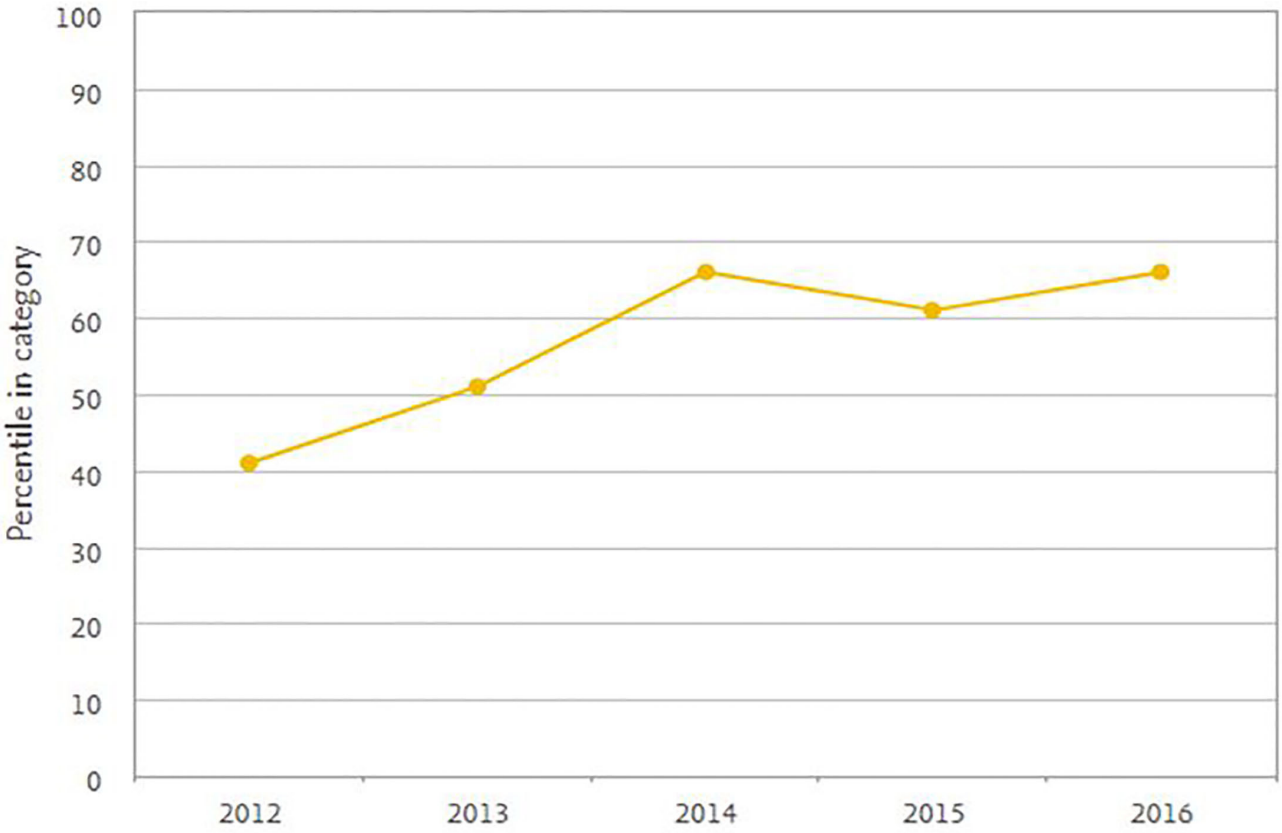

Figure 2. Percentile trend compared with 75 journals in emergency medicine in Scopus CiteScore for *Western Journal of Emergency Medicine* (higher is better).

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Thank you for your faith in our efforts.

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Decreasing Emergency Department Walkout Rate and Boarding Hours by Improving Inpatient Length of Stay

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Introduction: Patient progress, the movement of patients through a hospital system from admission to discharge, is a foundational component of operational effectiveness in healthcare institutions. Optimal patient progress is a key to delivering safe, high-quality and high-value clinical care. The Baystate Patient Progress Initiative (BPPI), a cross-disciplinary, multifaceted quality and process improvement project, was launched on March 1, 2014, with the primary goal of optimizing patient progress for adult patients.

Methods: The BPPI was implemented at our system's tertiary care, academic medical center, a high-volume, high-acuity hospital that serves as a regional referral center for western Massachusetts. The BPPI was structured as a 24-month initiative with an oversight group that ensured collaborative goal alignment and communication of operational teams. It was organized to address critical aspects of a patient's progress through his hospital stay and to create additional inpatient capacity. The specific goal of the BPPI was to decrease length of stay (LOS) on the inpatient adult Hospital Medicine service by optimizing an interdisciplinary plan of care and promoting earlier departure of discharged patients. Concurrently, we measured the effects on emergency department (ED) boarding hours per patient and walkout rates.

Results: The BPPI engaged over 300 employed clinicians and non-clinicians in the work. We created increased inpatient capacity by implementing daily interdisciplinary bedside rounds to proactively address patient progress; during the 24 months, this resulted in a sustained rate of discharge orders written before noon of more than 50% and a decrease in inpatient LOS of 0.30 days (coefficient: -0.014, 95% CI [-0.023, -0.005] P< 0.005). Despite the increase in ED patient volumes and severity of illness over the same time period, ED boarding hours per patient decreased by approximately 2.1 hours (coefficient: -0.09; 95% CI [-0.15, -0.02] P = 0.007). Concurrently, ED walkout rates decreased by nearly 32% to a monthly mean of 0.4 patients (coefficient: 0.4; 95% CI [-0.7, -0.1] P= 0.01).

Conclusion: The BPPI realized significant gains in patient progress for adult patients by promoting earlier discharges before noon and decreasing overall inpatient LOS. Concurrently, ED boarding hours per patient and walkout rates decreased. [West J Emerg Med. 2017;18(6)982-992.]

INTRODUCTION

Healthcare reforms, stimulated by unsustainably escalating costs have led to an accelerating march away from volume-based payment models towards value-based models of payment that incentivize operational efficiencies and patient outcomes.[1,2] High volumes and occupancy rates continue to pose operational challenges for large urban community and teaching hospitals and can negatively impact their ability to deliver high-value care.[3,4] Such operational challenges are generally described in the extant literature under the umbrella terms "patient throughput," "patient flow," or "patient progress," all referring to the movement of patients through a hospital system from admission to discharge.[5] Fundamentally, patient progress in hospitals is hindered by inpatient and emergency department (ED) capacity and efficiency issues. Much of the existing literature in this arena derives from ED studies and process improvements performed in the focused environment of the operating room;[6] inpatient studies on patient progress have been performed as well.[7,8]

In the ED, bottlenecks along a patient's path contribute to hindering progress in "input," i.e., registration and triage; "throughput," i.e., patient evaluation and management by providers and nursing staff; and "output," i.e., discharge, transfer, or admission. Some of these barriers lead to "boarding" of inpatients in the ED.[9] Care of these patients may be delayed, as ED and inpatient teams struggle with the incoming ED volume and the time-sensitive exigencies of patients already occupying inpatient beds. As a result, some patients leave the ED without being seen by a provider ("walkouts") because of long wait times. Patients who leave against medical advice or who leave before treatment is complete are not included in the "walkouts" category. Each of these outcomes has the potential to adversely affect safety, quality and patient and family experience.[10]

An inverse correlation between patient progress (improving throughput) and patient volumes has been demonstrated in several settings. Patient progress in the ED is significantly impacted by the daily census in the ED and the numbers of ED inpatient admissions.[11] Investigators have shown an association between ED length of stay (LOS), the number of ED admissions and hospital occupancy rates on inpatient services. Elective admissions for surgical and other procedures may compete directly with ED admissions for a limited number of inpatient beds.[12] Harrison et al. found that per capita discharge rates, even of patients with longer LOS, were significantly greater during high occupancy periods in the hospital.[13]

Deterioration in patient progress in the ED leads to a higher number of "walkouts," which is a particularly prevalent challenge in teaching institutions in metropolitan areas.[14] Several factors have been shown to increase the likelihood of "walkouts": longer durations of the ED "front-end" process from initial patient presentation to placement in an exam room,[15,16] and ED occupancy (i.e., the number of registered patients divided by the number of licensed ED beds) of greater than 140%.[17] This is particularly of concern for high-risk patients who occasionally experience adverse outcomes after "walking out" of the ED.[18] A larger number of these patients represent to the ED for care within 48 hours as compared with patients who complete evaluation and management during their initial ED presentation.[19] Institutional revenues may also be impacted negatively.[20]

Boarding of admitted patients in the ED (after the decision to admit has been made), hinders the ability to evaluate, manage, and accept transfer patients in a

Population Health Research Capsule

What do we already know about this issue?
The efficient movement of patients through their hospitalization (i.e., "patient progress") from ED admission to hospital discharge contributes significantly to quality and value, thus enhancing population health.

What was the research question?
Would a multi-disciplinary, multifaceted quality and process improvement process—the Baystate Patient Progress Initiative (BPPI)—optimize patient progress by reducing length of stay (LOS) and improving ED walkout rate and boarding hours?

What was the major finding of the study?
The BPPI resulted in a 0.30 day decrease in hospital LOS through multiple tactics. Despite the increase in ED volumes and severity of illness, this effort led to a two-hour reduction in ED boarding hours per patient and a one-third reduction in walkout rates.

How does this improve population health?
The improvements engendered by the BPPI work, based on the extant literature, are likely to improve safety, quality and patient experience—all essential elements of population health. Additionally, the BPPI clearly improved value and accessibility of care.

timely fashion, and thus may lead to ED crowding and ambulance diversion.[21,22] Active bed management using bed management rounds, assigning patients boarding in the ED to inpatient services, and empowering a "bed director" to mobilize additional throughput resources may significantly shorten ED LOS[23] and may also favorably impact LOS for patients discharged from the ED,[24,25] hospital LOS, ED patient satisfaction scores, and perhaps most importantly, decrease the numbers of patients boarding in the ED.[21]

Several studies have demonstrated an association between ED boarding, hospital LOS and mortality for both hospitalized patients and those directly discharged from the ED.[26-29] The adverse effect on mortality is particularly noteworthy in patients who require critical care. Patients who board for more than six hours in the ED before transfer to the critical care unit have a 4.5% higher inhospital mortality rate than those who board for less than that.[30] Patient progress also has a significant impact on hospital finances. This may be particularly relevant to large academic and referral hospitals where demand commonly exceeds the supply due to capacity constraints.[31] The prioritization in bed assignment to elective over ED admissions may delay patient progress by increasing inpatient and ED LOS.[32] An uneven weekly distribution of elective surgical and procedural admissions may have an adverse effect on functional bed capacity on days with high demand.[33] "Smoothing" the scheduling of such elective admissions has been demonstrated to have a beneficial effect on patient progress.[6,33]

Several groups have reported on initiatives to improve the balance between demand and capacity on inpatient units in acute care hospitals: active "pulling" of admissions from the ED;[34] multidisciplinary "plan-of-care" daily rounds;[35,36] managing "churn", i.e., patient movement and bed turnovers across different inpatient units during a single episode of care;[37] and highly scripted process improvements around the timing and communication process of discharges.[38,39] One other group has reported results from their multidisciplinary, quality improvement initiative around patient "flow."[8] The authors addressed process improvements in the ED, inpatient, and support department domains using a physician-led approach with operational support from external consultants. Their outcomes included an improvement in LOS and an increase in the rate of 11 AM discharges.[8]

METHODS

Setting

Baystate Medical Center (BMC), a 720-bed and 94 ED-bay, tertiary-care regional, academic medical center serving a population of approximately 850,000 people in western Massachusetts, is the referral center for Baystate Health (BH), a five-hospital, integrated health system serving the region and portions of two neighboring states. By 2012, BMC, the largest and busiest tertiary care referral hospital in the region, was experiencing consistently high ED and inpatient hospital volumes with many operational inefficiencies. Escalating ED walkouts and rising patient LOS on the inpatient units were emblematic of these inefficiencies. During fiscal year (FY) 2013, when the BPPI was initiated, BMC provided care for 109,111 ED visits and 26,335 adult, non-psychiatric and non-obstetric admissions, with a corresponding case-mix index (CMI) of 1.72, which is in the average range for like-size hospitals.

Based on these data and the potential negative impact of these factors, we embarked on a multi-disciplinary, institutional, performance improvement initiative—the Baystate Patient Progress Initiative (BPPI)—with the goal of decreasing ED walkouts and boarding hours, inpatient LOS and increasing the number of patients with written discharge orders before noon.

The chief operating officer/chief physician executive of BH commissioned the BPPI, and senior clinical and administrative leaders from the organization gathered to review hospital performance data and develop a shared vision for systems improvement. This event led directly to the formation of workgroups and selection of group leaders with a planned implementation on March 1, 2014.

The structure of BPPI comprised an executive steering committee that was responsible for the oversight of three discrete operational work teams. Each team was empowered to function autonomously, but the co-leaders were expected to report out metrics at pre-determined intervals. Three operational teams were organized to address various aspects of a patient's journey and progress through BMC and create long-term capacity to sustain improvements. The scope and activities were focused on the ED and adult Hospital Medicine (inpatient) services. The "ED" and "Right patient, Right bed, Right time" (RRR) teams involved the progression of clinical decision-making and care processes at the most common initial points of patient contact. The "Interdisciplinary Plan-of-Care" (IPOC) team specifically examined the progression of care on the inpatient units.

The initial meeting of each team's steering group involved a two-day instructional workshop on Lean Sigma methodology, team-building activities, formulation of a problem statement, and delineation of specific activities. Each sub-team then convened to develop individual projects and metrics using a Lean Sigma framework.[40] The scope of some projects/activities spanned more than one team (e.g. ED and RRR), thus engendering further opportunities for collaborations and spawning the formation of several "hybrid" teams. Large, academic medical centers represent highly complex systems that are often poorly understood, costly, and rife with

inefficiencies.[41] Key systems engineering principles were employed and combined with well-described waste elimination techniques to ensure effectiveness.[41]

Metrics

The key system-level measures adopted by the executive steering committee for the ED and adult Hospital Medicine (inpatient) services were the following: 1) number of registered ED patients and walkouts per day; 2) number of boarding hours per ED admission; 3) percentage of inpatient discharge orders written before noon; 4) percentage of inpatients on daily IPOC; and 5) inpatient LOS. The measures were calculated and reported as monthly means for the days in each month. The metrics for each team and sub-teams of BPPI are shown in the Table.

Statistical Analysis

We measured the primary analytic outcomes monthly as either mean daily counts or as percentages over the specified time period. Mean daily counts were computed as the total monthly count divided by the number of days in the month. As these mean daily counts were approximately normally distributed, we analyzed data using parametric testing. Linear trends over time in mean daily volumes or mean daily walkouts were estimated using linear regression. For outcomes measured as percentages, we used generalized linear models, designating the distributional family as binomial and a log link function. Robust standard errors were used in these analyses. All regression slope coefficients are reported with 95% confidence intervals (CI) and p-values. We added trend lines to figures to aid in interpretation. Our investigational review board did not require review of the project since the project was designed for performance improvement.

RESULTS

Participants

The BPPI engaged more than 300 direct participants in the work of the teams. Of these participants, 43% represented frontline clinical staff, such as hospital-based physicians, nurses, and patient care technicians. The remainder of the participants was largely divided between other clinical- and non-clinical support staff. Of the total participants, 40% were nurses and 22% were physicians or advanced practice clinicians.

Volume and Walkouts

Over the 24-month study period from March 2014 to February 2016, the mean daily volume increased by about one patient each month over the time period (coefficient: 1.0, 95% CI [0.3, 1.7] P = 0.006) from an estimated 288 patients per day to about 311 per day (Figure 1). These patient volumes make BMC currently the busiest single-site ED in Massachusetts.[42] Despite progressively rising volumes in the ED, activities of the clinical teams of the BPPI (Table) led to a steady decrease in the monthly mean number of walkouts from approximately 31 patients per day (10.5%) to 21 patients per day (6.7%) over the study period (Figure 1). This resulted in a decrease in the monthly mean number of walkouts by 0.4 registered patients in the ED (coefficient: -0.4; 95% CI [-0.7, -0.1] P= 0.01).

ED boarding hours per patient

ED boarding hours per patient, defined as the duration of time from the decision to admit or assignment to observation while admissions and observation cases are receiving care in the ED, declined through the same 24-month time period from an initial estimate of 7.6 hours to 5.5 hours (coefficient -0.09 hours/month; 95% CI: -0.15, -0.02; p=0.007). This occurred even as admission volumes increased (Figure 2). The literature suggests that boarding hours correlate with wait times and walkout rates.[9,16-20] We analyzed incremental changes in the number of boarding hours needed to generate every 1% of left without being seen and found that through the BPPI work we realized progressive, incremental changes from 36 to more than 90 boarding hours needed to generate every 1% of walkouts. These improvements in efficiency in the ED enabled us to reduce walkouts significantly with decreasing boarding hours while experiencing significant increases in ED volumes over time (Figure 1).

Discharge order entry before noon

Improving the timeliness and efficiency of the discharge process was an early focus of the RRR team. Because ED patient arrival patterns at BMC tend to result in peak admission volumes between 1400 hours and 2200 hours, the goal of optimizing discharge order entry by noon, as clinically appropriate, was selected to allow at least two hours for nursing and case management to complete the required documentation and tasks to allow patient egress by early- to mid-afternoon. The rate was approximately 43% at the launch of the initiative. Through the tactics of a focused sub-team of RRR (Table), the rate of discharge order entry before noon progressively rose to 54.1% and was sustained at that level for the duration of BPPI (Figure 3). Discharge orders written before noon increased about 0.5% per month (coefficient 0.5%; 95% CI [0.3%, 0.8%] p < 0.001). The RRR team determined that bed capacity on the inpatient units might be further enhanced by focusing on a subset of patients who could be appropriately discharged earlier in the morning. Even earlier discharge order entry before 10AM was made a priority starting in July 2017. Using similar tactics (Table) to those employed to increase the rate of discharge orders before noon, the team improved the rate of discharge order

Table. Baystate Patient Progress Initiative operational team projects/activities, tactics, and metrics.

Team	Projects/activities	Tactics	Metrics
ED	• Staffing to demand • Discharge – green light to leave ED • Transportation – request to leave ED • Triage – entry to assessment	• Analyze historical arrival patterns. Set productivity benchmarks. Change schedules • Develop discharge standard work • Develop discharge standard work. Align staffing to demand • Develop Triage standard work. Re-align RN role combined with clerk	• Each shift is staffed to expected historical demand • Reduce time from ready to leave to discharge • Reduce time from bed assign to leave ED • Reduce wait time and time to full assessment
RRR	• Discharge efficiency • Gray Zone • Alternate sites of care • Early initiation of plan-of-care • Geographic rounding • Geographic admitting	• Highlight discharge orders at hospitalist huddles • Assign 2 senior clinicians to ED for 1 week each. • Collaborate with post-acute teams on building care models • Hospitalist Medicine collaborative team to create capacity to see patients in ED • Create schedules to align Hospitalists with nursing units	• Define the care team. Set time to round as a team. Build script and run in a simulated environment • Calculate expected discharges based on historical data. IPOC team to identify expected discharges for tomorrow. • Map out flow of discharge process. Set discharge windows. • Develop white boards collaboratively with patients and ancillary staff • Collaborative work with IT/Informatics to build IPOC in EMR. • Develop My-Plan that is presented daily to patients • Move beyond pilot units
IPOC	• Collaborative rounding • Discharge prediction • Day of discharge • Patient information boards • IPOC components in EMR • My-plan for patients • Medicine spread • H&V spread • Surgical spread	• Define the care team. Set time to round as a team. Build script and run in a simulated environment • Calculate expected discharges based on historical data. IPOC team to identify expected discharges for tomorrow. • Map out flow of discharge process. Set discharge windows. • Develop white boards collaboratively with patients and ancillary staff • Collaborative work with IT/Informatics to build IPOC in EMR. • Develop My-Plan that is presented daily to patients • Move beyond pilot units	• % Pts with IPOC every day • % discharge accuracy • % Pts discharged within 2 hours of order • % Pts with boards completed daily • % Pt with My-Plan daily • # of units following standard work

ED, emergency department; *RRR*, Right patient, Right bed, Right time; *IPOC*, interdisciplinary plan of care; *H&V*, heart & vascular; *EMR*, electronic medical record; *IT*, information technology.

entry by 10AM by 123% (Figure 3) from 13% to 29%, or an increase of 4.2% per month, (coefficient 4.2%; 95% CI [2.4%, 6.1%] $p < 0.001$).

Interdisciplinary plan of care

The IPOC team was charged with improving performance and patient progress from the time of arrival on the designated inpatient unit through discharge. A primary focus of this team was the development of a process and operational pathway for IPOC bedside rounds.[36] IPOC rounds were disseminated across all medical and surgical units with the team goal for this activity to involve at least 75% of adult inpatients daily. The percent of adult patients seen on daily IPOC rounds increased significantly by about 2.6% per month (coefficient 2.6%; 95% CI [2.0%, 3.3%]; $p < 0.001$) from 44% to about 83% overall (Figure 4).

Inpatient LOS

An important, overarching, cross-team metric tracked by the BPPI Executive Steering Committee was the diagnosis-related group (DRG)-adjusted, mean LOS for all non-psychiatric, non-obstetric, adult inpatients at BMC. Despite a 9% increase in total annual inpatient volume on the adult Hospital Medicine service over the 24-month time frame after the launch of the initiative, LOS

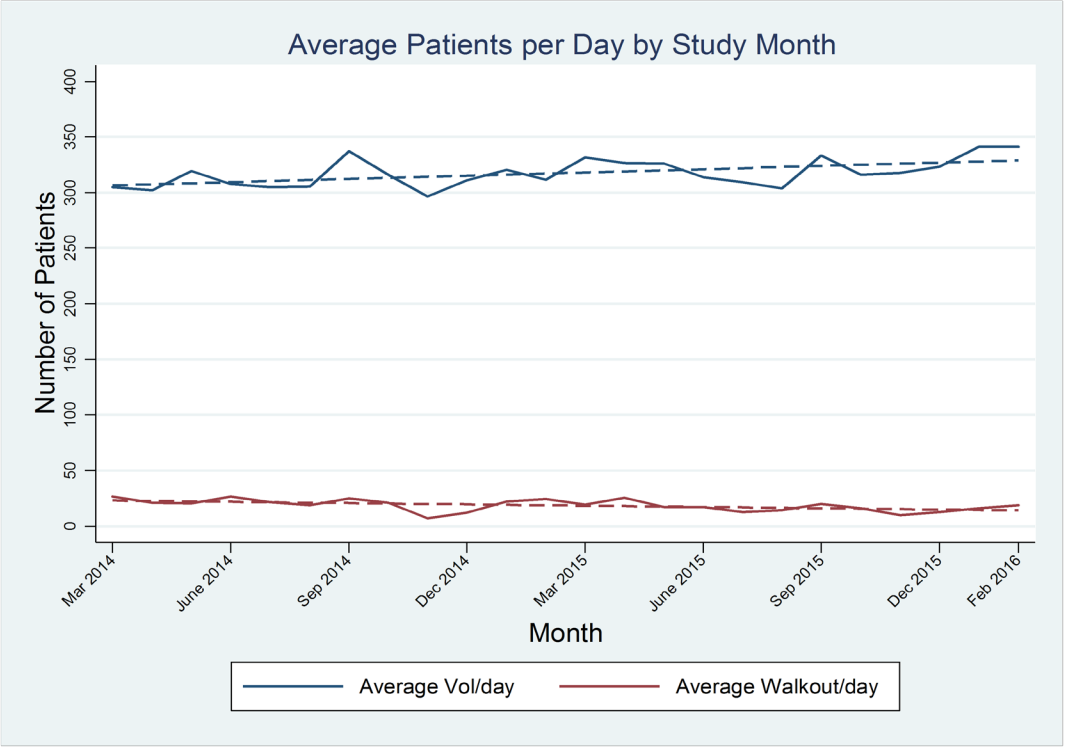

Figure 1. Mean number of registered emergency department patients and walkouts per day.
Mean # of Patients /day: coefficient 1.0 (95% CI [0.3,1.7] P < 0.006).
Mean Walkouts/day: coefficient -0.4 (95% CI [-0.7, -0.1] P= 0.01.

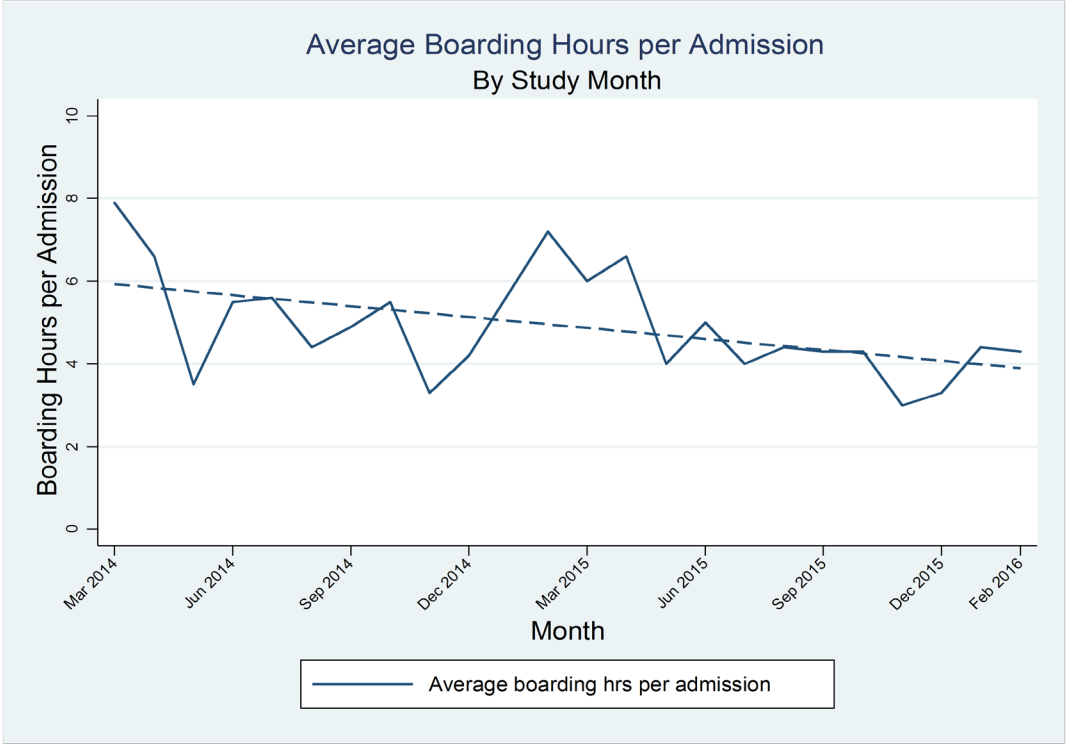

Figure 2. Mean boarding hours per admission: coefficient -0.09 (95% CI [-0.15, -0.02] p=0.007).

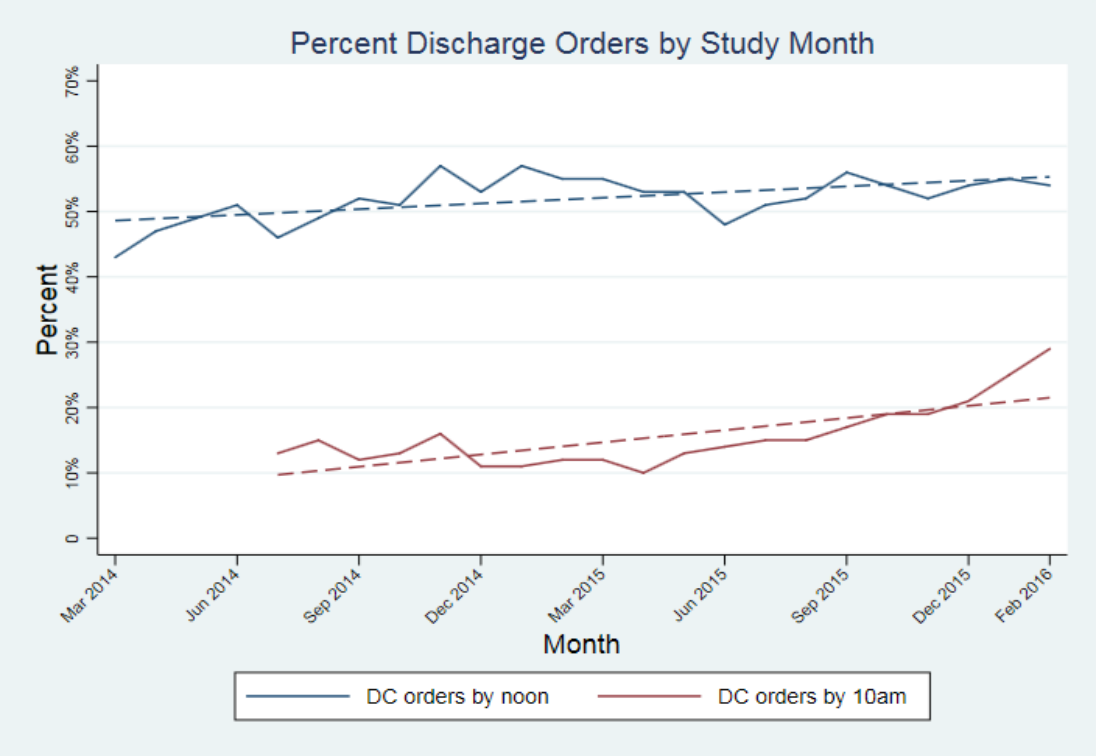

Figure 3. Percent discharge (DC) orders before noon: coefficient 0.5% per month (95% CI [0.3%, 0.8%] p < 0.001).

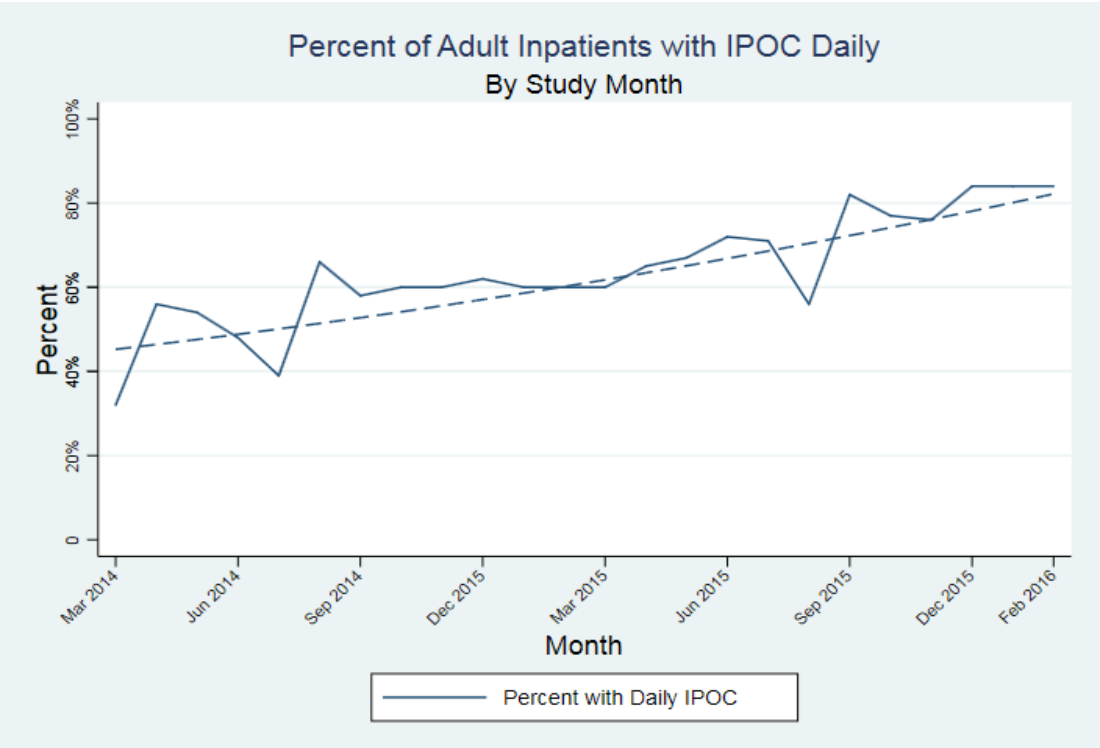

Figure 4. Percent of adult Hospital Medicine inpatients with daily interdisciplinary plan of care (IPOC): coefficient 2.6% (95% CI [2.0%, 3.3%] p <0.001).

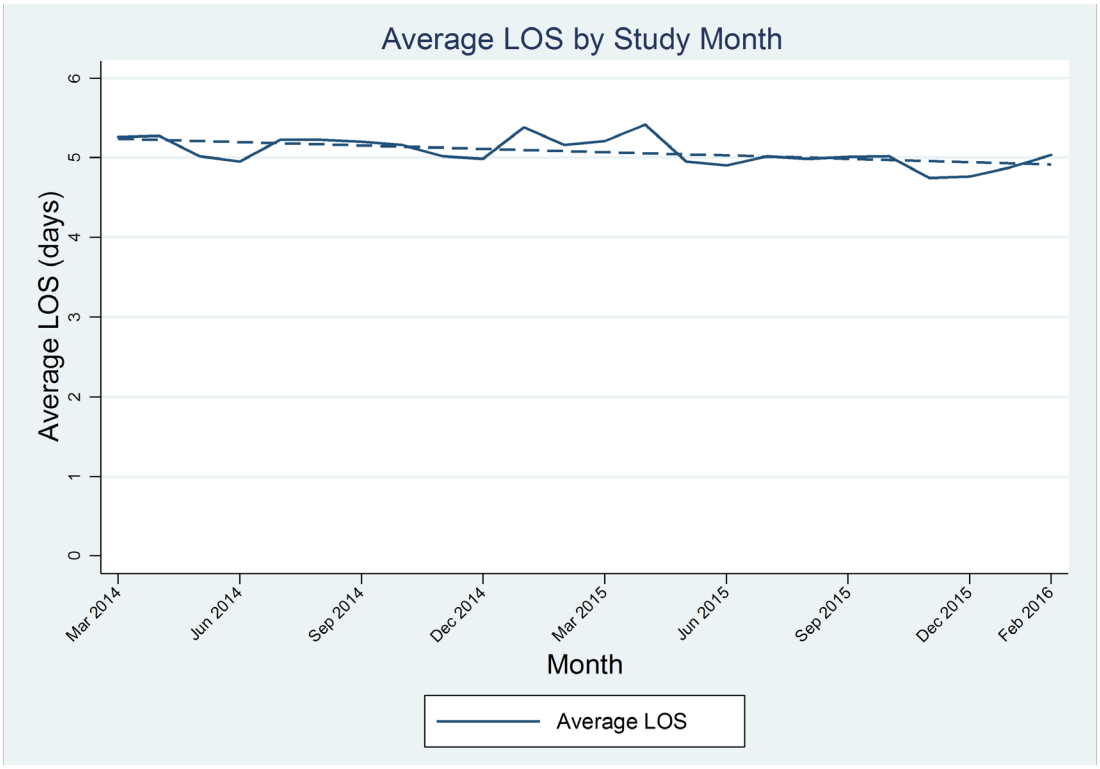

Figure 5. Mean inpatient length of stay (LOS): coefficient: -0.014 (95% CI: -0.023, -0.005; P< 0.005).

progressively decreased from a baseline of 5.3 days to 5.0 days, representing an absolute improvement of 0.30 days overall (coefficient: -0.014 days /month; 95% CI [-0.023; -0.005]; P< 0.005 [Figure 5]). The mean daily percent of ED patients who were admitted or assigned to observation (27.8%) did not change significantly over this time.

DISCUSSION

The BPPI, over the two-year charter, achieved several important goals. Through the broad dissemination and adherence to IPOC rounds, which resulted in enhanced communication, coordination, and discharge planning, we progressively and significantly decreased LOS by 0.30 days during the initial phases of BPPI (Figure 5). This created an increase in functional inpatient capacity of 20 open beds per day since we discharged roughly 24,300 patients in the last 12 months of the BPPI [23,000 x 0.3/365 = 20]. In part, this was accomplished by creating inpatient capacity through a focused effort to maximize early discharges as appropriate, yielding a statistically significant, sustained rate of discharge order entry before noon of more than 50% (Figure 3). Additional inpatient bed capacity was created through the coordinated tactics of the IPOC team, targeting daily interdisciplinary bedside rounds to proactively address patient progress milestones during the inpatient component of the hospitalization. Despite progressively accelerating ED (8.3%) and inpatient admission volumes, and a nearly 4% rise in CMI, we concurrently decreased ED boarding hours per admitted patient as well as ED walkout rates by nearly 44% (Figures 1 and 2). While targeted efforts were undertaken and implemented by the ED team to improve ED throughput times, we firmly believe that reducing boarding hours per patient was a very significant contributor to success. Previous literature has notably demonstrated that high ED boarding is a significant contributor to walkouts.[43]

The gains in patient progress achieved through the BPPI become even more meaningful when examined through the prism of other factors that limit bed capacity at our hospital. Because 90% of adult medical beds and 65% of all adult medical/surgical beds are in semi-private rooms, at any given time we are compelled by clinical exigencies to sacrifice capacity by closing beds due to infection control or behavioral issues. Our effective bed utilization (i.e., the number of admitted patients/the number of licensed beds minus closed beds) at these times averaged 103.8%. The literature on bed utilization in acute care hospitals suggests that efficient patient flow is optimal at or below 85%.[44] Thus, our gains in patient progress occurred despite extraordinary barriers related to constricted

inpatient bed capacity. Others have used LOS data from specific patient populations to match bed capacity with demand. Such efforts have resulted in significant reductions in median ED LOS for patients ultimately admitted to adult medicine/surgery units.[45]

A common thread of the extant published literature on patient progress appears to be the segregation of initiatives to specific clinical areas of the hospital such as the ED, operating room, or in some cases the inpatient units. Thus, component parts of the admitted patient's journey from clinical presentation for care to ultimate disposition and transition out of the hospital may be addressed in various studies by a targeted intervention, but patient progress in the literature is generally not addressed as in this work, as a continuum with multiple "nodes" where quality or process improvement interventions could have an amplified impact. Jweinat et al. reported a collaborative initiative involving several, concurrent process improvement efforts in distinct hospital areas that were physician led but supported by external consultants.[8] Although the structure and operations of their initiative were distinct from those of the BPPI, several of their outcomes were comparable, thus lending credence to the potential utility of a combination of approaches to these common challenges.

The structure of BPPI is likely to have facilitated the achievement of favorable outcomes. The leaders from each of the five operational teams served on and reported to the BPPI Executive Steering Committee, thus ensuring frequent, direct accountability to each other and allowing information sharing and active contributions across the key teams. The information sharing and communication that occurred in the monthly Executive Steering Committee meetings provided real-time feedback to team leaders and enhanced their ability to adjust tactics with their teams in nimble fashion. Additionally, leaders of the Executive Steering Committee regularly briefed the senior institutional leadership team of BH to ensure that the BPPI continued to be aligned with our enterprise strategic goals and had the resources needed to achieve its goals.

The three clinical operational teams of BPPI (ED, RRR and IPOC) were structurally and functionally organized to follow the patient journey from point of initial clinical contact (the ED for most admissions) to their stay on the inpatient units and subsequent transition from the hospital back to the community. This design was intentional; we believe that it compelled us to address, concurrently and in parallel, many of the variables that affect patient progress in a complex hospital system. Moreover, we believe that such a high level of engagement and participation of clinicians was fundamental to the success of the BPPI.

LIMITATIONS

Several aspects of our study may limit its generalizability. Because BMC is an academic medical center, we have both "teaching" and "non-teaching" clinical services, each with somewhat distinct operational procedures. Although we addressed both in the BPPI, it is possible that some of our approaches may not apply to non-academic centers. However, because our structure inherently creates additional complexities, we believe our outcomes may potentially underestimate those that could be obtained in a more homogeneous system. Additionally, our institution employs essentially all the inpatient provider staff, including emergency and Hospital Medicine clinicians. This facilitates goal alignment of individuals and teams with those of the system, thus enabling the execution of such an enterprise-wide project as the BPPI. Due to the design as a two-year performance improvement project, we cannot claim to have demonstrated a "cause-and effect" relationship between inpatient LOS, ED boarding and ED walkouts although common sense and logic would argue that an association exists. Certainly, previous literature has demonstrated that ED boarding is a significant driver of walkouts.[43] Moreover, it is possible that the Hawthorne effect contributed to the beneficial outcomes. As a systemwide initiative, it was not possible to "blind" providers, nurses and other staff with direct patient-care responsibilities to its purpose. The BPPI consumed significant institutional resources, mainly in the form of participant time; however, we did not attempt to estimate the costs, and therefore cannot address the relative cost effectiveness of this initiative.

CONCLUSION

Through the implementation of a broad, cross-disciplinary, multifaceted, system improvement initiative, we successfully effected significant improvements in patient progress at our institution. These improvements are evidenced by clinically and statistically significant declines in inpatient LOS related to early hospital discharge order entry and multidisciplinary discharge planning. Concomitantly, the ED walkout rate decreased significantly and ED boarding hours remained stable per patient in the face of progressively rising volumes. The BPPI approach may be useful to inform others in healthcare struggling with similar patient progress challenges.

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Injuries Associated with Hoverboard Use: A Case Series of Emergency Department Patients

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Introduction: Since hoverboards became available in 2015, 2.5 million have been sold in the US. An increasing number of injuries related to their use have been reported, with limited data on associated injury patterns. We describe a case series of emergency department (ED) visits for hoverboard-related injuries.

Methods: We performed a retrospective chart review on patients presenting to 10 EDs in southeastern Virginia from December 24, 2015, through June 30, 2016. We used a free-text search feature of the electronic medical record to identify patients documented to have the word "hoverboard" in the record. We reported descriptive statistics for patient demographics, types of injuries, body injury location, documented helmet use, injury severity score (ISS), length of stay in the ED, and ED charges.

Results: We identified 83 patients in our study. The average age was 26 years old (18 months to 78 years). Of these patients, 53% were adults; the majority were female (61.4%) and African American (56.6%). The primary cause of injury was falls (91%), with an average ISS of 5.4 (0-10). The majority of injuries were contusions (37.3%) and fractures (36.1%). Pediatric patients tended to have more fractures than adults (46.2% vs 27.3%). Though 20% of patients had head injuries, only one patient reported using a helmet. The mean and median ED charges were $2,292.00 (SD $1,363.64) and $1,808.00, respectively. Head injuries resulted in a significantly higher cost when compared to other injuries; median cost was $2,846.00.

Conclusion: While the overall ISS was low, more pediatric patients suffered fractures compared to adults. Documented helmet use was low, yet 20% of our population had head injuries. Further investigation into proper protective gear and training is warranted.[West J Emerg Med. 2017;18(6)993-999.]

INTRODUCTION

Self-balancing personal transporters are increasing in popularity since they were first made available for commercial use in 2001. Previous models, such as the Segway®, had a handle bar for balancing and increased control, yet significant injuries were still reported with the use of these devices.[1-4] Recent hands-free models, commonly referred to as "hoverboards," have only been available commercially since 2015.[5] It is estimated that 2.5 million hoverboards have been sold in the U.S., totaling nearly one

billion dollars' worth of sales[6] and were one of the most popular gifts for Christmas 2015.

The hoverboard is a two-wheeled device that can reach speeds up to 16 miles per hour.[5] As compared to the Segway®, which contains a sensor in the handlebar for control, each wheel of the hoverboard is responsive to slight movements of each foot independently. This design allows one to move forward, backward, or rotate with only minimal movement of the feet. They are powered by a rechargeable lithium battery. With this new form of travel, there have been emerging guidelines for rider protection, including helmets, knee pads, elbow pads, wrist guards, and shoes,[5,8] but compliance and evidence behind these guidelines are unknown.

With the device's increasing popularity, reported numbers of injuries related to their use are increasing.[9-12] In addition, there is a risk of the device overheating and subsequent fire hazard[7] due to a faulty lithium battery.[9] These problems have resulted in hoverboard recalls, limitations on airplane travel,[7] or bans from large cities. While there have been several small, single-institution, pediatric-based studies evaluating injury complexes from hoverboard-related injuries,[9-12] to our knowledge no study to date has evaluated the unique injury patterns across all ages associated with its use and the associated healthcare costs. We aimed to address this gap in the literature. The purpose of our study was two-fold: 1) to describe the injury complex associated with hoverboard accidents by examining the types of injuries, areas of the body affected, and differences in pediatric and adult populations; and 2) to examine charges associated with hoverboard injuries within an emergency care setting.

Population Health Research Capsule

What do we already know about this issue?
Previous reports on hoverboard-related injuries have focused on the pediatric population and were limited to pediatric EDs.

What was the research question?
We sought to describe the injury complex across all ages and describe the associated healthcare costs in a large community hospital-based system.

What was the major finding of the study?
Pediatric patients suffered more fractures when compared to adults and helmet use was low, yet 20% of our population had head injuries.

How does this improve population health?
Pediatric patients appear to be at risk for injuries related to hoverboards. Further research is needed identify factors associated with the injuries to improve safety standards.

METHODS

We performed a retrospective chart review on patients with hoverboard-related injuries presenting to local emergency departments (ED) from December 24, 2015, through June 30, 2016. We reviewed patient charts from 10 hospital EDs within an integrated healthcare organization in southeastern Virginia. The total combined volume of these EDs during the study period was 222,611 visits. Each hospital ED uses EPIC as their electronic medical record (EMR) system. The institutional review board at Eastern Virginia Medical School approved this study with a waiver of consent due to its retrospective design.

We identified study patients using a free-text search of the EMR ED documentation provided by emergency nurses and physicians. The terms "hoverboard," "hover board," "hoover board," and "hooverboard" were specified in the search to account for misspellings and typos. We included patients in the study if their ED records matched any of the search criteria during the study period. Patients without a diagnosed injury from a hoverboard were excluded. The data set was reviewed by two emergency physician reviewers (GW and LG) who extracted the discrete data from the EMR using a templated electronic form. The data collection form consisted of 16 discrete questions (i.e., date, location, etc) and two free-text options for descriptions of the mechanism of injury and the injury complex. Out of convenience, the abstractors were not blinded to the hypothesis.

We conducted statistical analysis using IBM SPSS Statistics for Windows, version 22.0.[18] Descriptive statistics for patient demographics, types of injuries, body injury location, documented helmet use, injury severity score, length of stay (LOS) in the ED, and ED charges were reported. We analyzed data at either the patient or encounter level, depending on the study aim. Patient demographics, injury type, and injury site data were analyzed and reported at the patient level. We analyzed bivariate associations between age category (pediatric or adult) and demographic variables, injury types, and injury sites using Pearson's chi-square test. Differences in charge amounts between the two age categories were examined using independent samples *t*-test.

For the purpose of analyzing ED costs, data are reported at the encounter level and exclude the two encounters that were admitted to the hospital because we were unable to separate the ED charges from the total charges. Therefore, results from charge data represent 84 encounters. Outliers in

charge amounts were addressed by Winsorizing data to the next highest data point within three standard deviations (SD) of the mean.[19] A test of the assumptions prior to conducting a one-way analysis of variance to identify differences in charges by injury location and injury type revealed heterogeneity across groups; therefore, we used non-parametric tests. The Kruskal-Wallis test was used to examine statistically significant differences in median charges by areas of injury on the body and charges by types of injury. For all statistical tests, we used an alpha level of .05.

RESULTS

Data Review

Between December 24, 2015, and June 30, 2016, 84 patients presented to one of the 10 EDs with injuries attributable to hoverboard use. One patient was excluded from the study because she did not sustain injuries from her accident. The remaining 83 patients represent those with diagnosed injuries who were either treated and released from the ED or admitted to an inpatient setting. Of the 83 patients, two presented multiple times to the ED with hoverboard-related injuries, resulting in 86 encounters. These data included two patient encounters that were admitted to the hospital. Both patients were admitted to a medical floor bed and neither required admission to a critical care bed.

Characteristics of Patients

The majority of patients were female (61.4%) and African American (56.6%), with a mean age of 26.2 years old (standard deviation [SD] =16.20) and median age of 24.0 years old. The youngest patient was 18 months old and the oldest was 78 years old. Additional contextual data taken from notes in the patients' charts revealed that 14% of patients did not own the hoverboard that led to their injury. The 18-month-old patient was not the primary rider; she fell from a hoverboard while being supported by an older sibling and hit her head on a coffee table. Adult patients (age 18 years and older) constituted over half (53.0%) of the injuries. The mean pediatric age was 11.7 years old (SD = 3.36) and mean adult age was 39.1 years old (SD = 11.35). One-quarter (25.3%) of the patients had one or more comorbidities documented. Comparison of pediatric and adult patients using chi-square analysis found the two groups to be equally distributed in sex, race, and level of comorbidity (Table 1).

Injury Type and Site

The predominant mechanism of injury was falls (91.6%). Injury severity scores (ISS) ranged between 0 and 10 (M=5.46, SD=3.12), indicating low injury complex overall among the patients. The majority of injuries were contusions (37.3%) and fractures (36.1%). Eleven (13.1%) patients suffered from multiple types of injuries, most frequently concussions and contusions. Children most often suffered fractures, whereas adults tended to have contusions (Figure 1).

The location of injury to the body was divided into three zones with respect to distance from the hoverboard: lower extremity, chest and upper extremity, and head and neck. The chest and upper extremity (53.0%) were the most common injury sites, followed by lower extremity injuries (32.5%). Six (7.2%) patients suffered injuries to multiple areas of the body. Both children and adults most frequently suffered injuries to their chest and upper extremity (Figure 2).

To further examine injury type and injury site by age category, we grouped together injuries that fell into more than one category. The relation between these variables was non-significant, χ^2 (5, N=83) = 7.85, p =.16. The frequency in types of injuries was similar between pediatric and adult patients. Although not statistically different, a higher percentage of pediatric patients sustained fractures compared to adults in the sample (46.2% vs. 27.3%, respectively). The chi-square test of independence revealed no statistically significant difference in injury site by age category, χ^2 (3, N =

Table 1. Characteristics of patients with hoverboard injuries (N=83).

	Pediatric (n=39); n (%)	Adult (n=44); n (%)	χ^2	p-value
Sex				
Female (n=51)	24 (47.1)	27 (52.9)	.00	.99
Male	15 (46.9)	17 (53.1)		
Race				
African- American (n=47)	18 (38.3)	29 (61.7)	3.29	.07
White (n=36)	21 (58.3)	15 (41.7)		
Comorbidities				
None (n=62)	33 (53.2)	29 (46.8)	3.83	.05
1 or more (n=21)	6 (28.6)	15 (71.4)		

*p < .05.

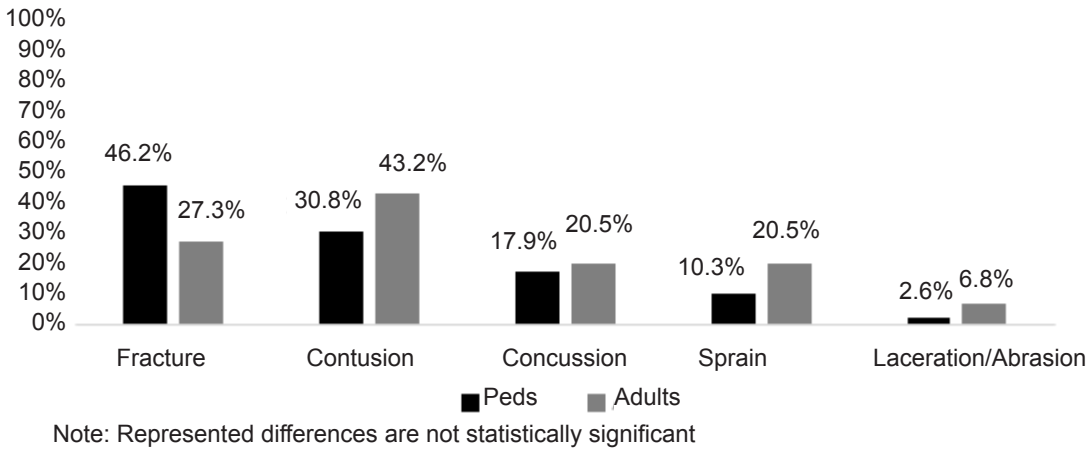

Figure 1. Percent of hoverboard injuries by injury type and age category (*N*=83). *Peds*, pediatrics.

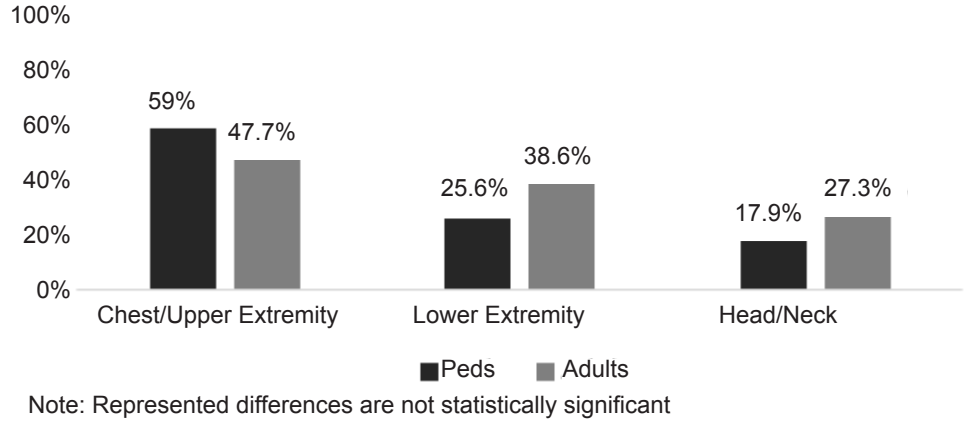

Figure 2. Percent of hoverboard injuries by injury site and age category (N=83). *Peds*, pediatrics.

84) = 4.00 p =.26. Location of injury was similar between pediatric and adult patients. One patient reported helmet use at the time of the injury, yet 20.2% of patients had a closed head injury.

Charges from Injuries

The mean charge amount was $2,292.00 (SD=$1,363.64) per ED visit; the median was $1,808.80. The mean charge for an adult patient was $2,532.83 (SD=$1,619.87) and the mean charge for a pediatric patient was $2,014.12 (SD= $935.61). Review of the independent samples *t*-test revealed no statistically significant difference between pediatric and adult patients in overall ED charge amounts, $t(72.03) = -1.83$, $p = .07$. A Kruskal-Wallis test with pairwise comparisons revealed a significant difference in ED charges by injury site, $H(3) = 8.71$, $p = .03$. Patients who sustained head and neck injuries incurred significantly higher charges compared to charges related to lower-extremity injuries (Table 2). No other pairwise comparisons were significantly different in median charge amounts. We conducted a second Kruskal-Wallis test with pairwise comparisons to examine differences in median charges by type of injury. These differences were non-significant, $H(5) = 10.29$, $p = .07$. Tables 3 and 4 provide median charges by injury site and type, respectively. Of note, lacerations and abrasions incurred the highest median charge at $4,800.00 per ED visit; however, data was based on only two encounters.

DISCUSSION

Our study is the first observational ED-based study to include both pediatric and adult patients in examining the injury complex and charges associated with hoverboard-related injuries. We had a near-equal distribution of pediatric and adult patients in our sample, yet we found that children

Table 2. Results of Kruskal-Wallis pairwise comparisons of charges by injury site (N=84).

Pairwise comparisons	Test statistic	Standard error	Standard test statistic	p-value
Lower extremity- head/neck*	22.17	7.88	2.82	.03
Lower extremity- chest/upper extremity	12.95	6.50	1.99	.28
Multiple- chest/upper extremity	8.46	10.70	.79	1.00
Multiple- head/neck	17.69	11.58	1.53	.76
Chest/upper extremity- head/neck	9.23	7.09	1.30	1.00
Lower extremity- multiple	-4.49	11.23	-.40	1.00

*p < .05.

less than 18 years of age had a higher incidence of fracture than adults. Likewise, both groups were predominately injured by falls. Previous studies have found that children are physiologically at risk for falls, given that they are less mature developmentally in coordination, balance, and motor strength, along with their higher center of gravity. These factors may leave them more susceptible to injuries[13] compared to their adult counterparts.

There are a limited number of studies on hoverboard injuries that include both adult and pediatric patients. A recent review of hoverboard injuries in the Canadian Hospitals Injury Reporting and Prevention Program (CHIRPP)[12] found that patients under the age of 19 years were more commonly injured than adults in their case series. However, a noted limitation of the CHIRPP is that it skewed to surveil for pediatric patients. It derives its data from 11 pediatric hospitals and only six general hospitals.[12] The average age of an injured patient was 12.7 years and only one patient was over the age of 19. Our study sample had a near-equal distribution of adults age 18 years and older (51.8%) and youth (48.2%) seen in the ED. Our study appears to represent a diverse population across 10 different community EDs.[12]

Hoverboard injuries place a patient at increased risk of fractures to the upper extremity according to a pediatric radiology review of fractures related to hoverboards.[10] These findings were replicated by researchers with CHIRPP, who found that nearly 70% of their injuries occurred in the upper extremity.[12] In addition, Ho found that 77% of all fractures were to the upper extremity in their sample as well.[11] Our study had a lower percentage of upper extremity injuries (53.0%) compared to the previously cited literature. Nevertheless, our findings are consistent with prior studies[12] in which the upper extremities were more often injured compared to either the lower extremity or head and neck.

A key strength of this study is that it is the first to cite financial implications associated with hoverboard injuries. In head-injured patients, the median cost of the hospital care increased by over $1,000.00 compared to non-head injured patients. This rise in cost is most likely due to the cost of CT imaging of the head and cervical spine as compared to radiographs to evaluate extremity injuries.

In our study, the overwhelming cause (92%) of injuries was from falls. Yet, there is currently no formal training on hoverboard use, and recommendations on safety equipment for proper hoverboard use is sparse.[8] Furthermore, we found that most injuries (30%) occurred to the wrist. Wrist guards have been found to reduce the force from a fall by up to 50% in adults,[14] but in our study there was no documented wrist brace use.

Similar to our study, documented helmet use in children riding recreational toys is low. Helmet use rate has been documented as low as 8-37% when evaluating children riding non-motorized scooters as compared to our helmet use rate of 1.3%.[15-17] Likewise, the evaluation of head-injured hoverboard patients will increase their ED evaluation by over $1000.00, further highlighting the need for proper protection with helmets.

Although prior studies have demonstrated significant morbidity and mortality associated with collision with motor vehicles,[15] we did not have any specific cases involving hoverboards colliding with motorized vehicles. However, it is an important consideration when addressing safety concerns, as hoverboards are used on hard surfaces such as sidewalks, parking lots and roads. In addition, there have been concerns over hoverboards catching fire or exploding.[8] We did not encounter this complication in our population.

Table 3. Median emergency department hoverboard-injury charges by site (N=84).

Injury site on body	N	Median ED Charge ($)
Head/neck	17	2,846
Chest/upper extremity	39	1,873
Lower extremity	22	1,289
Multiple sites	6	1,802
Overall	84	1,809

ED, emergency department.
Note: Medians are based on adjusted/Winsorized charge values.

Table 4. Median emergency department hoverboard-injury charges by type (N=84).

Injury site on body	N	Median ED charge ($)
Laceration/abrasion	2	4,810
Concussion	8	2,847
Fracture	29	1,892
Contusion	23	1,672
Sprain	11	1,591
Multiple types	11	2,047
Overall	84	1,8089

ED, emergency department.
Note: Medians are based on adjusted/Winsorized charge values.

Experience is imperative to operating a hoverboard safely. We found that almost 48% of all ED visits for hoverboard-related injuries occurred in the first month after December 24. Likewise, 14% of our patients were on their friend's or family's hoverboards and we speculate they were less experienced.

As research on hoverboard injuries increases, differences in injury severity and patient populations with other self-balancing personal transporters are emerging. Compared to recent Segway® injury studies,[2] our population suffered significantly less severe injuries. We found the average ISS was 5.44 (range 0-10) while the Segway® study reported an ISS range of 4-27 for their 10 admitted patients. They did not provide the ISS for discharged patients. Admitted patients from Segway® injuries suffered severe injury complexes including intracranial hemorrhage, pneumothorax, trimalleolar fracture, pelvic fractures, and complex facial fractures.[2].

In our review, only four patients required transfer or admission to the hospital for fracture-related care or due to delayed infection caused from a fall. Two pediatric patients required transfer to the local pediatric hospital and two adult patients were admitted from the ED. None required intensive care admission, and most were able to be treated in the ED and safely discharged home. Other differences include our population was significantly younger than Segway®-injured patients and did not have any concomitant anticoagulant use, which may explain why the injuries were less severe.

LIMITATIONS

Our study has several limitations. First, our sample size does not represent the entire southeastern Virginia population. While it is representative of patients treated in the EDs of one of the primary healthcare systems in the area, our study did not include data from other hospital systems, children's hospitals, or the large military healthcare system in the area, resulting in possible under-reporting of children and military-based families. Given the small sample size, our study limits its extrapolation to larger populations. Secondly, with our free-text search, it is possible that we did not identify all hoverboard injuries if they used a brand name in documenting. Likewise, we were dependent on the documentation provided in the EMR, and therefore data elements may have been present but not documented, which would have altered our analysis.

The retrospective nature of our study also does not allow us to know the factors surrounding the injuries. For example, we could not confidently identify the speed of the injury or the exact mechanism of the fall that resulted in the injury complex. Only two reviewers (GW and LG) extracted data and each then reviewed the other's work to ensure accuracy. However, no inter-rater reliability score was examined. Finally, the sample size may have limited the study's power to detect statistical differences between children and adults in the types of injuries sustained, areas of the body affected, and ED charge amounts. With respect to our cost analysis, we had a small sample size for lacerations and concussions, which limited the comparative value of the cost.

Follow-up studies with at least a full year's data are warranted to increase statistical power and to fully explore seasonality in injury patterns. The fact that our study did not have a majority youth representation may be because we did not have access to data from the local pediatric hospital.

CONCLUSION

While the overall ISS of hoverboard-related injuries was low, children less than 18 years of age had a higher percentage of fractures compared to their adult counterparts. Documented helmet use in the current study was extremely low, with 20% of patients experiencing closed head injuries, leading to an increased cost for those ED visits. Further investigation into the risk of hoverboard use is needed. Prospective studies are needed to identify the factors associated with hoverboard-related injuries that will serve to better inform safety standards in using protective equipment.

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Hepatitis A Virus: Essential Knowledge and a Novel Identify-Isolate-Inform Tool for Frontline Healthcare Providers

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Infection with hepatitis A virus (HAV) causes a highly contagious illness that can lead to serious morbidity and occasional mortality. Although the overall incidence of HAV has been declining since the introduction of the HAV vaccine, there have been an increasing number of outbreaks within the United States and elsewhere between 2016 and 2017. These outbreaks have had far-reaching consequences, with a large number of patients requiring hospitalization and several deaths. Accordingly, HAV is proving to present a renewed public health challenge. Through use of the "Identify-Isolate-Inform" tool as adapted for HAV, emergency physicians can become more familiar with the identification and management of patients presenting to the emergency department (ED) with exposure, infection, or risk of contracting disease. While it can be asymptomatic, HAV typically presents with a prodrome of fever, nausea/vomiting, and abdominal pain followed by jaundice. Healthcare providers should maintain strict standard precautions for all patients suspected of having HAV infection as well as contact precautions in special cases. Hand hygiene with soap and warm water should be emphasized, and affected patients should be counseled to avoid food preparation and close contact with vulnerable populations. Additionally, ED providers should offer post-exposure prophylaxis to exposed contacts and encourage vaccination as well as other preventive measures for at-risk individuals. ED personnel should inform local public health departments of any suspected case. [West J Emerg Med.2017;18(6)1000–1007.]

INTRODUCTION

The incidence of hepatitis A virus (HAV) infection steadily decreased in the United States (U.S.) and other developed countries following the introduction of the HAV vaccine. Although vaccine became available in the U.S. in 1995, vaccination was not routinely recommended for children in California until 1999, and across the U.S. in 2006. The incidence of HAV decreased from six cases per 100,000 in 1999 to 0.4 cases per 100,000 in 2011.[1,2] However, there has been a resurgence in the incidence of HAV in the U.S., with recent outbreaks occurring in San Diego, Los Angeles, New York City, Michigan, Hawaii, and several other counties and states. Between August 1, 2016, and October 12, 2017, there have been 397 confirmed cases of HAV in Michigan with 15 fatalities and 320 hospitalizations (85.6%). The Michigan Department of Health and Human Services has not yet identified a common source of the outbreak as of October 12, 2017.[3] San Diego's public health officer declared a local health emergency on September 1, 2017, due to the ongoing outbreak of HAV. As of October 17, 2017, the county has identified a total of 507 cases with 19 deaths and 351 (69%) hospitalizations related to the outbreak.[4] Between June and October 2016, Hawaii reported 292 confirmed cases of HAV with 74 patients requiring hospitalization.[5] This outbreak was linked to raw scallops served at a local sushi

chain and a subsequent product recall was instated with no new cases reported as of July 11, 2017.[6] A 2016 multistate outbreak of HAV linked to contaminated frozen strawberries resulted in 143 recognized cases and 56 hospitalizations.[7]

These HAV outbreaks pose a unique challenge for public health officials for several reasons: the prolonged incubation period (15-50 days); infected individuals can transmit the disease up to two weeks *prior* to symptom onset; many infected persons remain asymptomatic; and many patients affected in these outbreaks are homeless and/or illicit drug users (both injection and non-injection), causing difficulty in contacting and following up infected persons.[3,4] Emergency Department (ED) providers in affected areas may encounter and treat a large number of these patients. Additionally, if the disease arises in other regions, it is likely that ED providers would be the first point of contact for many symptomatic patients. Given the contagious nature of HAV, as well as potential morbidity and mortality associated with the disease, it is of great importance that cases of the infection be accurately recognized, isolated and treated, with prompt notification of public health authorities. ED providers have a unique opportunity to advocate for vaccination of vulnerable populations, and EDs have enacted vaccination programs during acute outbreaks.[8] After a thorough review of HAV infection, this paper describes a novel 3I tool, initially developed for Ebola virus and subsequently adapted for measles, MERS and mumps,[9-12] for use by ED providers in the initial detection and management of HAV patients.

Population Health Research Capsule

What do we already know about this issue?
Public health officials are reporting outbreaks of hepatitis A virus (HAV), the cause of a highly contagious illness that can lead to serious morbidity and occasional mortality.

What was the research question?
Investigators sought to modify the "Identify-Isolate-Inform" (3I) Tool for use in management of HAV outbreaks.

What was the major finding of the study?
A novel HAV 3I Tool is created for real-time application in managing patients presenting to the Emergency Department (ED).

How does this improve population health?
HAV presents a renewed public health challenge. ED providers have an essential role in assisting public health with management of this vaccine-preventable disease.

CLINICAL PRESENTATION

HAV infection often presents with a prodromal period characterized by nausea, vomiting, anorexia, fever, malaise and abdominal pain. After a few days to weeks, patients may develop dark urine and pale, clay-colored stools as well as jaundice and pruritus. In some infected persons, there is no prodromal phase or it is so mild that the infected person does not present for medical care until jaundice develops. Approximately 70% of infected adults will exhibit initial symptoms; jaundice occurs in 40-70% of cases.[13] During the prodromal phase, infected persons are highly contagious as there is viremia, and large quantities of infectious virus are shed in the stool. On physical examination, patients commonly present with fever, jaundice, scleral icterus and hepatomegaly.[14,15] Less commonly, patients may demonstrate extrahepatic signs and symptoms of the disease, including splenomegaly, rash and arthralgias. In very rare cases, hematologic abnormalities (e.g. aplastic anemia, red cell aplasia and thrombocytopenia), neurologic abnormalities (e.g. optic neuritis and transverse myelitis), rheumatologic findings (e.g. leukocytoclastic vasculitis, glomerulonephritis, cryoglobulinemia) as well as toxic epidermal necrolysis and myocarditis can occur.[16-21]

RISK FACTORS

Populations at highest risk for HAV infection include travelers from high-income developed countries who visit endemic areas of Africa, Asia, and parts of Central and South America, men who have sex with men, close contacts (household or sexual) with infected persons, persons exposed to daycare centers, as well as the homeless, the incarcerated, and illicit drug users.[23,24,27] In the 2016-17 Michigan and San Diego outbreaks in the U.S., half to three-quarters of infected individuals were homeless, recently incarcerated or illicit drug users.[3,22] In the Hawaii outbreak from scallops and in the multistate outbreak from frozen strawberries, these populations were not at higher risk. Between December 2016 and June 2017, there has been an ongoing HAV outbreak in 20 European countries and Tel Aviv, Israel. As of September 27, 2017, 2,873 cases of HAV infection have been identified. 980 of these cases involved male patients. Of cases among male patients, 738 (76%) occurred among men having sex with men.[25] Additionally, 17 cases of HAV in Tel Aviv have been linked to men having sex with men.[26] Between January and August of 2017, there has also been an increase in HAV infection in men who have sex with men in New York City, with 46 identified patients as of September 22, 2017.[28]

DIAGNOSIS

Clinically, HAV infection cannot be distinguished from other forms of viral hepatitis. Typically, the alanine aminotransferase level is very high, even in mild cases, including in the prodromal phase, usually approaching 1,000 units/L or greater, and is typically greater than the aspartate aminotransferase. Healthcare providers should suspect HAV infection in patients with the above-mentioned common symptoms (see "Clinical Presentation"), particularly in conjunction with elevated liver function tests. At initial presentation, persons with suspected viral hepatitis should have serologic testing for hepatitis A, B, and C, to include HAV immunoglobulin M (IgM), hepatitis B surface antigen, hepatitis B core IgM, and hepatitis C antibody. Serologic testing for HIV should be performed if HIV-status is not known. The prothrombin time/international normalized ratio should also be checked. Anti-HAV IgM is an indicator of acute infection and can be detected in blood for up to six months after infection. Anti-HAV IgG is indicative of either past infection or vaccination.[29]

COMPLICATIONS AND SPECIAL POPULATIONS

Less than 1% of cases of HAV infection in adults will progress to fulminant liver failure. Within the U.S., only 3% of cases of liver failure in adults have been attributed to HAV infection.[30,31] Among children in the U.S., HAV infection accounts for up to 1% of cases of acute liver failure.[32] However, in countries with a higher disease incidence, some studies report that HAV infection accounts for up to 60% of pediatric liver failure cases.[33,34] Patients with underlying liver disease, including those with chronic hepatitis B or C, are at greater risk for development of fulminant hepatic failure if they become infected with HAV infection.[35] HAV-related acute liver failure has a spontaneous survival rate of approximately 69%. The remainder of individuals will either successfully undergo liver transplantation or progress to death.[31] Management of acute liver failure due to HAV infection is similar to the management of liver failure due to other causes.

Unlike hepatitis B and C, HAV infection has no chronic carrier state and does not lead to chronic hepatitis or cirrhosis. Persons with chronic liver disease caused by hepatitis B or C who subsequently develop HAV infection may have increased morbidity and mortality.[36] HAV infection can be complicated by the development of cholestatic hepatitis with a protracted period of jaundice. Clinical symptoms include jaundice, pruritus, fever, weight loss and diarrhea for a period of greater than three months. Laboratory tests will show elevated bilirubin, alkaline phosphatase and transaminitis. Cholestatic hepatitis will typically resolve without further intervention and treatment is limited to supportive management.[37,38]

Relapsing hepatitis can complicate some cases of HAV infection. A relapse of symptoms may occur a couple of weeks to several months after the original illness. Symptoms during relapse are typically milder in severity when compared to the initial acute illness. Treatment is focused on supportive care, and resolution typically occurs without further intervention.[39] HAV can rarely lead to the development of autoimmune hepatitis that can have a prolonged and complicated clinical course.[40]

TRANSMISSION AND PERSONAL PROTECTIVE EQUIPMENT

The fecal-oral route is the primary mechanism of transmission for HAV. Transmission typically occurs via close person-to-person contact (sexual or household) or via exposure to food or water contaminated by human feces, even in minute amounts. For all practical purposes, humans are the only host for the HAV virus. The incubation period for HAV is about 28 days on average, but can range from 15-50 days. Patients are considered contagious for both two weeks prior to, and up to 1-2 weeks after symptom onset.[41] Rarely, the virus can be excreted in the stool for weeks to months, especially in immunocompromised children. The virus can be contracted from cooked food if the food is either not heated to an adequately high temperature (>185° F, >85° C) or if it is contaminated after being cooked.[43] Healthcare providers treating potentially infected patients should observe standard precautions including using gloves and handwashing with soap and warm water. Importantly, HAV virus may not be inactivated by alcohol-based hand rubs.

Infectious virus may remain viable on surfaces for months and is resistant to many chemical agents, but is killed by household bleach (hypochlorite). Chlorine bleach solution should be used to disinfect frequently touched surfaces. Some outbreak cities have initiated power-washing of sidewalks and street areas with a bleach and chlorine solution in areas with a high density of homeless populations. Gown and gloves should be worn prior to disinfecting and cleaning affected areas. Further isolation measures are not routinely recommended.[45,46]

DIFFERENTIAL DIAGNOSIS

The differential diagnosis for a patient presenting with symptoms of HAV virus infection is broad. It includes hepatitis B, C, D and E viruses. Other infections in which acute hepatitis sometimes manifests include Epstein-Barr virus, cytomegalovirus, yellow fever, disseminated herpes simplex, adenovirus, HIV infection, malaria, leptospirosis, syphilis, Rocky Mountain spotted fever, typhoid fever and Q fever.[47] Non-infectious causes of similar symptoms should also be considered, including drug-induced liver injury (e.g., from acetaminophen), Budd-Chiari syndrome, Amanita phalloides mushroom poisoning, and autoimmune hepatitis.[48]

TREATMENT

HAV is typically a self-limited infection and treatment is primarily directed towards supportive care, including analgesics, hydration and medication for pruritus. Patients should be instructed to avoid hepatotoxic medications and alcohol. In cases of acute liver failure due to HAV, transfer to a liver transplantation center should be considered. Other

complications of HAV infection should be managed via a standard approach to those disease entities.[47]

PREVENTION

The primary method of prevention of HAV infection is through vaccination. In the U.S., the vaccination is a two-dose series licensed for use in all individuals above the age of 12 months. The Centers for Disease Control and Prevention (CDC) recommends vaccination for the following: all children at one year of age; children and adolescents 2-18 years of age who live in areas with high disease incidence who have not been vaccinated at age one; persons traveling to or temporarily residing in developing countries with increased incidence of HAV; men who have sex with men; patients who use illegal drugs (both injection and non-injection); persons with occupational risk factors (persons who either work with HAV-infected primates or with HAV virus in a laboratory setting); persons with chronic liver disease or who have received/are awaiting liver transplants; persons with clotting-factor disorders; and close contacts of adopted children from countries with increased incidence of HAV infection. In the future homeless individuals may be added to the list of persons for whom vaccination is recommended.

The HAV vaccine is composed of an inactivated virus; accordingly, it is safe for administration to immunocompromised persons. The safety of the vaccine in pregnancy is indeterminate at this time (although thought to be low risk). A discussion of risks as well as benefits should be held with pregnant patients prior to administration of vaccination.

Persons with recent exposure to HAV can be administered the single agent HAV vaccine within two weeks of exposure to prevent infection. They should not be given the combined HAV/HBV vaccine as post-exposure prophylaxis (PEP) since a single dose of the combination may be less efficacious in inducing protective antibody. While the regular vaccination schedule requires an additional vaccine dose in six months, this may be impracticable in homeless and drug-using populations. For outbreak control, a single vaccination is effective and has an efficacy of 94-100% in adults and 97-100% in children.[49] Intramuscular immune globulin (IG) can also be used for the same purpose. The IV formulation of IG should be not be used since it contains lower titers of protective antibody.

Immunocompromised patients, children aged less than 12 months, patients with chronic liver disease, and patients with an allergy to the vaccine or vaccine component should be treated with intramuscular IG at dose of 0.1 mL/kg. CDC recommends PEP with IG rather than vaccine for persons over age 40. Some public health departments (e.g., California Department of Public Health) recommend vaccine without IG through age 59, and vaccine plus IG for persons aged 60 and over. Persons administered IG should receive HAV vaccine concurrently if it is also recommended for other reasons. Immunocompromised persons may also be offered the vaccine in addition to IG, but vaccine response may be reduced. PEP is recommended for close personal contacts of infected individuals, unvaccinated staff members and attendees at affected child-care centers, and for persons exposed to food or water from a common infected source. Some ED and prehospital providers who are caring for high-risk populations during outbreaks have been offered vaccination. Even if unvaccinated, healthcare workers who manage a patient infected with HAV do not routinely require PEP as long as standard precautions and adequate hand hygiene are observed.[43,44]

DISPOSITION

Due to the self-limiting nature of HAV infection, most immunocompetent patients without major comorbidities can be managed as outpatients with instructions to maintain good hand hygiene, avoidance of sharing of food or towels, and with supportive measures. Standard admission criteria should be used to assess symptomatic patients and determine whether hospitalization is required. As noted above, patients with acute hepatic failure due to HAV should be transferred to a liver transplantation center if feasible.

IDENTIFY-ISOLATE-INFORM

The identify-isolate-inform tool, initially developed for Ebola virus disease,[9] can be modified and applied to the ED evaluation and management of patients presenting with symptoms suggestive of HAV infection (Figure). The first branch of the algorithm entails *identifying* suspected cases based on clinical signs/symptoms and exposure history. Of note, patients are contagious *prior* to symptom onset and some patients may never develop symptoms. In addition, a typical milder *relapsing hepatitis* may occur two weeks or more after initial symptom onset in approximately 2- 20% of patients (10% in the 2017 San Diego outbreak) making it important to query patients about whether their symptoms are recurrent.

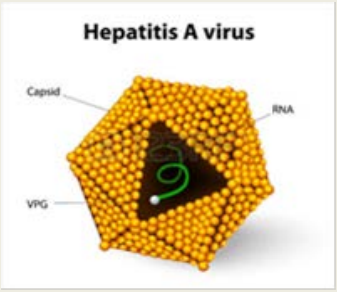
As transmission of HAV is mainly fecal-oral, patients require standard and enteric precautions, but airborne and respiratory droplet *isolation* precautions are not required. Blood samples should be obtained from patients with suspected HAV to confirm the diagnosis. Providers caring for patients with suspected HAV infection should observe strict standard precautions and hand hygiene with soap and warm water in all cases. Healthcare providers should ensure to wash hands for at least 10-20 seconds.[46,50] Healthcare workers should additionally use contact precautions when caring for incontinent or diapered patients.

Patients should be counseled on the importance of hand hygiene. Affected patients should also be instructed to avoid food preparation for others and patients who work in food service, health service or in child care facilities should be advised to avoid work until two weeks after onset of initial symptoms or jaundice (whichever occurs later). Patients presenting within two weeks of exposure should be offered PEP (vaccination or

Identify, Isolate, Inform

Emergency Department Evaluation and Management of Patients Under Investigation (PUI) for Hepatitis A Virus

Information Current as of October 18th, 2017



IDENTIFY/IMMUNIZE

SYMPTOMATIC SIGNS AND SYMPTOMS

- Nausea
- Anorexia
- Fever
- Malaise
- Abdominal pain
- Jaundice
- Elevated serum aminotransferase levels

ASYMPTOMATIC* EXPOSURE HISTORY

- Household or sexual contact with an infected person
- Ingestion of contaminated food or water
- Travel to countries with high rates of endemic infection

- Provide postexposure prophylaxis (vaccination and/or IG)** within 2 weeks of exposure
- Offer ED vaccination to populations at risk: homeless, illicit drug users (injection and non-injection), men who have sex with men

ISOLATE

- Observe standard precautions
- Observe contact precautions when caring for incontinent and diapered patients
- Observe hand hygiene with soap and water; wash hands for at least 10-20 seconds
- Patients should avoid work in food preparation, healthcare and child care until two weeks after symptom onset
- Confirm diagnosis with serum IgM testing

INFORM

Report immediately to
- Local Health Department
- Hospital Infection Control

* Patients are contagious *prior* to symptom onset

** Immunocompromised patients, children aged less than 12 months, patients with chronic liver disease and patients with an allergy to the vaccine or vaccine component should be treated with IG. Per CDC, treatment with IG rather than the vaccine is also preferred for all patients over the age of 40.

The Identify-Isolate-Inform 3I Tool was conceived by Dr. Kristi L Koenig, County of San Diego EMS Medical Director & Professor Emerita, UC Irvine

Figure. Identify-Isolate-Inform tool adapted for Hepatitis A virus.

IG as appropriate, based on age and comorbidities). A healthcare advisory released July 20, 2017, followed by a CDC publication on September 15, 2017, recommended an increase in the dosage for IG for pre- and post-exposure prophylaxis.[42]

Healthcare providers should promptly *inform* the local public health department of suspected and confirmed cases of HAV. Timely notification is particularly important when homeless and illicit drug users are affected as these patient populations can be difficult to trace once discharged from the ED. Providers should also notify hospital infection control personnel of suspected cases and abide by any additional legal requirements such as notification of exposed prehospital personnel.[43,51]

Because vaccination is a key component of outbreak control, some public health experts have recommended adding another "I" to the algorithm, specifically to represent "immunize."[52] Immunization of at-risk populations who present to the ED for unrelated reasons is an important public health intervention.[8] To assist providers with remembering to vaccinate, the "Identify" branch of the 3I algorithm can be thought of as "Identify/Immunize" for management of both infected and vulnerable populations. Of note, it takes approximately two weeks for immunity to develop after vaccination administration.

CONCLUSION

HAV is a highly contagious viral disease with the potential for severe morbidity and mortality. Although the overall incidence of the disease has been decreasing in developed countries since the development of the HAV vaccine, there have been a number of large outbreaks in several U.S. states and elsewhere. The Identify-Isolate-Inform tool will serve as a useful instrument for ED providers to apply in the evaluation and management of patients who present with possible HAV exposure or infection.

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Why Emergency Physicians Should Care About the Salton Sea

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The deterioration of the ecosystem surrounding the Salton Sea, a 376-square mile lake located between Imperial and Riverside Counties in Southern California[1] has an important effect on the health of the surrounding impoverished population. The greater Salton Sea area comprises 177,000 people demographically divided into 80.9% Latino, 13.7% White/Non-Hispanic, and 10.5% African American.[2] Median income and poverty percentiles in the area are 23.02% and $35,000 compared to the rest of California at 15.28% and $61,400 respectively.[3,4] This area is also disproportionately affected by pediatric asthma with 20% of its pediatric population diagnosed with asthma compared to 8% nationally.[5] Currently, emergency departments in Imperial County treat three times more pediatric asthma visits than elsewhere in California.[5,6] Recently, there has been new governmental, academic, and community interest in this issue, and as emergency physicians we have a unique opportunity to become involved in the health of the Salton Sea as well as the surrounding community.

The Salton Sea is a terminal body of water without outflow and relies on agricultural runoff, and the New, Whitewater, and Alamo rivers to maintain its water level. The last filling of the lake occurred in 1904 when the Colorado River flooded, and the surrounding area has since become heavily populated and a vital part of the Coachella Valley economy and integral part of the Southern California ecosystem.[7] Over the last decade, the lake has been decreasing in size due to evaporation, increasing its salinity. Without efforts to sustain the sea, it is projected to decrease to 1/3 its size in the next 50 years, potentially crippling the local economy, with catastrophic effects on the health of the impoverished surrounding population, and adversely affecting air quality in Southern California.[8]

Approximately 1,300,000 acre-feet of water each year evaporate from the Salton Sea (one acre-foot = 326,000 gallons).[1] Without outflow, it is dependent on river water diversion as well as runoff from agricultural irrigation to equal its evaporative rate. In recent years, water levels have dropped drastically due to the 2003 Quantification Settlement Agreement, which diverted large amounts of river water to urban San Diego.[9] This uncompensated evaporation causes salinity levels of the lake to increase. If there is no intervention to address these rising salinity levels, life in the lake will become unsustainable, crippling the fishing, agricultural and recreation economies, as well as having a drastic effect on the ecosystem. [1,7-9] Greater exposed lakebed from evaporation will create dust storms, increasing the particulate burden in the atmosphere as well as releasing toxic chemicals such as hydrogen sulfide, arsenic, and pesticides from irrigation run off.[10] Currently, the particulate matter in the atmosphere surrounding the lake exceeds California and National Ambient Air quality standards, but it is currently unclear how much of this is attributable to the lake evaporation.[11] These pollutants act as a pulmonary irritant and likely play a role in the high incidence of chronic lung disease in the area.[10,11] Additionally, these dust particles are very fine and may spread, affecting the air quality of the Los Angeles and San Diego metropolitan areas.[1]

Though certain options like desalination and water diversion are possible to restore lake volume and improve salinity, they are very costly and water diversion is difficult in the drought-ridden Southwest. Fortunately, there are other strategies to restore and protect the Salton Sea. Potential renewable energy projects endorsed by the Geothermal Energy Association to take place at or around the sea (i.e. solar, geothermal, wind), have the potential to finance Salton Sea air quality and habitat restoration.[12] Additionally, surrounding areas have become booming residential areas due to the lower cost of land. Between 2005-2012 the population grew by 10.5% and is anticipated to double in 50 years.[13] The projected growth is a potential strategic opportunity to mobilize people fleeing high Los Angeles metro-area housing prices to take interest in the restoration and preservation of the Salton Sea.

Recently there has been increased governmental interest in the health of the Salton Sea. Senate Bill 615 (SB-615) requires the California Natural Resources Agency to develop and fund a 10-year plan by 2018 with the U.S. Department of the Interior to address and improve habitat and air quality and projected lakebed exposure of the Salton Sea. This will be done in consultation with the Salton Sea Authority, a nonprofit agency dedicated to its revitalization.[14] This bill, which was passed in June of 2017, contains a series of declarations regarding the deteriorating physical condition of the Salton Sea, the importance of habitat restoration projects, and the importance of efforts to control dust

emissions improving air quality in the area.[14]

Current research by the University of Southern California and the University of Iowa on lakebed composition, as well as airborne particulate matter, aims to establish the composition of the lakebed and released air particles, as well as community-level research to establish the incidence of pulmonary disease in the area. This is key to determining particle toxicity and the extent to which evaporation affects the atmosphere as well as how it will affect the current population.[15]

The revitalization of the Salton Sea and improving the air quality of the area will require a multi-tiered effort of local community empowerment, local and state government, healthcare providers, researchers and environmental activists. This is not only pertinent to the greater Salton Sea area, but may reach those in adjacent, heavily populated metropolitan areas. It is our duty as emergency physicians to help those suffering from health disparities through participation in research, community empowerment, and involvement with local government.

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Trends in Regionalization of Care for ST-Segment Elevation Myocardial Infarction

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Introduction: California has led successful regionalized efforts for several time-critical medical conditions, including ST-segment elevation myocardial infarction (STEMI), but no specific mandated protocols exist to define regionalization of care. We aimed to study the trends in regionalization of care for STEMI patients in the state of California and to examine the differences in patient demographic, hospital, and county trends.

Methods: Using survey responses collected from all California emergency medical services (EMS) agencies, we developed four categories – no, partial, substantial, and complete regionalization – to capture prehospital and inter-hospital components of regionalization in each EMS agency's jurisdiction between 2005-2014. We linked the survey responses to 2006 California non-public hospital discharge data to study the patient distribution at baseline.

Results: STEMI regionalization-of-care networks steadily developed across California. Only 14% of counties were regionalized in 2006, accounting for 42% of California's STEMI patient population, but over half of these counties, representing 86% of California's STEMI patient population, reached complete regionalization in 2014. We did not find any dramatic differences in underlying patient characteristics based on regionalization status; however, differences in hospital characteristics were relatively substantial.

Conclusion: Potential barriers to achieving regionalization included competition, hospital ownership, population density, and financial challenges. Minimal differences in patient characteristics can establish that patient differences unlikely played any role in influencing earlier or later regionalization and can provide a framework for future analyses evaluating the impact of regionalization on patient outcomes. [West J Emerg Med. 2017;18(6)1010-1017].

INTRODUCTION

Despite the relative decrease in the incidence of ST-segment elevation myocardial infarction (STEMI) over the past decade, STEMI still comprises about 25-40% of acute myocardial infarction incidents.[1] STEMI patients can be diagnosed early in their course with 12-lead electrocardiography (ECG) performed in the field by paramedic personnel and transmitted wirelessly to the hospital. This technology has accelerated the delivery of STEMI care, such as improving target times to treatment and emergency medical services (EMS) transport.[2,3]

In an effort to optimize access to and delivery of care, policies from the American Heart Association (AHA) have advocated for establishing regional systems and networks.[4] Implementation of regionalized care has numerous potential benefits, including greater likelihood of primary percutaneous coronary intervention (PCI) treatment, improved door-to-balloon times, and lower rates of mortality, stroke, and heart failure.[2]

Several regions in the United States have begun adopting innovative successful efforts to regionalize STEMI care, demonstrating feasible outcomes by integrating inter-hospital transfers and prehospital protocols;[2] however, barriers to system implementation have existed over the last decade.[2,3] Characterizing the trends of regionalized STEMI care systems can help provide an understanding of the elements that encourage or prevent regionalization in order to better inform areas looking to restructure or improve the organization of current EMS services and health systems.

In California, EMS care is divided into 33 separate local EMS agencies (LEMSAs), and while all LEMSAs must have their EMS plans abide by general state EMS authority mandates, no specific mandated protocols exist to define regionalization of care.[5] Recent steps have been taken to improve this, including development of protocol parameters to be incorporated into all local EMS protocols for common, severe medical complaints such as chest pain.[5] The variations between LEMSAs and their regionalization-of-care protocols provide an opportunity to study the spectrum of how STEMI regionalization of care has been implemented.

Previous work studying the effects of STEMI regionalization has not fully addressed demographic and clinical patient and hospital characteristics,[6-9] potentially missing some underlying differences. Our descriptive characterization of the population will help identify any drastic differences between counties, ruling out potential causes of patient outcome differences outside of the adoption of regionalization protocols such as racial differences in PCI access and mortality outcomes.[10-12] We aimed to perform a careful examination of underlying demographic characteristics for potential differences to provide the necessary groundwork for analyzing the impact of regionalization on patient outcomes in California. Therefore, the two major objectives of this paper were to 1) describe STEMI regionalization-of-care trends in California; and 2) examine the differences in patient demographic, hospital, and county trends between earlier vs. later regionalized counties across the state.

Population Health Research Capsule

What do we already know about this issue?
Regionalization of care is a system that directs ambulances with STEMI patients to hospitals with PCI capabilities, which has been shown to improve treatment times.

What was the research question?
What are current trends in regionalization of care for STEMI patients in California?

What was the major finding of the study?
We found hospital and potential geographic differences between earlier and later regionalized counties.

How does this improve population health?
Our findings identify potential barriers to establishing regionalized systems of care, and may provide a framework for regionalization of care in other regions.

METHODS

Study Design

We collected survey responses from all California EMS agencies (details below), and linked the survey responses to 2006 California non-public hospital discharge data to understand the patient distribution at baseline. We obtained hospital information from annual surveys conducted by the AHA and annual reports submitted through the Healthcare Cost Report Information System maintained by the Centers for Medicare and Medicaid Services. We used county-level data from the U.S. Census for population demographics. We calculated the numbers of STEMI patients each year using *International Classification of Diseases, Ninth Revision* codes 410.0 through 410.6 and 410.8[13] per EMS agency. The institutional review board approved this study under expedited review.

Study Setting and Population

Directors or STEMI coordinators from each EMS agency were asked to fill out a STEMI Regionalization Survey

designed to evaluate the degree and duration of STEMI regionalization of care in each EMS jurisdiction. All 33 LEMSAs representing 58 counties in California responded and filled out the survey, resulting in a 100% response rate.

STEMI Regionalization Survey

Rokos et al.[14] provided a detailed approach on the development of the STEMI Regionalization Survey. The survey was developed to serve as an evidence-based assessment tool to evaluate and assess the degree and duration of STEMI regionalization of care for each EMS agency. The questions were categorized based on different elements of a STEMI regionalized system: availability of prehospital 12-lead ECG devices; destination protocols; designation of PCI-capable hospitals as STEMI Receiving Centers (SRC) that function 24/7; inter-hospital transfer protocols from non-PCI hospitals to SRCs; and hospital quality improvement (see Supplement for a copy of the survey). Each EMS agency was asked to identify the existence of each element as of 2014, as well as the year the element was implemented. As such, the survey represents the regionalization-of-care status for each EMS agency between 2006 (the first full year that clinical coding separated STEMI from non-STEMI) and 2014.

Categories of Regionalization Status

For the years evaluated, the survey assessed the degree of each EMS agency's regionalized status by providing four multiple-choice options aimed at capturing the level of regionalization reached for each of the elements above: 1) Level A (none- 0%); 2) Level B (some- <50%); 3) Level C (most- 50-94%); and Level D (all- ≥95%). We developed four categories to capture both the prehospital (EMS devices and destination protocols) and inter-hospital (non-PCI-capable referral hospitals) components of regionalization defined as follows: no regionalization; partial regionalization; substantial regionalization; and complete regionalization. Table 1 provides a summary of the regionalization category definitions.

RESULTS

In 2006, only eight out of 58 counties (representing 42% of California's STEMI population) had reached regionalization, with five counties (representing 13% of STEMI patients) considered completely regionalized (Table 1 and Figure). In 2011, the number of counties that had reached partial, substantial, and complete regionalization increased by 11, 14, and 13, respectively, from 2006. By 2014, all counties had at least one regionalization-of-care protocol in place; 30 out of 58 counties completely regionalized (representing 86% of STEMI patients), while the number of partially and substantially regionalized counties did not change from 2011 (Figure).

Of the counties that were not regionalized at baseline, 22 counties became partially regionalized, 12 became substantially regionalized, and 16 became completely regionalized in their first year of regionalization. The counties that became completely regionalized in their first year of regionalization generally were more populated than other counties. Not shown in the graph, a greater proportion of counties in Southern California reached complete regionalization by 2014, compared to Northern California, where the majority of counties reached only either partial or substantial regionalization. To collect the data we had to ensure the confidentiality of all counties and that no specific county would be identified in our results; thus, we are unable to provide maps of regionalization progress over time.

Table 1. ST-segment elevation myocardial infarction regionalization categories.

	None	Partial	Substantial	Complete
Criteria				
Prehospital protocols				
<50% coverage	X			
50-94% coverage		X (either)	X (both)	
≥95% coverage				X
Inter-hospital transfer protocols				
<50% coverage	X			
50-94% coverage		X (either)	X (both)	
≥95% coverage				X

None: Neither prehospital nor inter-hospital protocols were in place, or the protocols were implemented in less than 50% of the emergency medical service (EMS) agency jurisdiction.
Partial: Between 50% to 94% of the EMS agency jurisdiction had either prehospital or inter-hospital protocols in place, but not both.
Substantial: Between 50% to 94% of the EMS agency jurisdiction had both prehospital and inter-hospital protocols in place.
Complete: At least 95% of the EMS agency jurisdiction had both prehospital and inter-hospital protocols in place.

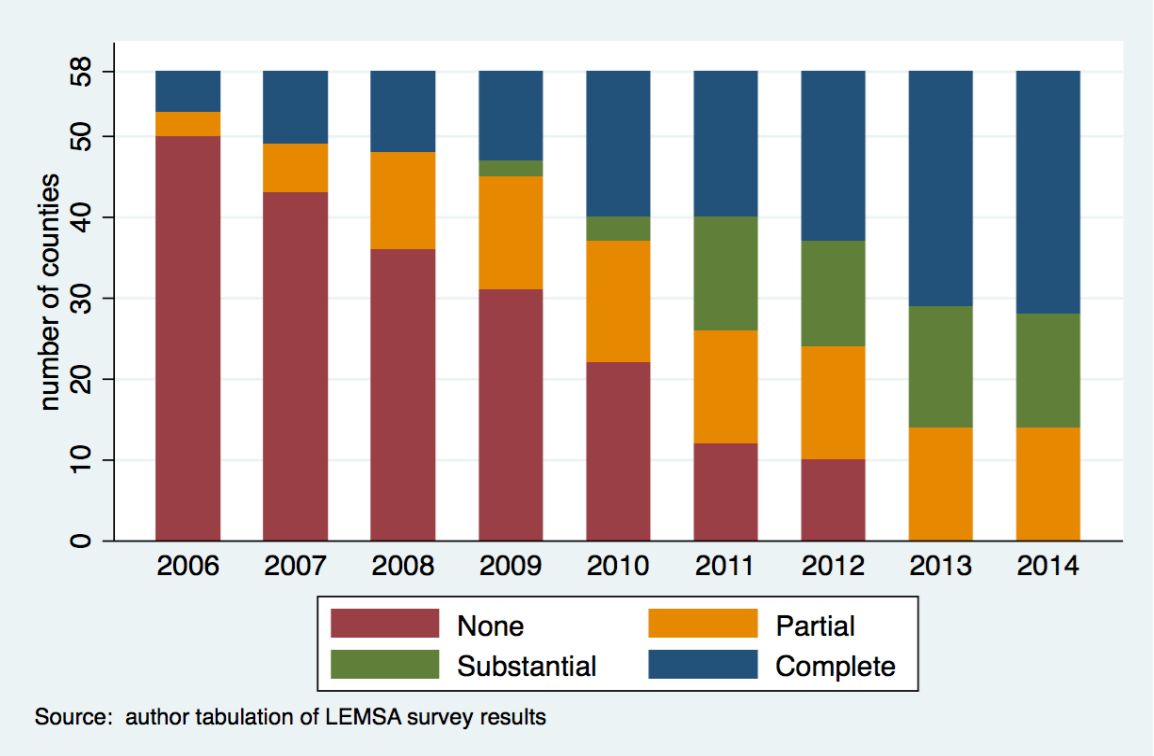

Figure. California STEMI regionalization status between 2006 and 2014.
STEMI, ST-segment elevation myocardial infarction; *LEMSA*, local emergency medical service agency.

Patient Demographic, Hospital, and County Trends

Table 2 shows a description of patient demographics by year of regionalization, where we considered "regionalized" as any level of regionalization (full descriptive statistics in Appendix Table 1). Subsequent sensitivity analyses using a more conservative definition of regionalization restricted to substantial or complete regionalization showed no changes. At baseline, already-regionalized communities compared to the whole sample had a slightly higher proportion of black (8% v. 5%), Hispanic (20% v. 16%), and Asian residents (10% v. 8%), and fewer White residents (58% v. 66%). While the proportion of Medicare-insured residents between earlier and later regionalized counties did not differ substantially, later regionalized counties had a higher proportion of privately insured residents (36% after 2011 vs. 33% before 2006), and earlier regionalized counties had a slightly higher proportion of Medicaid-insured patients (10% before 2006 v. 8% after 2011). Underlying co-morbidities of patients in earlier vs. later regionalized counties did not differ dramatically.

At the hospital level, earlier regionalized counties had a higher proportion of for-profit hospitals (22% before 2006 v. 11% after 2011), while later regionalized counties had a higher proportion of teaching hospitals (14% after 2011 v. 8% before 2006) and hospitals part of a system (88% after 2011 v. 72% before 2006). Additionally, counties that regionalized by 2006 had a Herfindahl-Hirschman Index (HHI, a measure of market concentration) mean of 0.14, indicating a low concentration of hospitals, 0.33 for counties regionalized by 2011, indicating a high concentration of hospitals, and 0.21 for counties that regionalized by 2014, indicating a moderate concentration of hospitals.

At the county level, communities that regionalized later had a slightly higher mean per capita income ($39,615) compared to those that regionalized earlier ($37,956), consistent with earlier regionalization trends in communities with higher proportions of Medicaid-insured individuals. However, we found no apparent trends in the percentage of the population identified as living under the poverty line, part of a racial/minority group, or elderly (> 65 years).

DISCUSSION

STEMI regionalization and its impact have been particularly well-documented in the literature for North Carolina,[15] and our study adds to that literature with the first description and documentation, to our knowledge, of regionalization-of-care efforts for STEMI patients in California. Our survey results cover years 2006-2014, showing that generally Southern California areas regionalized faster. In our description of patient and hospital characteristics in earlier vs. later regionalized counties, we found that while patient characteristics differed little,

Table 2. Descriptive statistics at baseline (2006) by year of regionalization of care for STEMI patients in California.

	Whole sample		Regionalized as of 2006		Regionalized between 2007-11		Regionalized after 2011	
	N	%	N	%	N	%	N	%
Sex								
Female	6131	35%	2576	35%	2596	34%	959	35%
Male	11598	65%	4824	65%	4954	66%	1820	65%
Race/ethnicity								
White	11656	66%	4266	58%	5490	73%	1900	68%
Black	941	5%	556	8%	243	3%	142	5%
Hispanic	2784	16%	1463	20%	1050	14%	271	10%
Asian	1440	8%	735	10%	390	5%	315	11%
Other non-White races	908	5%	380	5%	377	5%	151	5%
Age distribution								
Less than 65	8140	46%	3349	45%	3425	45%	1366	49%
65 and above	9563	54%	4035	55%	4118	55%	1410	51%
65–69	1877	11%	765	10%	797	11%	315	11%
70–74	1729	10%	729	10%	759	10%	241	9%
75–79	1893	11%	803	11%	817	11%	273	10%
80–84	1877	11%	782	11%	828	11%	267	10%
85+	2187	12%	956	13%	917	12%	314	11%
Payment Categories								
Medicare	8909	50%	3610	49%	3952	52%	1347	48%
Medicaid	1380	8%	731	10%	440	6%	209	8%
Private Insurance	5870	33%	2424	33%	2452	32%	994	36%
Indigent	448	3%	159	2%	231	3%	58	2%
Self-pay	794	4%	360	5%	325	4%	109	4%
Other	328	2%	116	2%	150	2%	62	2%
Other admission hospital characteristics								
For profit	3078	17%	1636	22%	1124	15%	318	11%
Government	2180	13%	696	10%	1219	17%	265	10%
Teaching hospital	1457	9%	557	8%	520	7%	380	14%
Member of a system	13387	77%	5173	72%	5817	78%	2397	88%
Mean total beds in hospital (SD)	277	141	298	151	267	132	245	126
Mean occupancy rate (SD)	0.69	0.14	0.68	0.15	0.68	0.14	0.73	0.13
Mean HHI index (SD)	0.23	0.25	0.14	0.20	0.33	0.28	0.21	0.15
County characteristics								
Mean per capita income (SD)	$37,938	$10,516	$37,956	$8,950	$37,302	$9,606	$39,615	$15,418
% Population below poverty line (SD)	13	4.16	14	4.14	12	3.70	13	4.43
% Minority Population (SD)	22	8.71	25	6.90	18	7.86	27	10.21
% Population ≥ 65 years (SD)	11	1.77	10	0.76	11	2.09	11	2.22
Patient	17729		7400		7550		2779	
Population	36,457,548		16,260,460		14,755,954		5,441,135	
Counties	58		8		38		12	

HHI, Herfindahl-Hirschman Index*; SD*, standard deviation.

hospital characteristics varied to some degree. This is important in laying the groundwork for future analyses of the impact of regionalization on mortality outcomes.

Factors of Early/Later Regionalization

Competition

Our descriptive characteristics of hospitals show that counties with low concentrations of hospitals regionalized earlier than regions with high or moderate concentrations of hospitals, suggesting that competition may be a deciding factor in how quickly a county can regionalize. Generally, it has been well documented that competition between hospitals can prevent a region from reaching full regionalization.[3,16] Many hospitals within EMS agency catchment areas may be concerned with changes in patient volume, primarily due to potential misidentification of STEMI by prehospital personnel in patients with relevant symptomatology (e.g., chest pain, diaphoresis, shortness of breath), diverting potentially non-STEMI patients away from non-PCI-capable hospitals, which could result in losing additional revenue on top of revenue lost from STEMI patients being diverted away from non-PCI hospitals.[17,18] Moreover, greater competition can exist in areas more concentrated with PCI-capable hospitals. Counties with a large number of available PCI-capable hospitals relative to the size of the county could have a lesser need for regionalization due to a higher likelihood of the nearby hospital having PCI capability.[19]

Administrative/structural differences in hospitals

Cardiac services such as PCI are considered one of the more profitable services a hospital can provide; therefore, it was not surprising when we found that generally, earlier regionalized counties had a greater percentage of for-profit hospitals. This could reflect the administrative and operational structural differences between for-profit and non-profit/government hospitals or the limitations facing non-profit/government hospitals to secure funding to become PCI-capable and regionalize. However, previous literature has suggested that our findings likely reveal the inclination of for-profit hospitals to offer PCI services and be motivated to regionalize faster as it would increase hospital revenue,[20] suggesting that policymakers should look to increase incentives to prioritize increasing PCI services or regionalization of care, such as counting these activities as uncompensated care or requiring such capabilities as government regulations or for non-profit status.

Population Density

Population density could potentially act as a barrier to earlier regionalization. Counties with denser cities may have a lesser need as the closest hospital likely is PCI-capable, even if the number of available PCI-capable hospitals is relatively small. On the other hand, counties with more spread-out cities may have a greater need as more residents are likely to be located nearest to a small hospital, without PCI capability. We found that Southern California counties generally regionalized faster as they geographically tend to be more "spread out," which provides some evidence that population density could be a potential factor in adopting regionalization protocols. Our findings suggest that regionalization could be more beneficial in lower population density areas, especially in areas with relatively larger rural populations. Although high population density areas may benefit less from regionalization, they could be more susceptible to reduced PCI access due to crowding, and may benefit more from increasing the number of PCI-capable hospitals in the area or PCI capability within the existing hospitals.[21]

Other Potential Factors

Other potential factors that we did not specifically study but were mentioned by EMS administrators and medical directors may have contributed to the pace and degree to which each county regionalized. For instance, while regionalization of care provided the primary impetus to improve compliance with the 2004 AHA guidelines requiring a door-to-balloon time within 90 minutes,[22] purchasing prehospital ECG devices for all ambulances could be a substantial financial burden that EMS agencies cannot or do not want to bear as PCI-capable hospitals ultimately reap the financial rewards of adopting regionalization protocols.[21,23] Factors not associated with EMS regulation, such as success obtaining external grants and private philanthropy for individual EMS agencies and availability of prehospital ECG devices, may have assisted with earlier regionalization of care,[24] as reported by certain counties in Southern California. Furthermore, management factors such as "champions for change" and leadership influence in pushing for quality improvement may have also allowed for earlier regionalization, similar to quality improvement in other types of healthcare systems.[25,26] On the other hand, conflicting and evolving literature on long-term outcome improvements offered by recognition of STEMI by field personnel and direct transport to PCI-capable SRCs could have delayed decisions to adopt regionalization protocols.[21,27,28]

Overall, examining trends in the regionalization of care has the potential to offer insight into how the reorganization of care can affect patient outcomes. These findings have important implications, as hospitals and EMS networks will require financial and organizational restructuring after adopting regionalization protocols. On a larger level, regionalized systems may allow providers and hospitals to benefit from reforms, such as the Medicare and CHIP Reauthorization Act of 2015,[29] which has encouraged delivery systems to focus on value and quality, including access to timely cardiac care, rather than volume and public reporting.[30]

Our descriptive characteristics establish that earlier and later regionalized counties do not differ dramatically in patient characteristics, and their differences would therefore not be expected to confound our later analysis of mortality

outcomes. Furthermore, while hospital characteristics do vary considerably, previous literature suggests that although hospital ownership may influence the willingness and rate of regionalization, patient outcomes do not differ widely between for-profit hospitals and non-profit hospitals.[31] Future research studying the impact of regionalization of care for STEMI patients, as well as how and why certain systems had an easier time regionalizing early, may provide further insight into the impact and process of how such changes can be replicated in other settings.

LIMITATIONS

Our study included several limitations. First, while we were able to receive responses to all questions from each EMS agency, we were only able to receive best approximate estimates in some responses of when each EMS agency reached a level of regionalization as in certain counties, the current administrator or medical director of the EMS agency might not have been present or have had knowledge of the state of cardiac care regionalization in 2005. Second, some directors and administrators could not provide records documenting the timeline of their protocols because these records did not exist or were erased. In these cases, we attempted to verify information by having external reviewers familiar with California's regionalization trends examine the data and provide face validity checks for the provided responses. When questions arose for either limitation, we contacted the initial agency again and attempted to triangulate our information with other sources (e.g., previous administrators or medical directors, the AHA Mission Lifeline regional network directors and administrators) to obtain more accurate information. Last, our data only covered California, meaning that while our findings may provide general insight into the regionalization of care, they may not be entirely generalizable to other states across the nation.

CONCLUSION

Our survey results allowed us to identify prehospital and inter-hospital elements within each EMS agency's STEMI program to assess the degree, duration, and trends of their regionalization-of-care efforts. We identified hospital competition, hospital ownership, population density, and financial barriers to be some potential factors in slowing down or preventing complete regionalization of care. We did not find any dramatic differences in the underlying population characteristics based on regionalization-of-care status in our study period, providing some reassurance for future studies evaluating the impact of regionalization that any findings would be less likely due to differences in patient characteristics. Our findings allow providers and policymakers to recognize the barriers to establishing and potentially reorganizing regionalized systems of care, and may serve as a framework for continued regionalization of care in other regions.

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Poor Access for African Researchers to African Emergency Care Publications: A Cross-sectional Study

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Introduction: Based on relative population size and burden of disease, emergency care publication outputs from low- and middle-income regions are disproportionately lower than those of high-income regions. Ironically, outputs from regions with higher publication rates are often less relevant in the African context. As a result, the dissemination of and access to local research is essential to local researchers, but the cost of this access (actual and cost-wise) remains unknown. The aim of this study was to describe access to African emergency care publications in terms of publisher-based access (open access or subscription) and alternate access (self-archived or author provided), as well as the cost of access.

Methods: We conducted a retrospective, cross-sectional study using all emergency medicine publications included in Scopus between 2011 and 2015. A sequential search strategy described access to each article, and we calculated mean article charges against the purchasing power parity index (used to describe out-of-pocket expense).

Results: We included 666 publications from 49 journals, of which 395 (59.3%) were open access. For subscription-based articles, 106 (39.1%) were self-archived, 60 (22.1%) were author-provided, and 105 (38.8%) were inaccessible. Mean article access cost was $36.44, and mean processing charge was $2,319.34. Using the purchasing power parity index it was calculated that equivalent out-of-pocket expenditure for South African, Ghanaian and Tanzanian authors would respectively be $15.77, $10.44 and $13.04 for access, and $1,004.02, $664.36 and $830.27 for processing. Based on this, the corrected cost of a single-unit article access or process charge for South African, Ghanaian and Tanzanian authors, respectively, was 2.3, 3.5 and 2.8 times higher than the standard rate.

Conclusion: One in six African emergency care publications are inaccessible outside institutional library subscriptions; additionally, the cost of access to publications in low- and middle-income countries appears prohibitive. Publishers should strongly consider revising pricing for more equitable access for researchers from low- and middle-income countries. [West J Emerg Med. 2017;18(6)1018-1024.]

INTRODUCTION

Given the stark differences in emergency care resource requirements and availability between high-income countries and low- and middle-income countries, it is important that African emergency care research is both conducted and disseminated in accessible format within Africa. Evidence-based care from emergency care research conducted elsewhere often does not apply directly in the African context as the former assumes access to resources that does not translate to the latter.[1] Publications from the African region made up only 1.8% (829 of 46,901) of global emergency medicine (EM) publication output between 2010 and 2015; but this

number is not representative of the relative size of the African continent, nor its relative higher burden of disease, morbidity and mortality compared to other world regions.[2,3] This can be attributed, at least in part, to the small, local, emergency care academic community and the apparent lower interest of emergency care journals (mainly representing high-income settings) in research from low- and middle-income settings.[2]

The fact that around three-quarters of African emergency care publications are published in international journals suggests a necessarily high rate of collaboration – indeed 40% of African emergency care publications included authors from outside Africa, while only 12% of collaboration came from other African countries.[4-7] Thus taking into account a local, developing, emergency care knowledge economy and the relative irrelevance of high-income setting-produced research, the importance of sharing local African-related emergency care research within Africa should be a given. It is, however, not known how much of the continent's scientific emergency care output is readily accessible to the local emergency care community. The aim of this study was to describe access to African emergency care publications (published between 2011 and 2015) in terms of publisher-based access (open access or subscription) and alternate access (self-archived or author provided), as well as the cost of access or publication (article access, or processing charges, respectively).

Population Health Research Capsule

What do we already know about this issue?
Open access publication was founded on the principle that access to research should be universal. Despite this, universal access is not yet a given everywhere.

What was the research question?
What access (cost or otherwise) do African researchers have to African emergency care-related publications?

What was the major finding of the study?
One in six African emergency care publications are inaccessible to African researchers due to firewalls and cost.

How does this improve population health?
Accessible research is a key contributor to a stable knowledge economy – better access means better knowledge translation, which impacts population health outcomes.

METHODS

We employed a cross-sectional study design, using retrospective, secondary published data from the Scopus database (Elsevier, Amsterdam), supplemented by prospective data solicited from corresponding authors of a smaller cohort of these publications (Figure 1). We included all 722 African EM publications included in the Scopus database between 2011 and 2015, and performed the initial analysis using SciVal (Elsevier, Amsterdam). SciVal is a subscription-based data manager that interacts with Scopus, allowing detailed analysis through automated keyword searches around various aspects of publications from the five years available at the time of data extraction. Using SciVal, we extracted publications from the Scopus database from the African region (based on lead author affiliation) and EM specialty (based on keywords provided by the author as well as the journal during the indexing process). The final sample was then further filtered to include only original articles, reviews, meta-analyses, case reports and editorials. We also collected the publication title, journal title, full author list (including affiliations), and the corresponding author name and contact email.

To determine access to the sampled publications we used the following sequential search:

1. We accessed all the respective journal websites, noting whether publications were either open access or subscription based. Article process charges (for open-access publications) and article access charges (for subscription-based publications) were also collected. Variations in cost, where different charges applied depending on different income regions, were collected as such.

2. We undertook a keyword search (using publication title and author list) using Google, PubMed Central and the following commercial repositories: ResearchGate, Mendeley, and Academia.edu for self-archived copies of either publisher or post-print versions of the subscription-based publications. The publisher version of a publication is the version that is published on the official journal website following copy-editing. The post-print version of a publication is the final manuscript that was accepted for publication following peer-review, but prior to copy-editing. We did not include a search of the torrent site Sci-Hub, given that it would automatically obtain any requested publication not yet in its repository through a non-transparent, widely-considered controversial process (see "Discussion").[8]

3. Finally, for any subscription-based, un-archived publications, we sent an email request to respective corresponding authors to share an authorized version of their publication. Articles were then checked and categorized as communicable, non-communicable, injury- or policy-themed publications to provide perspective on publication themes. A hypothetical corrected charge, using the World Health

Organization (WHO) purchasing power parity (PPP) index was calculated on article process and access charges.[9] PPP is based on the hypothesis that similar items should cost the same, irrespective of currency differences, no matter where it is bought in the world. The WHO PPP index describes the deviation from parity using the United States dollar ($) as a baseline. The correction represents the hypothetical out-of-pocket expense for the same goods. We described purchasing power for the following three African countries: South Africa, Ghana and Tanzania. The reasoning for selecting these specific countries was that each offers specialist training in EM, representing a regional, emergency care, research collaboration hub, as well as representing a different income group (high-middle, low-middle and low income, respectively).[10,11] The study received ethical approval through the University of Cape Town's Human Research Ethics Committee.

We analyzed data using Microsoft Excel (Microsoft Office, Redmond, U.S.) and they are presented as proportions and tables. Article access and process charges are provided in U.S. dollars ($) and described by the mean and standard deviation. We used XE for currency conversions.[12] Calculations were made using the exchange rates published on December 12, 2016: $1 was respectively worth 13.77 South African rand, 4.30 Ghanaian cedi and 2 176.52 Tanzanian shilling. The PPP index for 2016 was 5.96 for South Africa, 1.23 for Ghana and 779.21 for Tanzania. We used the X^2-test to test associations between categorical variables (article categories, etc.) with a *p* value less than 0.05 accepted as significance. The 95% confidence interval (CI) was provided to describe precision between continuous variables (article process and access charges, etc.).

RESULTS

Figure 1 describes how the sample was derived, as well as the main findings of the study. Exclusions consisted of duplications and mis-indexed publications. The final sample consisted of 666 publications from 49 journals. We failed to access 15.8% (105/666) of publications – one of every six publications. The difference in access between open-access and subscription-based publications was significant (X^2=12.46, p<0.01). The difference in access between self-archived publications and those not found was also significant (X^2=8.62, p=0.03). But the difference in access between publications provided by the corresponding author and those where the author did not respond was not significant (X^2=5.24, p=0.16).

Not all journals charged for article processing or access. The mean article access and process charges by journals that charged for these were $36.44 (standard deviation of $6.05) from 36 journals, and $2,319.34 (standard deviation of $869.90) from 41 journals. The corrected cost of a single-unit article access or process was 2.3, 3.5 and 2.8 times higher than the standard rate, respectively, for South African, Ghanaian and Tanzanian authors. This is graphically presented in Figure 2. The error bars represent the 95% CI and indicate the significant difference between standard charges and PPP-corrected charges.

Discounts and waivers were applied by some journals with regard to article process charges. Thirteen (26.5%) journals exclusively published open access, with a further 29 (59.2%) offering the option to publish open-access options in a subscription-based journal. Of the 13 fully open-access journals, four charged no article processing fee. Articles published via these four journals made up 18.2% (121 articles) of the entire sample, of which one, the *African Journal of Emergency Medicine*, published 117 (17.6%) articles – both the single largest contributor to the sample and the cheapest, given that it also charged no article process fees. Authors from South Africa (high-middle income) were eligible for a full article process-charge waiver from one journal and a reduced charge from another one. Authors from Ghana (low-middle income) were eligible for a full article process charge waiver from 15/42 (35.7%) journals and a reduced charge from another two. Authors from Tanzania (low income) were eligible for a full article process-charge waiver from 16/42 (38.1%) journals and a reduced charge from another one. The Table provides the charges for South African, Ghanaian and Tanzanian authors that would result in similar out-of-pocket spending to the standard rate. Of the open-access journals (including journals with an open- access option), the following provided article processing fees less than the charges described in the table: *Annals of Burns and Fire Disasters* ($104.57), *Western Journal of Emergency Medicine* ($400, full waiver for Ghana and Tanzania) and the *Journal of Emergencies, Trauma and Shock* ($600). Of the subscription-based journals, only *Traumatology Journal*, an acute psychiatry journal, provided article access less than the charges described in the table ($11.95).

African and non-African first authors were respectively responsible for 70.3% (468) and 29.7% (198) of all publications. The majority of publications were either injury-themed, 40.7% (271), or policy-themed, 39.9% (266).

Table. Representative article access and processing fees for South Africa, Ghana and Tanzania that would result in similar out-of-pocket spending to the United States.

Charge	Standard charge	South Africa	Ghana	Tanzania
Article processing	$2,319.34	$1,004.02	$664.36	$830.27
Article access	$36.44	$15.77	$10.44	$13.04

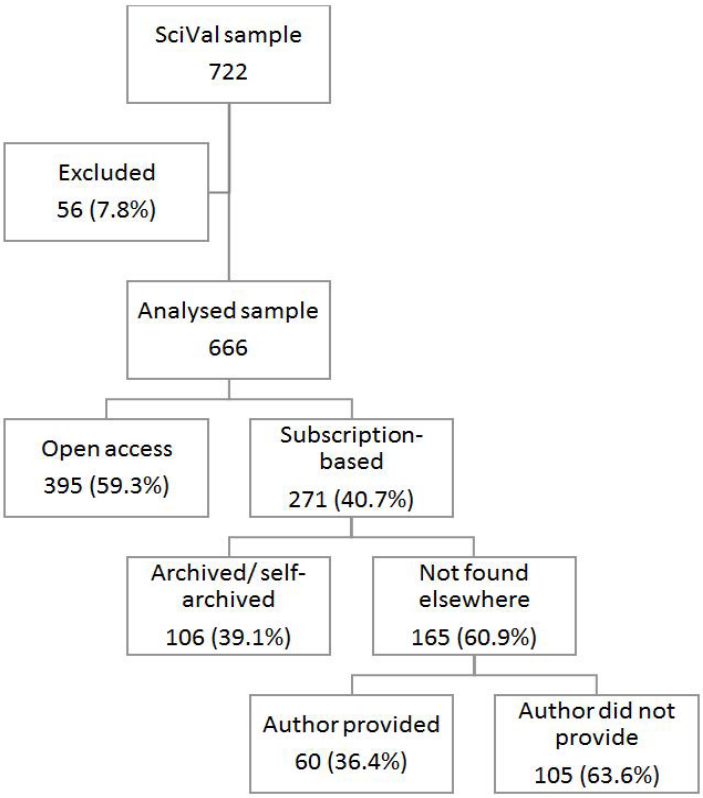

Figure 1. Sample derivation and main findings of the study (numbers of published articles).

Supplement A provides detail of the publication themes. African first authors were more likely to publish open access although the difference was not significant (X^2=3.24, p=0.07). Non-African first authors' publications were more likely to be found elsewhere (repositories, etc.) but again the difference was not significant (X^2=2.03, p=0.15). Non-African first authors were also more likely to provide their publications on request but the difference was not significant (X^2=0.41, p=0.52). Supplement B provides detail of access to publications comparing African and non-African first authors.

DISCUSSION

Of the small number of African emergency care articles published between 2010 and 2015, around one in six publications were cost-prohibitive. The cost of accessing subscription-based publications is likely to be prohibitive, even for South Africa, a higher-middle income country. It is telling that only one journal out of 36 provided access charges within the out-of-pocket scope of any of the three African countries. For African emergency care to grow, increased research output is essential to fuel its knowledge economy. Only a small number of higher learning institutions on the continent currently offer training in EM, of which only two offer dedicated research degrees.[11] Furthermore, local emergency care researchers tend to be clinician-researchers, largely unaffiliated with academic institutions. African academic libraries for their part similarly suffer from having to purchase subscriptions using devalued currencies that result in significantly higher costs when compared to high-income countries' costs.[13]

Van Hoving et al. reported that 58% of African emergency care researchers struggled frequently with publication access, suggesting that local emergency care researchers are unable to make do given poor access and the significantly higher out-of-pocket expense related to publication.[14] The combination of these elements creates a perfect storm that threatens the growth and development of the specialty locally. Fortunately, article-processing fee waivers and discounts exist for low-middle and low income countries, which is likely why African authors were able to publish via open access more regularly. It was disappointing to see that authors from South Africa (a higher-middle-income country) would incur a significantly higher out-of-pocket publication cost; higher-middle-income countries are as a rule excluded from waivers and discounts.

Open-access publications (largely contributed to by African first authors) made up the bulk of publications, while self-archiving and author-provided publications were fewer. It is interesting to note that policy-themed publications made up nearly half of all non-African first author publications, suggesting that non-African first authors' main research contribution appears to be deriving emergency care-related policy – something one would have expected to be more within local authors' remit. The study did not specifically consider whether non-African first authors collaborated on policy publications with local authors. It is, however, not unusual for publications regarding African matters (including policy) to shun African authors. Ironically, a recent World Bank/ Elsevier collaboration regarding African publication prowess in science, technology, engineering and mathematics did not include any African authors.[15]

There were very few communicable and non-communicable disease-themed publications compared with injury-themed publications (which led the publication tally alongside policy). Injury appears to be a particular research focus in Africa: the WHO's Decade of Action for Road Safety started in 2011 and this will have had a tangible impact in the region on both policy and publication priority.[16] The journal *Burns* and *Annals of Burns and Fire Disasters* included the second and fourth most African emergency care publications between 2010 and 2015, respectively.[17] Yet given the unmistakable rise in non-communicable disease in Africa (along with its increasing contribution to mortality), a deeper focus on emergency care-related research in these fields should be encouraged to avoid being left unprepared.[18,19]

An article about access to scientific work for authors from low- and middle-income countries would not be complete without a brief discussion about article access using the torrent

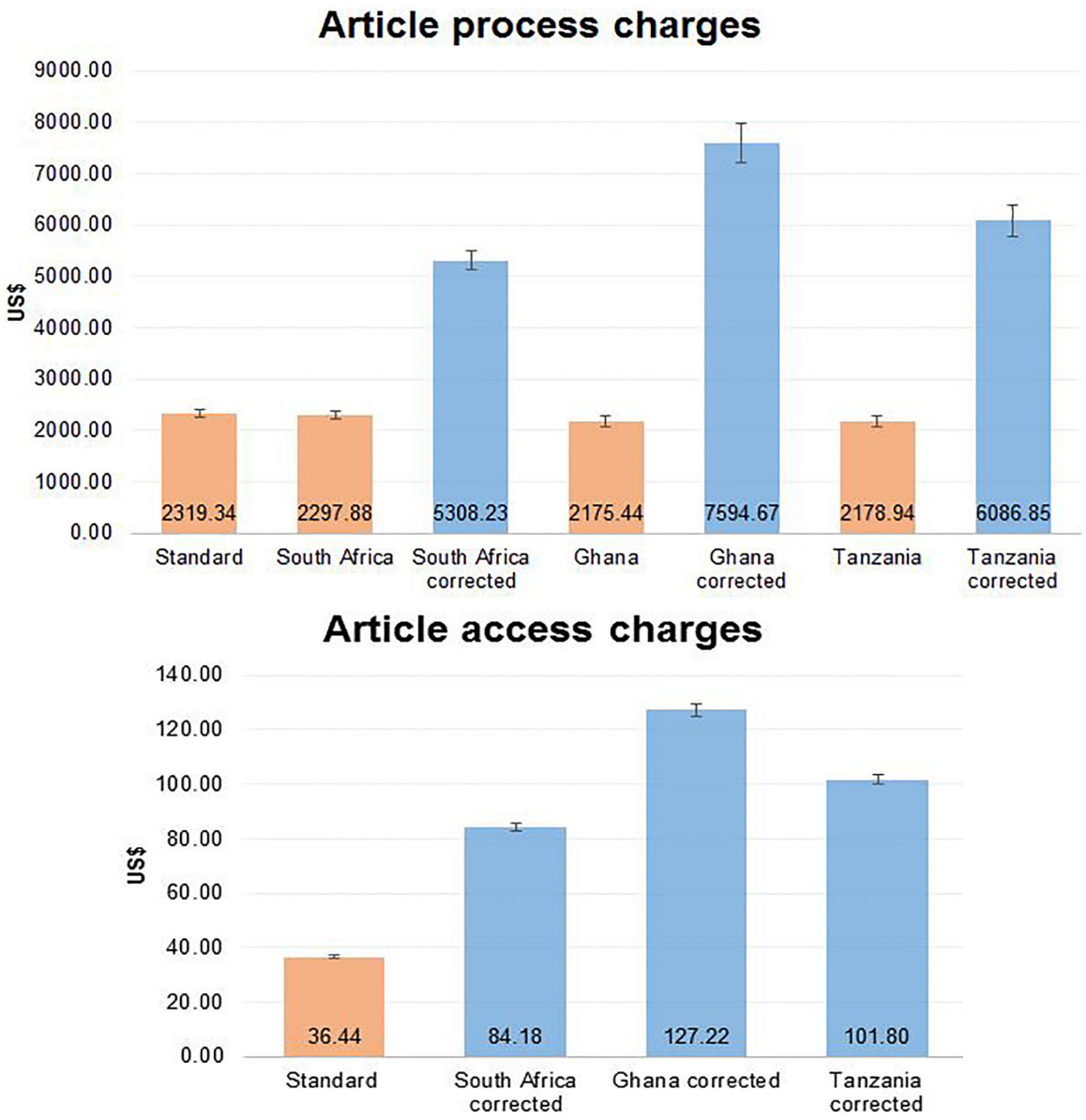

Figure 2. Article-process charges at the top with access charges below. The red bars indicate standard charges and blue bars indicate purchasing power parity-corrected charges.
The error bars indicate the 95% confidence interval.

site, Sci-Hub. As mentioned in the "Methods" section, we did not include Sci-Hub in our search criteria. It is likely that we would have been able to access the majority of subscription-only articles there. However, it remains a highly controversial route of article access.[20] In terms of its reach, a recent report in *Science* revealed that Sci-Hub was widely used in low- and middle-income regions, such as Eastern Europe, the Middle East, the Indian subcontinent and Southeast Asia, but not so much in sub-Saharan Africa.[21] Interestingly, the seemingly low penetration figures provided for sub-Saharan Africa should not necessarily be misconstrued as poor uptake of Sci-Hub in this region.[22] The ratio of active researchers to population size is substantially lower in this region than anywhere else. If this regional ratio was used as a denominator, it would likely provide a very different view of Sci-Hub usage.

LIMITATIONS

There were a number of limitations of this study. As we used a convenience sample, the sample was small and unpowered. It is also possible that published research was shared with local emergency care researchers that was not traceable through an Internet-search strategy. The WHO PPP

index is based on household expenditure, which in turn is affected by relative market prices, exchange rates, wages, interest rates, etc., of which purchasing article access or processing is but one small element. However, we felt that using an index that took into account a person's basic needs (as represented by household expenditure) would provide relevant context. It is true that purchasing power is constantly in flux, although for most African states it hasn't changed much compared to the dollar over the last five years.[9]

This study does not account for access initiatives such as Hinari, a WHO initiative set up along with a number of major publishers to enable journal access to low- and lower-middle income countries. Hinari and the majority of the other initiatives, however, require institutional access, excludes higher-middle income countries (which our study has shown to also have financial limitations) and does not assist with article- process charges. Furthermore, Hinari's own research shows that the service is not accessible in the very countries it aims to support.[23] An impact survey published by Hinari in 2014 revealed that despite 902 (88%) respondents agreeing that access to scientific literature was important, and 883 (81%) being aware of the access provided through Hinari, only 492 (48%) had access to it.[23] Today, however, publishers can easily make use of geo-blocking (Internet-content access control based on geographical location) to provide a more efficient yet still selective access to low- and middle-income countries without the assistance and limited resources of the WHO.

Finally, our search for accessible versions of articles could have been improved if the open access search engines, Unpaywall and Open Access Button, had been used.[24,25] These are browser plug-ins that can identify searched articles and then check whether it is accessible anywhere else. We were not aware of these search engines at the time of data collection. Future studies should include these search engines to optimize searches.

CONCLUSION

In conclusion, nearly half of African emergency care publications would be inaccessible without local university-library access. As a result, researchers without library access must be content with searching for self-archived publications online or contacting authors for a copy, as the cost of accessing these publications through article-access charges is prohibitive. Given the renewed focus on improving emergency care in low- and middle-income settings this may prove to be highly significant. Currently, low-and middle-income populations, including those in Africa, make up around 85% of the world's population, of which the vast majority will have similar access problems.[26] It is also unlikely that access is only restricted in this way to emergency care publications. Publishers should therefore strongly consider revising pricing policies to allow more equitable access to publications for researchers in these regions. Strong advocacy is needed from organizations such as the WHO to ensure that operational agendas correlate with access to information.

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Team Size and Stretching-Exercise Effects on Simulated Chest Compression Performance and Exertion

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Introduction: Investigators conducted a prospective experimental study to evaluate the effect of team size and recovery exercises on individual providers' compression quality and exertion. Investigators hypothesized that 1) larger teams would perform higher quality compressions with less exertion per provider when compared to smaller teams; and 2) brief stretching and breathing exercises during rest periods would sustain compressor performance and mitigate fatigue.

Methods: In Phase I, a volunteer cohort of pre-clinical medical students performed four minutes of continuous compressions on a Resusci-Anne manikin to gauge the spectrum of compressor performance in the subject population. Compression rate, depth, and chest recoil were measured. In Phase II, the highest-performing Phase I subjects were placed into 2-, 3-, and/or 4-compressor teams; 2-compressor teams were assigned either to control group (no recovery exercises) or intervention group (recovery exercises during rest). All Phase II teams participated in 20-minute simulations with compressor rotation every two minutes. Investigators recorded compression quality and real-time heart rate data, and calculated caloric expenditure from contact heart rate monitor measurements using validated physiologic formulas.

Results: Phase I subjects delivered compressions that were 24.9% (IQR1-3: [0.5%-74.1%]) correct with a median rate of 112.0 (IQR1-3: [103.5-124.9]) compressions per minute and depth of 47.2 (IQR1-3: [35.7-55.2]) mm. In their first rotations, all Phase II subjects delivered compressions of similar quality and correctness ($p=0.09$). Bivariate analyses of 2-, 3-, and 4-compressor teams' subject compression characteristics by subsequent rotation did not identify significant differences within or across teams. On multivariate analyses, only subjects in 2-compressor teams exhibited significantly lower compression rates (control subjects; $p<0.01$), diminished chest release (intervention subjects; $p=0.03$), and greater exertion over successive rotations (both control [$p\leq0.03$] and intervention [$p\leq0.02$] subjects).

Conclusion: During simulated resuscitations, 2-compressor teams exhibited increased levels of exertion relative to 3- and 4-compressor teams for comparable compression delivery. Stretching and breathing exercises intended to assist with compressor recovery exhibited mixed effects on compression performance and subject exertion. [West J Emerg Med. 2016;18(6)1025-1034.]

INTRODUCTION

Effective chest compressions are paramount for successful resuscitation of cardiac arrest.[1] Compressions of adequate rate and depth and reduced "hands-off time" maximize coronary perfusion pressure and improve the likelihood of return of spontaneous circulation.[1-5] However, the quality of chest compressions performed *in situ* during inhospital and out-of-hospital cardiac arrest resuscitations continues to be poor.[1,6,7]

Provider fatigue is a major factor in the quality of chest compressions; several studies have demonstrated a significant decay in compression quality after 60 to 90 seconds of continuous compressions.[8-13] Studies evaluating groups of providers performing continuous compressions in intervals separated by periods of rest[8,14] demonstrated that the quality of compressions improved in the first minute of an individual compressor's rotation when compared with the last minute of the same compressor's preceding rotation, suggesting some degree of recovery during rest.[8,14] This recovery pattern was observed for single providers with short rest (30 seconds)[8] as well as for teams of rotating providers with longer rest (1-3 minutes).[14]

Along with increasing the size of provider teams performing compressions so as to prolong rest periods, another approach to mitigate provider fatigue is to actively facilitate recovery during rest periods. Static stretching of muscles in lengthened positions for a prescribed period of time is commonly practiced before exercise alone or as part of a warm-up routine.[15,16] Some studies suggest improved performance following static stretching,[15,17] while others suggest that stretching can reduce maximal muscle performance (although minimally).[15,16] Additionally, deep breathing exercises are commonly used relaxation techniques,[18] and there is evidence to suggest that even a short duration (two minutes) deep-breathing exercise improves lung function, heart rate, and blood pressure.[19-20]

Given the variety of factors contributing to chest compressor exertion and potential approaches to mitigate compressor fatigue, we set out to study the impact of 1) the size of resuscitation teams, specifically the number of alternating providers delivering chest compressions; and 2) targeted rest-recovery exercises on chest compression quality and individual provider exertion during a simulated cardiac arrest scenario. The primary hypothesis was that larger teams of compressors would deliver sustained high-quality compressions with less individual-provider exertion compared to smaller teams. The secondary hypothesis was that rest periods with an experimental recovery exercise intervention between compression rotations would mitigate provider fatigue and help maintain high-quality chest compressions throughout the resuscitation. Although previous investigations have independently evaluated resuscitation team size, rest duration, and recovery on chest compression performance and fatigue,[14,21] this study was the first to concurrently evaluate their effects on compression quality and individual providers' levels of exertion.

Population Health Research Capsule

What do we already know about this issue?
Effective chest compressions are critical for resuscitation success, but difficult to perform. Provider fatigue is a limiting factor; mitigating fatigue may improve compression quality.

What was the research question?
Do larger compression team sizes or targeted recovery exercises improve compression quality and reduce provider exertion?

What was the major finding of the study?
Smaller teams exhibited greater exertion than larger teams. Recovery exercises had mixed effects on performance and exertion.

How does this improve population health?
Implementing strategies to mitigate provider fatigue may facilitate sustained high quality chest compressions and may improve the likelihood of successful resuscitation of cardiac arrest.

METHODS

Study Design, Setting, and Population

The prospective simulation study was approved by the institutional review board. Investigators conducted the study in two phases, with Phase I assessing and ranking volunteering subjects by quality of chest compressions, and Phase II testing study hypotheses on the highest-ranked Phase I subjects. Phase I of the study was conducted on campus at a medical school facility, and Phase II was conducted at a hospital-affiliated medical simulation center. First- and second-year medical students were recruited via email and voluntarily enrolled in the study sessions. The study was conducted from February 2015 to June 2015.

A convenience sample of 45 medical students was used for the study. Defined and limited by the research budget, the study sample size was comparable to those of similar studies that previously evaluated chest compression quality and provider fatigue in simulated settings.[8-12,14,21,22]

Phase I Study Protocol, Metrics, and Sessions

Investigators obtained written informed consent and self-reported demographic data from all participants (gender, age, height, weight, previous cardiopulmonary resuscitation [CPR],

basic life support [BLS] or advanced cardiovascular life support [ACLS] training, and year in medical school). After a scripted introduction to research aims, study methods and simulation setting, subjects were oriented to the study manikin system. A Resusci-Anne SkillReporter manikin (Laerdal, Wappingers Falls, NY) was situated on a waist-height table, a footstool was provided, and compressions were performed in the standing position. Immediately prior to data collection, participants practiced chest compressions by performing approximately 20 compressions with real-time performance feedback from PC SkillReporting software v2.1.0.

After orientation, each subject independently performed four minutes of continuous chest compressions on the manikin without real-time feedback. Continuous measurements of compression rate, compression depth, and chest recoil were obtained. At the end of the Phase I session, each participant received a $10 gift card. Study-subject performance metrics were composited into a ranking list based on each individual participant's total number of correct compressions delivered.

Phase II Study Protocol, Metrics, and Sessions

Subject Assignment to Resuscitation Teams of Different Sizes

The best-performing Phase I participants were offered the opportunity to enroll in the study's second phase. Based on an anticipated Phase II enrollment of 30 Phase I subjects (top 75% of Phase I performers), investigators planned to assign volunteering Phase II subjects to fifteen 2-compressor, ten 3-compressor, and/or six 4-compressor teams. Each enrolled Phase II participant completed a minimum of two distinct sessions in different teams that were scheduled at least three hours apart to ensure adequate subject recovery. Each individual Phase II subject received an additional $25 gift card for continued participation.

Chest Compression Quality Metrics

Each Phase II team performed continuous chest compressions for a 20-minute simulated cardiac arrest resuscitation with sequential compressor rotation every two minutes in accordance with 2010 American Heart Association guidelines,[2] e.g., subject 1 (two minutes), then subject 2 (two minutes), then subject 3 (two minutes), then subject 1 (two minutes), etc., for a 3-compressor team. Simulation time was strictly monitored with a stopwatch, and participants were notified at the one minute, one minute forty-five second, and two minute marks; 10 seconds were allotted for switching between team members and for facilitation of subsequent review of individual compressor performances. Measurements of compression rate, compression depth, and chest recoil were continuously obtained (Figure 1). Of note, Phase II compressions were performed by kneeling subjects on a manikin placed on the floor in order to accommodate the significant height

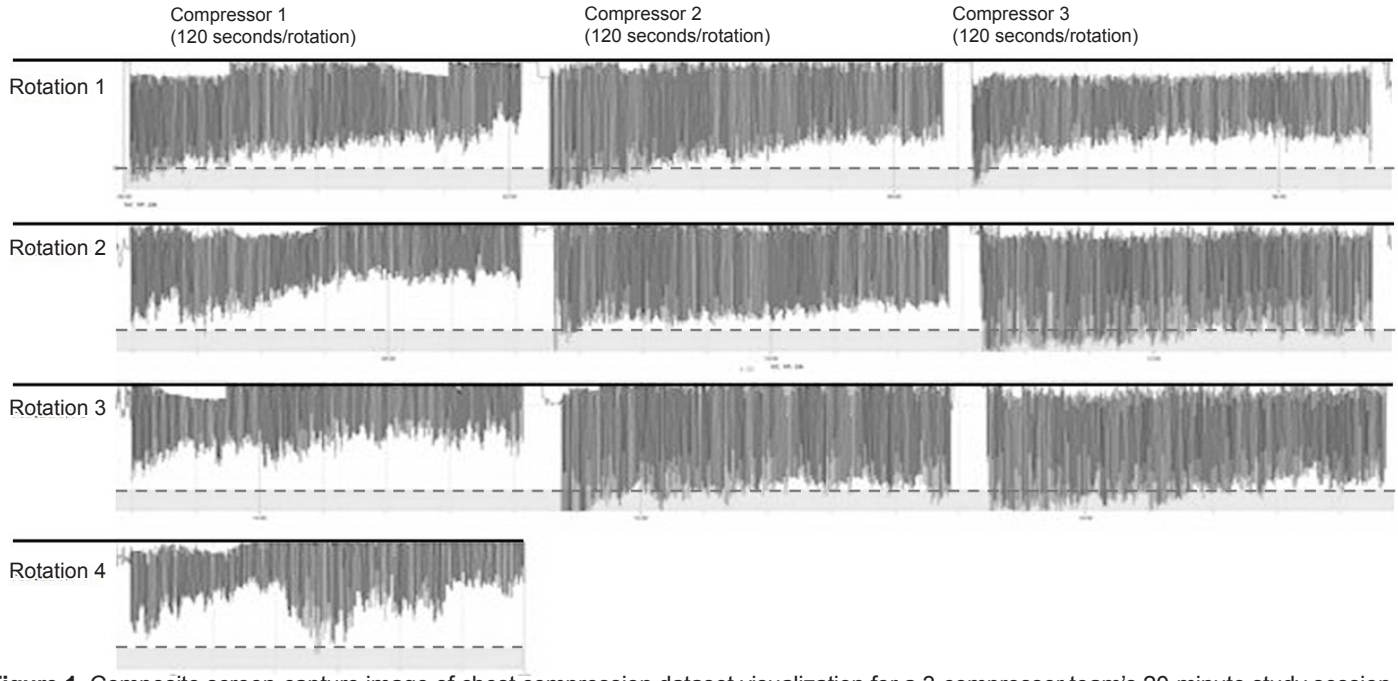

Figure 1. Composite screen-capture image of chest compression dataset visualization for a 3-compressor team's 20-minute study session, starting at left with time progression to the right and downward. Compression plots for each member of the team are displayed in columns; compression plots for each 3-compressor rotation are displayed in rows. Note the generally inadequate compression depth (appropriate depth indicated by dashed bars), frequency of inadequate chest release (leaning), progressive reduction in compression depth within each compressor's rotation, as well as the between-compressor and within-compressor variability in compression performance.

differences between alternating subjects, as the frequent bed-height adjustments necessary to minimize subject height-related research confounds otherwise would have proved impractical. (Previous studies have evaluated the quality of continuous chest compressions while kneeling, standing on the floor, or standing on a footstool with bed height adjustment for each provider – these found no significant difference in compression quality between subjects in kneeling and those in footstool positions.[23,24])

Investigators used compressions delivered during a single rotation by an individual subject in 2-compressor (control or intervention group), 3-compressor, and/or 4-compressor teams to calculate the following variables: compression rate, compression depth, and chest recoil; percent of compressions with correct depth and recoil; and number of correct compressions delivered. Each individual subject's changes (Δ) in performance metrics across his/her compressor rotations were calculated for each rotation relative to his/her first rotation performance.

Exertion Metrics

In order to measure compressor exertion, all subjects wore chest-strap heart rate monitors (H7, Polar Electro, Kempele, Finland) paired wirelessly with Polar Beat iOS software v1.4.4 on iPod Touch 5 devices (Apple, Cupertino, CA) to acquire real-time heart rate (HR) data during their compression rotations. Investigators used HR and demographic data to derive the following surrogate metrics for each subject's level of exertion: 1) percent attained of his/her maximal predicted heart rate, i.e., %mHR = [mean HR during a compression rotation] / [predicted maximal HR derived with the Tanaka formula[25]]; and 2) calculated estimate of caloric expenditure (in kilocalories [kcal]) during a compression rotation.[26]

Recovery Intervention

To address the secondary research objective, a physical therapist was consulted to assist with the development and implementation of an efficient stretching and breathing exercise that could be easily performed by compressors during their rest periods. The intervention consisted of a stretch and concurrent diaphragmatic breathing – the stretch was a shallow lunge with ipsilateral arm raised in the air (Figure 2); participants were instructed to switch sides approximately every 30 seconds. Only the 2-compressor teams were assigned to one of seven control or six intervention groups prior to the start of the session (due to inadequate numbers of 3- and 4-compressor teams for controlled experimentation). Those in the intervention group were instructed on how to perform the stretch and diaphragmatic breathing exercises immediately before simulations; control subjects were instructed to rest in a chair between compressor rotations.

Data Analysis

Investigators analyzed participant demographic data on age, gender, height, weight, and body mass index (BMI) with

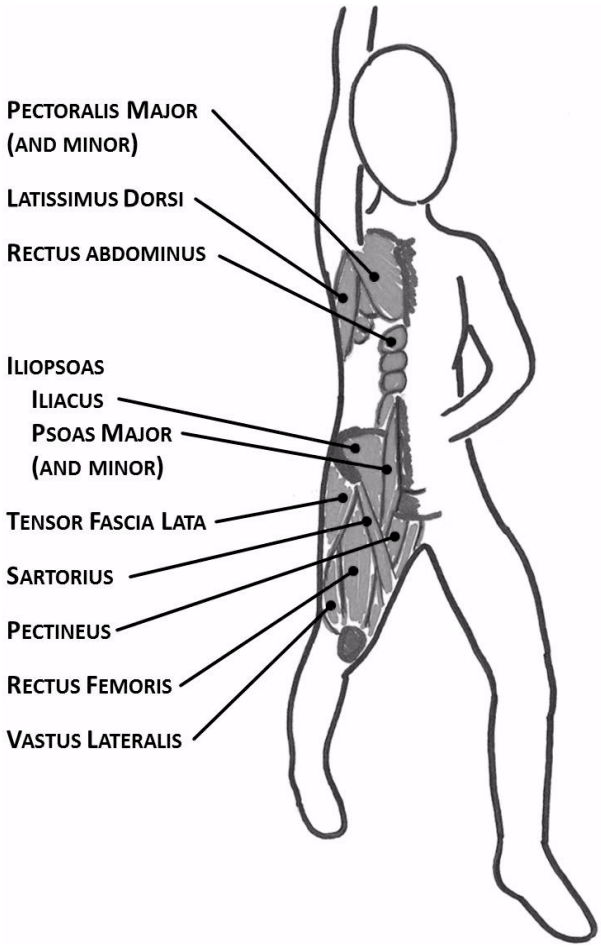

Figure 2. Diagram demonstrating recovery intervention with stretching and concurrent diaphragmatic breathing for experimental 2-compressor teams. The stretch was a shallow lunge with ipsilateral arm raised in the air; the highlighted muscle groups are those targeted by the stretch. Participants were instructed to switch sides approximately every 30 seconds.

Kruskal-Wallis and Fisher's exact tests. Subject compression performance data were summatively characterized by compression rate, compression depth and chest recoil; percent of compressions with correct depth and recoil; and number of correct compressions delivered. Each subject's HR and caloric expenditure data were managed as continuous variables and analyzed across compressor rotations by assignment to control or intervention group and by team size. All compression and exertion metrics were modeled using binominal generalized linear mixed models, nesting observations within each subject and with a pre-specified α level of 0.05 (SAS version 9.3; SAS Institute, Cary, NC). Team size, intervention, and compression rotation were treated as fixed effects along with all interactions, with the three-way interaction treated as the primary hypothesis test for differential change according to study group.

RESULTS

Phase I Results

Of 49 subjects who expressed interest in the study, 45 enrolled and six canceled due to schedule conflicts for a total of 39 participants in Phase I. Complete Phase I data were available for 36 subjects (three subjects' data were lost to equipment malfunction). Subjects were a median of 24.0 (interquartile range [IQR]1-3: [23.0-26.0]) years of age with a median BMI of 23.7 (IQR1-3: [22.6-24.5]); 11 (27.8%) subjects were female. All subjects had received BLS training within the prior two years. Phase I chest compressions exhibited a median rate of 112.0 (IQR1-3: 103.5-124.9) compressions per minute (cpm), median depth of 47.2 (IQR1-3: [35.7-55.2]) mm, and were 24.9% (IQR1-3: [0.5%-74.1%]) correct.

Phase II Results

Twenty-six Phase II subjects comprised thirteen 2-compressor teams (seven control and six intervention teams); seven 3-compressor teams; and five 4-compressor teams. Demographic characteristics of the control and intervention 2-compressor teams, the 3-compressor teams, and 4-compressor teams were similar (Figure 3). Phase II subjects' median BMI was 23.0 (IQR1-3: [21.5-24.8]), and their median baseline HR was 40.7% (IQR1-3: [37.3%-43.9%]) of their predicted maximal HR.

Effects of Resuscitation Team Size

Chest Compression Quality

During their first compressor rotations, subjects in 2- (control and intervention), 3-, and 4-compressor teams did not exhibit differences in their compression rates (p=0.34), depths (p=0.25), and recoil (p=0.82); percent and number of correct first-rotation compressions were not significantly different between all study groups (p=0.09); see Figure 4 for details. Multivariate analyses by team size, intervention and compressor rotation number revealed that 2-compressor control team subjects delivered fewer compressions in later rotations (mean estimated slope of change over each subject's sequential compressor rotations, with confidence intervals [CI]: -3.4% [95% CI {-5.7% to -1.3%}] in cpm per rotation; p<0.01). The number of correct compressions, proportion of correct compressions, and compression depth were not different across different teams or rotations on multivariate analyses.

Exertion

At baseline, all study groups had similar median %mHR (p=0.73) and caloric expenditure (p=0.85); see Figure 5 for details. Subjects in the 2-compressor teams (both control and intervention) exhibited significant increases in exertion (and

Demographic Characteristic		2-Compressor Teams (n=26 *total* 2-compressor subjects; median and inter-quartile ranges)	3-Compressor Teams (n=21 subjects; median and inter-quartile ranges)	4-Compressor Teams (n=20 subjects; median and inter-quartile ranges)
Age (years)	2-Compressor *Control* Group (n_C=14 subjects; median and inter-quartile ranges)	24.0 (23.0 – 24.8)	24.0 (22.0 – 26.0)	24.0 (22.8 – 26.0)
Gender (female, %)		21.4%	23.8%	25.0%
Weight (kg)		67.6 (61.2 – 79.9)	68.0 (61.2 – 79.4)	70.3 (61.2 – 78.2)
Body Mass Index (BMI)		22.3 (21.3 – 26.2)	23.1 (21.6 – 24.9)	23.3 (21.5 – 25.3)
Maximal predicted HR (bpm)*		190.2 (189.7 – 190.9)	190.2 (188.8 – 191.6)	190.2 (188.8 – 191.1)
Baseline HR (% of mHR)		38.9% (37.1% – 43.9%)	39.1% (37.6% – 43.4%)	41.6% (38.5% – 44.2%)
Age (years)	2-Compressor *Intervention* Group (n=12 subjects; median and inter-quartile ranges)	25.0 (23.0 – 27.5)		
Gender (female, %)		25.0%		
Weight (kg)		73.5 (66.3 – 77.7)		
Body Mass Index (BMI)		23.4 (22.3 – 24.5)		
Maximal predicted HR (bpm)*		189.5 (187.8 – 191.1)		
Baseline HR (% of mHR)		41.6% (38.5% – 43.6%)		

Figure 3. Subject demographic characteristics: There were no significant differences in reported and calculated values for all study teams (Kruskal-Wallis test for continuous variables and Fisher's exact [2x4] test for binary variables).
bpm, beats per minute; *HR*, heart rate; *kg*, kilogram; *mHR*, maximal predicted HR.

Chest Compression Performance Metric		2-Compressor Teams (median and inter-quartile ranges)					3-Compressor Teams (median and inter-quartile ranges)				4-Compressor Teams (median and inter-quartile ranges)		
		1st rotation (n=14)	2nd rotation (n=14)	3rd rotation (n=14)	4th rotation (n=14)	5th rotation (n=14)	1st rotation (n=21)	2nd rotation (n=21)	3rd rotation (n=22)	4th rotation (n=6)	1st rotation (n=20)	2nd rotation (n=20)	3rd rotation (n=10)
Rotation duration (sec)	2-Compressor *Control* Group (n_C=14 subjects; median and inter-quartile ranges)	124.6 (120.6–127.2)	121.0 (112.5–127.4)	118.4 (114.1–127.1)	120.3 (118.7–127.8)	120.1 (116.2–121.7)	122.3 (120.7–124)	122.1 (117.1–126.6)	120.9 (115.8–124.7)	116.9 (112.2–120.0)	122.9 116.1–126.4)	120.5 (118.5–123.0)	119.2 (110.1–120.2)
Compression rate (cpm)		**118.8 (108.7–128.9)**	**119.2 (114.2–124.2)**	**116.4 (111.5–120.5)**	**112.8 (103.9–122.4)**	**111.7 (93.6–121.2)**	117.2 (111.9–122.0)	115.1 (108.6–124.1)	113.6 (107.1–124.2)	108.5 (103.4–110.9)	114.6 (103.5–116.5)	112.2 (101.2–116.7)	114.5 (103.7–118.1)
Δ from 1st rotation (cpm)		n/a	+2.3 (-7.3–+6.1)	-0.5 (-3.2–+4.1)	-6.1 (-12.4–-1.9)	-6.8 (-17.1–-2.4)	n/a	-2.6 (-7.2–-0.4)	-3.6 (-6.8–0.0)	-10.1 (-18.4–-6.1)	n/a	-1.8 (-9.1–+1.4)	+0.8 (-10.4–+8.6)
Depth (mm)		51.8 (46.1–57.4)	48.7 (44.9–57.9)	48.2 (43.0–56.5)	52.6 (45.8–57.1)	48.8 (41.1–56.3)	53.9 (44.3–58.7)	52.8 (48.8–59.3)	54.0 (49.1–59.6)	55.2 (48.8–59.2)	45.9 (40.4–55.5)	52.1 (44.3–58.0)	55.5 (49.4–59.4)
Δ from 1st rotation (mm)		n/a	-0.6 (-6.0–1.5)	-1.5 (-4.9–+0.6)	0.0 (-5.6–+2.3)	-0.9 (-2.9–+2.3)	n/a	-0.8 (-1.7–+0.7)	+0.5 (-1.2–+1.6)	+1.6 (-0.1–+4.1)	n/a	+1.3 (-1.1–+7.8)	+1.6 (-0.1–+4.5)
Chest recoil (mm from starting position)		6.1 (3.8–7.3)	4.8 (3.6–8.1)	5.4 (2.4–9.2)	5.8 (3.6–9.5)	4.1 (2.6–8.4)	6.0 (4.7–8.0)	5.6 (3.0–9.3)	7.7 (3.1–9.8)	7.8 (3.6–8.8)	4.8 (2.2–9.1)	7.3 (2.2–8.6)	7.6 (4.8–7.9)
Δ from 1st rotation (mm)		n/a	+0.0 (-1.1–1.2)	+0.6 (-1.8–+2.1)	+1.0 (-0.8–+3.1)	+0.1 (-1.2–+1.1)	n/a	+0.0 (-0.2–+0.2)	+0.0 (-0.1–+0.3)	-0.1 (-0.1–+0.2)	n/a	+0.1 (-0.5–+2.0)	+0.4 (-1.7–+1.5)
% of compressions correct (%)		64.7% (27.9%–86.4%)	27.4% (15.7%–82.0%)	23.7% (10.8%–71.0%)	15.3% (5.6%–60.9%)	29.2% (1.1%–46.6%)	46.7% (20.3%–96.1%)	53.8% (27.5%–80.8%)	60.2% (37.3%–82.4%)	67.5% (32.3%–88.9%)	8.8% (1.8%–50.2%)	25.3% (3.5%–73.6%)	41.8% (13.4%–85.3%)
Δ from 1st rotation (%)		n/a	-4.4% (-26.6%–+2.6%)	-18.1% (-33.4%–+3.4%)	-19.3% (-51.4%–-4.6%)	-16.0% (-26.9%–+5.9%)	n/a	+0.0% (-18.9%–+16.9%)	+2.0% (-9.0%–+30.9%)	-3.0% (-9.6%–+17.5%)	n/a	+0.8% (-1.4%–+31.4%)	+8.7% (0.0%–+28.4%)
Number of correct compressions delivered		76.5 (27.3–99.5)	33.5 (15.5–79.8)	26.0 (9.0–86.5)	14.0 (5.8–65.8)	30.0 (0.8–47.0)	55.0 (20.0–111.0)	61.0 (27.0–99.0)	69.0 (42.3–93.8)	74.0 (33.0–97.0)	9.0 (1.0–62.8)	29.5 (3.0–78.8)	50.0 (14.0–97.0)
Δ from 1st rotation		n/a	-7.0% (-25.3%–+5.3%)	-18.5% (-38.0%–-6.8%)	-21.0% (-60.8%–-13.3%)	-23.5% (-33.3%–+3.3%)	n/a	-1.0 (-14.0–+18.0)	+1.5 (-14.0–+33.0)	+5.5 (-13.8–+46.5)	n/a	+1.5 (-1.0–+35.3)	+17.5 (0.0–+33.0)
		1st rotation (n=12)	2nd rotation (n=12)	3rd rotation (n=12)	4th rotation (n=12)	5th rotation (n=12)							
Rotation duration (sec)	2-Compressor *Intervention* Group (n_I=12 subjects; median and inter-quartile ranges)	121.7 (119.5–126.7)	123.5 (116.3–128.7)	119.3 (114.5–122.0)	119.3 (117.2–123.5)	120.1 (118.5–124.2)							
Compression rate (cpm)		113.2 (108.4–120.3)	114.3 (111.7–121.7)	112.2 (105.2–116.3)	114.3 (103.3–117.0)	115.3 (104.1–120.4)							
Δ from 1st rotation (cpm)		n/a	-0.4 (-3.6–+3.7)	-4.9 (-9.8–+2.9)	-5.4 (-14.3–+3.6)	-4.6 (-10.5–+9.4)							
Depth (mm)		59.3 (51.2–59.7)	55.2 (51.4–58.7)	56.3 (46.8–58.3)	56.9 (47.0–58.8)	54.8 (44.9–59.3)							
Δ from 1st rotation (mm)		n/a	-0.3 (-2.4–0.0)	-1.2 (-2.5–-0.1)	-0.8 (-1.9–0.0)	-0.3 (-3.4–+0.4)							
Chest recoil (mm from starting position)		**5.4 (1.9–7.4)**	**4.6 (2.7–6.6)**	**4.7 (2.4–6.5)**	**5.5 (2.9–8.2)**	**7.5 (3.4–8.1)**							
Δ from 1st rotation (mm)		n/a	+0.2 (-0.4–+0.9)	+0.2 (-0.4–+0.6)	+0.8 (+0.2–+1.1)	+0.4 (-0.3–+1.5)							
% of compressions correct (%)		94.9% (26.7%–99.3%)	88.8% (7.8%–98.2%)	64.2% (6.8%–97.9%)	82.6% (3.3%–97.7%)	74.1% (1.6%–97.0%)							
Δ from 1st rotation (%)		n/a	0.0% (-3.2%–+0.1%)	-1.1% (-24.3%–0.0%)	-1.1% (-8.3%–0.0%)	-2.0% (-22.3%–-0.1%)							
Number of correct compressions delivered		102.5 (28.5–114.5)	102.5 (8.3–109.0)	65.5 (7.5–106.0)	83.5 (3.0–99.8)	67.0 (1.5–100.5)							
Δ from 1st rotation		n/a	0.0% (-6.8%–+0.3%)	-11.5% (-30.5%–0.0%)	-13.0% (-18.8%–-4.5%)	-13.5% (-36.5%–-1.5%)							

Figure 4. Subject compression performance across rotations by teams Results of descriptive statistics and comparative analyses of compressions by 2- (control and intervention), 3-, and 4-compressor teams are presented in tabular groups. Significant differences on multivariate analyses by study group (team size; control or intervention) and rotation are in bold.

cpm, compressions per minute; *HR*, heart rate; *kcal*, kilocalories; *mHR*, maximal predicted HR; *mm*, millimeter; *sec*, second.

Physiologic Exertion Metric		2-Compressor Teams (median and inter-quartile ranges)					3-Compressor Teams (median and inter-quartile ranges)				4-Compressor Teams (median and inter-quartile ranges)		
		1st rotation (n=14)	2nd rotation (n=14)	3rd rotation (n=14)	4th rotation (n=14)	5th rotation (n=14)	1st rotation (n=21)	2nd rotation (n=21)	3rd rotation (n=22)	4th rotation (n=6)	1st rotation (n=20)	2nd rotation (n=20)	3rd rotation (n=10)
Mean HR (% of mHR)	2-Compressor Control Group (n_c=14 subjects; median and inter-quartile ranges)	**67.8% (59.2%–72.0%)**	**71.1% (62.2%-77.1%)**	**72.7% (61.5%-79.0%)**	**74.5% (62.1%-78.9%)**	**75.4% (64.3%-80.0%)**	62.6% (55.8%–+75.7)	66.3% (57.0%–76.7%)	66.5% (56.5%–76.2%)	64.0% (57.4%–70.9%)	66.4% (60.2%–72.4%)	65.9% (62.8%–73.5%)	66.2% (61.8%–71.5%)
Δ from 1st rotation (%)		n/a	+2.4% (-0.4%–+4.6%)	+2.1% (-1.1%–+6.9%)	+1.8% (-0.5%–+8.9%)	+2.9% (-0.3%–+11.0%)	n/a	+2.7% (+1.1%–+4.6%)	+2.1% (+0.5%–+5.7%)	+4.4% (+0.3%–+4.8%)	n/a	+1.3% (-0.5%–+3.2%)	+0.5% (-2.1%–+5.7%)
Caloric consumption (kcal)		**9.3 (7.8–11.8)**	**11.0 (8.4–12.9)**	**11.4 (8.3–13.7)**	**11.5 (8.5–13.6)**	**11.3 (9.2–13.6)**	8.3 (6.7–13.3)	9.4 (7.5–13.5)	9.3 (7.2–13.1)	9.1 (8.2–9.6)	8.9 (7.4–12.3)	9.4 (7.1–12.1)	9.5 (8.5–11.1)
Δ from 1st rotation (kcal)		n/a	+0.6 (-0.1–+1.2)	+0.5 (-0.3–+1.9)	+0.5 (-0.2–+2.6)	+0.8 (-0.1–+3.1)	n/a	+0.7 (+0.3–+1.3)	+0.6 (+0.1–+1.6)	+1.1 (0.0–+1.4)	n/a	+0.3 (-0.2–+0.8)	+0.1 (-0.6–+1.3)
		1st rotation (n=12)	2nd rotation (n=12)	3rd rotation (n=12)	4th rotation (n=12)	5th rotation (n=12)							
Mean HR (% of mHR)	2-Compressor Intervention Group (n_I=12 subjects; median and inter-quartile ranges)	**63.0% (55.6%–70.4%)**	**68.4% (54.1–74.0)**	**69.9% (54.3%-74.7%)**	**67.8% (55.1%-75.5%)**	**67.0% (55.2%-76.5%)**							
Δ from 1st rotation (%)		n/a	+2.1% (-0.5%–+3.5%)	+2.4% (+0.8%–+3.7%)	+2.6% (+1.4%–+3.8%)	+2.7% (+0.7%–+5.1%)							
Caloric consumption (kcal)		**8.5 (7.5–11.7)**	**9.7 (7.5–12.1)**	**9.9 (7.7–12.2)**	**9.7 (7.7–12.1)**	**9.9 (7.7–11.5)**							
Δ from 1st rotation (kcal)		n/a	+0.6 (-0.1–.0.9)	+0.6 (+0.2–+1.1)	+0.6 (+0.3–+1.1)	+0.7 (+0.2–+1.4)							

Figure 5. Subject exertion across rotations by teams. Results of descriptive statistics and comparative analyses of individual exertion in 2- (control and intervention), 3-, and 4-compressor teams are presented in tabular groups. Significant differences on multi-variate analyses by study group (team size; control or intervention) and rotation are in bold; see text for details.

cpm, compressions per minute; *HR*, heart rate; *kcal*, kilocalories; *mHR*, maximal predicted HR; *mm*, millimeter; *sec*, second.

energy expenditure) over successive compressor rotations; see below for additional details by specific study group assignment. Changes in exertion (and energy expenditure) over successive rotations for subjects in 3-compressor teams and 4-compressor teams did not attain significance.

Effects of Recovery Intervention

Chest Compression Quality

Comparison of the 2-compressor control group with the 2-compressor intervention group revealed two significant differences in chest compression quality. Unlike the 2-compressor intervention subjects, the 2-compressor control subjects exhibited diminishing compression rates over successive compression rotations. Additionally, the 2-compressor intervention subjects exhibited increased leaning in later rotations, with a mean estimated slope of change over each subject's sequential compressor rotations of +0.2 [95% CI {+0.1 to +0.4}] mm per rotation (p=0.03) when compared against 2-compressor control group subjects who exhibited no significant change in leaning across rotations.

Exertion

Subjects in both the 2-compressor control group and 2-compressor intervention group exhibited increasing levels of exertion and energy expenditure over successive rotations. The 2-compressor control subjects who did not perform the experimental recovery intervention exhibited the following changes: +3.0 [95% CI {+0.9 to +5.2}] %mHR per rotation (p=0.02) and +0.4 [95% CI {+0.1 to +0.8}] kcal per rotation (p=0.03). The 2-compressor intervention subjects who performed experimental stretching and breathing exercises exhibited the following changes: +1.4 [95% CI {+0.6 to +2.3}] %mHR per rotation (p=0.01) and +0.2 [95% CI {+0.1 to +0.3}] kcal per rotation (p=0.02).

DISCUSSION

The 2010 AHA guidelines recommended rotating providers performing chest compressions every two minutes to mitigate provider fatigue.[2] Several previous investigations have evaluated the effect of rest duration on chest compression quality and fatigue.[8,14] In large healthcare facilities, cardiac arrest resuscitation teams can potentially include three, four, or more compressors who each have several minutes of rest between compression sets. Given that a significant proportion of chest compressions and cardiac resuscitations take place in settings with smaller cohorts of qualified personnel on duty at any one time, investigators applied basic cardiac arrest resuscitation simulation scenarios to examine the potential impact of smaller team sizes on compression performance and compressor exertion.

The experimental study of 2-, 3-, and 4-compressor teams revealed a definite reduction of approximately 3% in compression rate per rotation for only control 2-compressor teams on multivariate analyses (and without changes in other compression characteristics). Concurrently, levels of subject exertion displayed small, orderly, and coherent differences that were significantly associated with study group assignment. Specifically, all subjects featured similar baseline %mHR measurements despite considerable differences in the quality of their chest compressions. It is therefore of interest to note that subsequent physiologic monitoring revealed that only subjects in the 2-compressor teams exhibited increases in caloric expenditure and exertion over successive rotations. These findings suggest that the size of a smaller CPR compressor team may have a demonstrable effect on the quality of chest compressions delivered and provider exertion over the course of a typical cardiac arrest resuscitation. At the same time, the data suggest that teams with more than three compressors do not appear to differentially perform higher-quality chest compressions or exhibit reduced levels of provider exertion. Larger teams may therefore elect to direct additional personnel resources to perform other critical tasks during resuscitations without potentially compromising the quality of chest compressions performed.

Investigators also evaluated whether an experimental rest-recovery intervention would reduce provider exertion and improve compression quality in 2-compressor teams. Whereas data regarding the effects of static stretching on exercise performance are conflicting,[15-17] several previous studies have demonstrated improvement in pulmonary and cardiovascular function with deep breathing exercises.[19,20] In the current study, the 2-compressor team subjects who performed the recovery intervention exercises during rest periods were able to sustain adequate chest compression rates throughout the simulation and with less exertion when compared to control group 2-compressor team subjects. This suggests that targeted recovery exercises performed during rest periods may help mitigate provider fatigue and help facilitate the sustainment of adequate chest compression quality during cardiac arrest resuscitations. Providers in clinical practice settings where few compressors are available may benefit from performing the studied recovery exercises during cardiac arrest resuscitations.

This study's findings are in agreement with numerous previous studies that have established the provider-dependent and generally poor quality of CPR.[1,6,7,22,27] Study simulation sessions elicited a broad spectrum of chest compression performances from a cohort of young medical student subjects with normal BMI. Objective measurements revealed that 25% of Phase 1 participants were unable to deliver a single correct compression during their four-minute simulation session (data not shown). Despite the use of Phase I sessions as a screening process to enroll higher-performing subjects, approximately 50% of all Phase II chest compressions were still performed incorrectly (primarily due to inadequate compression depth). These findings raise significant concerns with respect to the current approaches of training and entrusting the delivery

of critical life-saving interventions to the general CPR resuscitator cohort. Furthermore, specific subject predictors of chest compression performance could not be derived from the dataset, with only correlations of intermediate strength identified between compression quality and subject weight (r=0.4) or BMI (r=0.35) for the studied demographic characteristics (data not shown).

It is somewhat remarkable that a significant proportion of the study's healthy, young, motivated, and recently-trained medical students delivered suboptimal (simulated) chest compressions. Accordingly, we expect that a typical CPR team (comprised of individuals of greater diversity with respect to age, gender, and baseline health and physical capability) would deliver chest compressions of even poorer quality in simulated and/or live settings. As a result, next-step interventions are not entirely clear. Advocacy for more frequent training with the judicious use of simulation technologies and the widespread application of accelerometer-based, real-time feedback devices for monitoring and assurance of compression quality are distinct possibilities.[1,28]

On the other hand, the objective identification and in-resuscitation recognition of poor CPR quality may fail to resolve a critical issue, i.e., the existence of a significant population of up-to-date BLS-certified healthcare professionals who are physically incapable of delivering chest compressions as specified by formal guidelines. The challenge is further complicated by the failure of mechanical auto-compression devices (engineered to methodically deliver correct compressions) to improve patient outcomes.[29] In the interim, further investigation into compressor team compositions and rest-recovery interventions may be warranted.

LIMITATIONS

The research budget and subject pool limited the Phase I sample size; investigators were unable to enroll a sufficient number of Phase II subjects to reach the target number of study teams. Study groups of 2-, 3-, and 4-compressor teams may not have been fully matched in baseline performance; this limited comparative assessments across teams of different sizes.

CONCLUSION

Members of 2-compressor teams exhibited greater levels of exertion relative to members of larger compressor teams for comparable simulated chest compression performance. Stretching and breathing exercises intended to assist with compressor recovery exhibited mixed effects on compression performance and subject exertion.

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Impact of Superstorm Sandy on Medicare Patients' Utilization of Hospitals and Emergency Departments

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Introduction: National health security requires that healthcare facilities be prepared to provide rapid, effective emergency and trauma care to all patients affected by a catastrophic event. We sought to quantify changes in healthcare utilization patterns for an at-risk Medicare population before, during, and after Superstorm Sandy's 2012 landfall in New Jersey (NJ).

Methods: This study is a retrospective cohort study of Medicare beneficiaries impacted by Superstorm Sandy. We compared hospital emergency department (ED) and healthcare facility inpatient utilization in the weeks before and after Superstorm Sandy landfall using a 20% random sample of Medicare fee-for-service beneficiaries continuously enrolled in 2011 and 2012 (N=224,116). Outcome measures were pre-storm discharges (or transfers), average length of stay, service intensity weight, and post-storm ED visits resulting in either discharge or hospital admission.

Results: In the pre-storm week, hospital transfers from skilled nursing facilities (SNF) increased by 39% and inpatient discharges had a 0.3 day decreased mean length of stay compared to the prior year. In the post-storm week, ED visits increased by 14% statewide; of these additional "surge" patients, 20% were admitted to the hospital. The increase in ED demand was more than double the statewide average in the most highly impacted coastal regions (35% versus 14%).

Conclusion: Superstorm Sandy impacted both pre- and post-storm patient movement in New Jersey; post-landfall ED surge was associated with overall storm impact, which was greatest in coastal counties. A significant increase in the number and severity of pre-storm transfer patients, in particular from SNF, as well as in post-storm ED visits and inpatient admissions, draws attention to the importance of collaborative regional approaches to healthcare in large-scale events. [West J Emerg Med. 2017;18(6)1035-1041.]

INTRODUCTION

National health security requires that healthcare facilities respond effectively and efficiently to disasters and public health emergencies. A key responsibility of the healthcare system is to anticipate, prepare for, and accommodate the increased demand for services following a catastrophic event, which is often referred to as "surge capacity."[1] Surge capacity is directly related to patient health outcomes. Patients admitted to the hospital during high surge periods have a significantly higher rate of mortality than those admitted in periods of low surge.

Further, emergency department (ED) crowding has been associated with increases in hospital length of stay for admitted

patients.[2] Increased hospital utilization after a disaster may result from illness or injury that is a direct effect of the event, as was the case following the 2013 Boston Marathon bombing or the 2016 Orlando nightclub shooting, or it may result from the movement of patients evacuated from a healthcare facility that can no longer care for them, as is common during severe flooding or sustained loss of electrical power.[3,4] While research has described methods for measuring surge capacity,[5,6,7,8,9,10] little data exists that quantifies increased ED and inpatient utilization after major disasters. Consequently, the ability of receiving facilities to conduct evidence-based surge capacity planning is compromised.

Superstorm Sandy made landfall in New Jersey (NJ) on October 29, 2012, resulting in at least 37 deaths, 346,000 damaged or destroyed homes, and an estimated economic loss of $30 billion statewide.[11,12,13] The NJ healthcare system was also directly affected, with two hospitals and many more nursing homes evac-uated.[14,15,16] This study analyzes hospital ED utilization patterns among fee-for-service (FFS) Medicare beneficiaries in NJ in the week before and after Superstorm Sandy's landfall in order to (1) determine whether hospitals prepared for significant increases in healthcare demand by discharging patients early in the days preceding landfall, and (2) better characterize the impact of this storm as it relates to Medicare-patient surge and ED utilization.

Population Research Capsule

What do we already know about this issue?
While research has described methods for measuring surge capacity, there is a paucity of data quantifying increased ED utilization after major disasters.

What was the research question?
What is the magnitude and destination of the medical surge associated with a major natural disaster?

What was the major finding of the study?
In the week after Superstorm Sandy made landfall, ED visits by Medicare patients increased by 14% for the state of New Jersey.

How does this improve population health?
The evidence promotes population health resilience, improves healthcare delivery during disasters, and identifies patients at risk for adverse health outcomes.

METHODS

Study Population

We analyzed de-identified Medicare claims available from the Research Data Assistance Center (ResDAC)[17] for ED utilization and patient disposition in New Jersey during Superstorm Sandy. We used this publicly available national data set to create a 20% random sample of FFS beneficiaries in NJ who were continuously enrolled from 2011 through 2012 (N=224,116). The percent of Medicare beneficiaries receiving FFS care in 2012 was 83.5%.[18] We matched the study population to a comparison group made up of beneficiaries from non-Sandy-affected states (all U.S. states except FL, SC, NC, VA, DC, MD, DE, PA, NY, CT, RI, MA, NH, and VT).

We used the Community Hardship Index (CHI) to represent county-level storm impact. The index, developed by Rutgers University in the aftermath of Sandy,[19] is comprised of weighted assessments of power loss; residential, commercial, and municipal damage; establishment of emergency shelters; and gasoline shortages, and controls for demographic differences in the population. Scores range from 1-100, with more severely impacted counties scoring higher.

Since this study involved the analysis of fully de-identified claims that cannot be traced back to the individual, it did not meet the definition of human subjects research as set forth in U.S. Code of Federal Regulations, and since there was no interaction or intervention with individuals and no identifiable private information used, it did not require review by an institutional review board.

Key outcomes

Study outcomes were pre-storm hospital discharges, case-mix index (CMI), average length of stay (ALOS) for admitted patients, hospital admissions through the ED from inter-facility transfers; and post-storm ED visits, including those that resulted in a hospitalization (admissions) and those that did not (discharges). CMI is an average of the service intensity weights associated with diagnosis-related group (DRG) for a given population. CMI range is from 0.1 to 30.0. A higher CMI indicates more resources are needed to treat more complex patients.[20] We identified inter-facility transfers using the hospital admission source variable or a hospital admission date falling between the admission and discharge dates of the transferring facility, and included patients who moved from hospital-to-hospital, hospice-to-hospital, and skilled nursing facility (SNF)-to-hospital.

Data Analysis

Pre-Storm

We used chi-square statistics and logistic regression to examine the effect of Superstorm Sandy on pre-storm hospital discharges by comparing the number of discharges during the week prior to landfall (October 22, 2012 – October 28, 2012) to those during the equivalent week the previous year

(October 24, 2011 – October 30, 2011), after adjusting for patient age, gender, and race. The same methods were used to calculate changes in pre-storm admissions through the ED from inter-facility transfers (hospital-to-hospital, hospice-to-hospital, and SNF-to-hospital).

We used t-test statistics and logistic regression to examine the effect of Superstorm Sandy on pre-storm CMI by comparing CMI of pre-storm hospital discharges and admissions from transfers the week prior to landfall to CMI of admissions from transfers on the equivalent week of the previous year. Ordinary least squares (OLS) was used to compute change in pre-storm ALOS, by comparing ALOS at discharge for matched DRGs the week prior to landfall to ALOS versus any other admission in 2011 and 2012 in NJ.

Post-Storm

We conducted two comparisons to assess post-storm ED utilization outcome measures among NJ Medicare FFS beneficiaries. First, we used a difference-in-differences (DD) regression to examine the effect of Superstorm Sandy on ED utilization among NJ beneficiaries by comparing the number of visits one week before landfall (October 22, 2012 – October 28, 2012) to utilization one week immediately after landfall (October 29, 2012 – November 4, 2012). This difference was then compared to the difference in visits between the equivalent weeks in the prior year (October 24, 2011 – October 30, 2011 and October 31, 2011 – November 6, 2011). The DD model was adjusted for patient age, gender, and race. Second, we used a difference-in-difference-in-differences (DDD) regression to test whether the storm's effects on ED utilization were due to unobserved bias (e.g. seasonal influenza) among NJ beneficiaries rather than from the storm itself.[21] This was accomplished by implementing a 1,000-iteration Monte Carlo simulation (MCS) that randomly matched 1:1 (with replacement) demographic characteristics and post-storm ED utilization outcomes of beneficiaries' cohorts in the NJ 2011 group from the first comparison to 2011 beneficiaries from states *not* impacted by Sandy. The Appendix includes a detailed description of the MCS process.

We conducted county-level analyses of storm impact by creating county-level quartiles based on the CHI associated with each county, with the first quartile (Q1) being the least severely impacted and the last quartile (Q4) being the most severely impacted counties (Table 1).

We performed all analyses using SAS software version 9.3 (SAS Institute Inc., Cary, NC). A two-sided P value of 0.05 or less was considered statistically significant.

RESULTS

The NJ study population consisted of 224,116 continuously enrolled Medicare FFS beneficiaries. The study population represented approximately 2.5% of the 8.9 million NJ residents in 2012 and 16.0% of all NJ Medicare beneficiaries.[22,23] Demographic and outcome variables did not differ significantly between the NJ 2011-12 beneficiaries and matched non-NJ beneficiaries (data not shown).

Pre-Storm

While some of the less severely impacted counties experienced a decrease in pre-storm hospital discharges, for the entire state there was a 7.1% relative increase in patients discharged during the week prior to Sandy's landfall (from 51.8% to 55.5%, ($P < 0.01$)) as compared to the equivalent week in 2011. When extrapolated from the 20% subsample used for analysis, this increase corresponds to an estimated 295 additional Medicare FFS patients discharged. Almost half of the increase consisted of discharges to home health services (46%), followed by discharges to SNF (24%), and 17% discharged to home. A disproportionate number of discharges occurred in the more severely impacted counties, with a 10.7% relative increase of discharges in CHI Q_3 and Q_4 (from 50.4% to 55.8% of patients discharged, [P<.01]). This corresponds to an estimated extrapolation of 425 additional Medicare FFS patients discharged in these areas relative to the prior year. Hospital discharges in the week prior to Sandy's landfall in CHI Q_4 alone were not statistically different.

ALOS among discharged patients in the pre-storm week was 0.3 days shorter than that of DRG-matched NJ patients who were discharged at any time in 2011 or 2012 ($P < 0.03$). However, patients discharged the week prior to Sandy's landfall did not have a statistically significant different CMI compared to the equivalent week in 2011, suggesting that factors other than clinical status may have influenced disposition decisions.

Table 1. Definition of county quartiles by Community Hardship Index (CHI).

Quartile (Q)	CHI	Number medicare FFS beneficiaries (N)	New Jersey counties
1st (Q_1)	< 39	37,581	Salem, Camden, Cumberland, Gloucester, and Burlington.
2nd (Q_2)	40-47	52,754	Warren, Passaic, Mercer, Cape May, Essex, and Atlantic.
3rd (Q_3)	48-58	56,193	Hudson, Bergen, Morris, Sussex, and Hunterdon.
4th (Q_4)	> 59	77,588	Union, Middlesex, Somerset, Ocean, and Monmouth.

FFS, fee-for-service.

Compared to the equivalent week in 2011, hospital admissions through the ED resulting from a SNF-to-hospital transfer increased 38.9% (from 9.0% to 12.5%, [P<.01]) during the pre-storm period, corresponding to an additional 140 extrapolated admissions. Hospital admissions resulting from hospital-to-hospital or hospice-to-hospital transfers were not statistically different.

Patients transferred to hospitals from SNFs had DRG-specific CMI upon admission that were 32.7% higher in the week prior to landfall when compared to patients transferred from SNFs in the prior year's equivalent week (1.40 vs. 1.96) (P<0.03). This suggests that more complex and/or more clinically ill patients were transferred from SNF-to-hospital during the pre-storm period. Of note, hospital admissions from inter-facility transfers did not vary significantly by CHI quartile (i.e., these occurred at a uniform rate statewide).

Post-Storm

As shown in Table 2, there were 14.3% more ED visits among Medicare FFS beneficiaries in the state of NJ in the week following Superstorm Sandy when compared to previous week and equivalent weeks the year prior. Of these, 80% were discharged and 20% were admitted as inpatients. This observed split differed from the baseline where 60% of patients were discharged and 40% admitted. When extrapolated from the 20% subsample used for analysis, this represents an estimated increase of 1,558 ED visits for all Medicare FFS beneficiaries, of which 1,244 were discharged and 314 were admitted. The Monte Carlo simulation validation results provided in Table 2 show an even higher increase in ED utilization, suggesting that using NJ the year prior provides a conservative reflection of actual clinical practice. Finally, in contrast to the pre-storm week, there was not a significant increase in the proportion of ED admissions due to transfers from SNFs after the storm.

Geographically, the 14.3% surge in overall Sandy-related ED visits in NJ was not evenly distributed throughout the state. In fact, ED utilization actually decreased in the least impacted counties while it increased in the most impacted counties. In the hardest hit counties (those with CHI > 59), the surge was more than double (14.3% vs. 35.5%) the overall statewide surge, with these counties experiencing more than twice as many ED visits resulting in a discharge (19.1% vs. 44.7%) and three times as many ED visits resulting in an admission (7.2% vs. 21.4%) as compared to the state average. An estimated 1,187 additional Medicare FFS beneficiaries were seen in EDs in the Q_4 counties with CHI > 59 in the week following Superstorm Sandy compared to the equivalent week of 2011 (Figure).

DISCUSSION

This study represents a first step towards describing pre- and post-storm ED and hospital utilization behavior during 2012's Superstorm Sandy in NJ. Our analysis of Medicare FFS claims suggests that NJ hospitals experienced multiple alterations in pre- and post-landfall patient movement for this population, including a significant surge in post-storm ED visits, associated with Sandy. In the week prior to the storm's arrival, hospitals statewide discharged 7.1% more patients and coastal counties discharged almost 11% more patients than during the equivalent time period the prior year. The majority of these patients were discharged to home health services and SNFs. In addition, SNF-to-hospital transfers increased by almost 40%. While hospitals did not discharge more severely ill patients, our data show that patients transferred from SNFs and admitted to the hospital through the ED were significantly sicker than those transferred the equivalent week in 2011.

Although our data show that hospital discharges in NJ increased up to 11% in the week prior to Superstorm Sandy, the reasons for this utilization behavior are unknown. Hospitals may have been concerned about their ability to remain open, or concerned that the storm would impact staff ability to get to work. They may have anticipated a post-storm surge in patients. Or, patients may have been eager to get home before the storm and advocated for earlier release. Importantly, SNF-to-hospital transfers increased by 38.9%, and patients who were moved in the pre-storm period were significantly sicker than transfer patients in 2011 and the patients being discharged from the hospital. The data suggest that while hospitals were freeing up space, they were simultaneously managing a sicker inpatient population.

Table 2. Estimated increase in emergency department (ED) utilization among New Jersey Medicare (fee-for-service) FFS beneficiaries by ED disposition in the week after Superstorm Sandy's landfall.

Post-storm utilization	Actual increase in ED visits	Extrapolated increase in ED visits (all Medicare FFS beneficiaries)	Percent increase in ED visits (2011 vs. 2012)*	Percent increase in ED visits (Monte Carlo simulation)
ED visits	312	1,558	14.3%	17.7%
Discharged	249	1,244	19.1%	23.0%
Admitted	63	314	7.2%	8.2%

*Significant at p < 0.01. Percentage increase in ED visits discharges and admits do not sum up to the total percentage increase as each one is calculated separately.

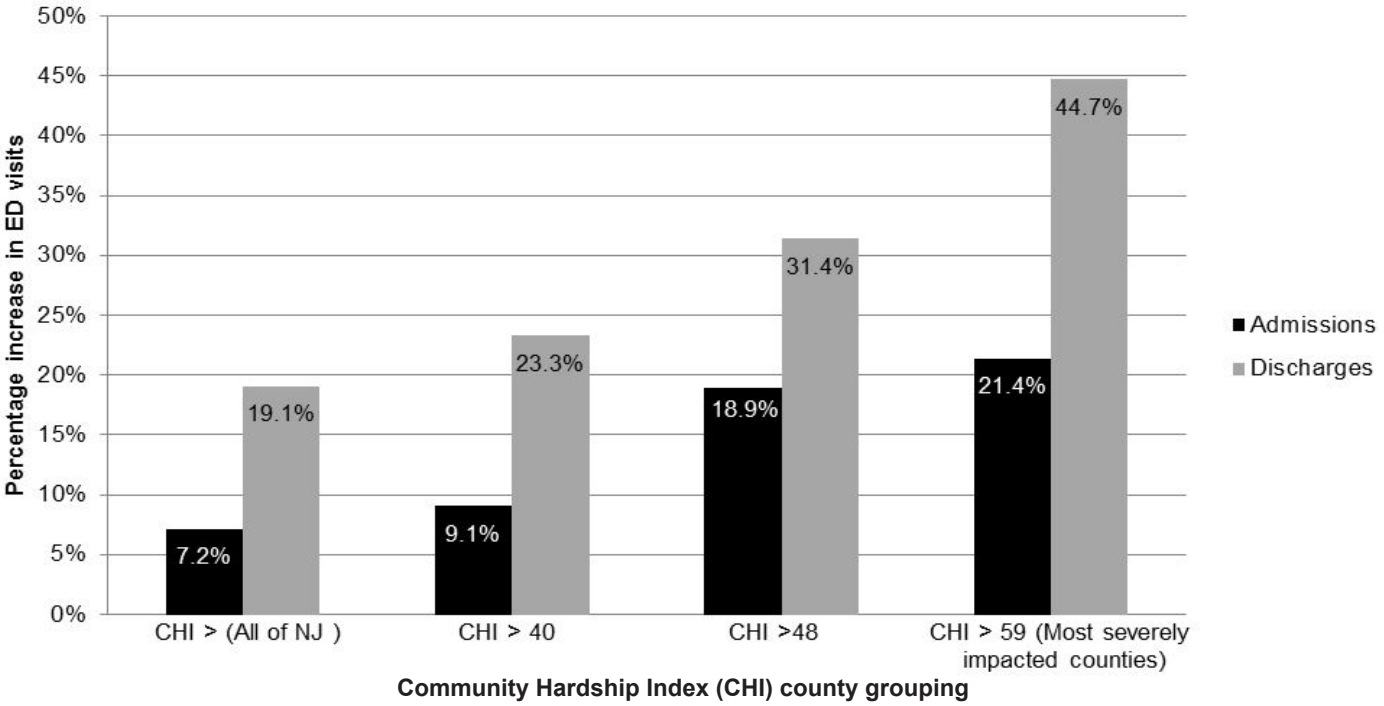

Figure. Percent increase in emergency department (ED) visits by Community Hardship Index (CHI) and ED disposition (2012 vs. 2011).

The top five hardest hit NJ counties experienced a 21.4% increase in inpatient admissions of patients covered by Medicare FFS. Identifying these at-risk individuals in a pre-disaster setting may improve their outcomes or even permit strategies to keep them out of the hospital altogether, similar to other studies that use Medicare data to identify electricity-dependent individuals (e.g., patients on dialysis) to improve disaster preparedness and response.[24] Using existing claims data in this manner can contribute to promoting local, regional, and national health security without additional data-reporting requirements.

These findings have important implications for how individual facilities, healthcare systems, and healthcare coalitions consider planning for serious weather events with warning. During severe disasters, facilities should expect variable increases in patient surge depending on location, population demographics, infrastructural resiliency, and other factors and plan accordingly. Under the guidance of the U.S. Department of Health and Human Services Hospital Preparedness Program (HPP), healthcare systems are currently advised to maintain the ability to free up at least 20% of their routine bed census within four hours of a disaster.[25] Our study provides empirical data in support of the need for facilities and healthcare systems to increase bed capacity in advance of severe weather events.

LIMITATIONS

The study has several important limitations. First, the study uses a retrospective design, which is inherently subject to selection bias. Second, the analysis is limited to Medicare FFS beneficiaries and may not represent the experience of other populations including the privately insured, patients with Medicare Advantage, and patients with Medicaid. The continuous enrollment inclusion criterion selected for Medicare patients who did not die between 2011 and 2012, and as such may bias our findings to reflect a relatively healthier population. Finally, actual hospital occupancy at the time of the storm was not assessed (either by this research or at the time by NJ public health officials). According to an American Hospital Association report, NJ had an average occupancy rate of 70% in 2012, so additional capacity beyond that identified here as a result of hospital discharges may have existed.[26] Daily hospital census data would be required to capture how many functional beds were available as the storm came ashore, but this cannot be extrapolated from Medicare data. Developing tools for measuring and communicating bed availability, occupancy, and associated surge capacity across healthcare coalitions in real time during such events will result in improved regional patient management.

CONCLUSION

Meteorological projections increasingly suggest that the incidence and severity of extreme weather events are likely to increase by the end of the 21st century.[27,28] Sustainable and resilient healthcare facilities that are prepared to care for patients who may experience new or exacerbated health

problems as a result of these extreme events is critical.[29] In addition to weather-related events, other threats to the public's health, including infectious diseases and injuries, require a health system prepared to respond. Unfortunately, there is little real-world, population-based evidence that describes the source, magnitude, and destination of the medical surge associated with natural or man-made disasters and public health emergencies. This evidence is important for promoting population health resilience, improving healthcare delivery during disasters, and identifying patients who may be at particularly high risk for adverse health outcomes. This study takes an important step in this direction, illustrating the relationship between the preparations for and medical impact of Superstorm Sandy in the state that bore the brunt of its landfall.

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Emergency Department Utilization by Children in the USA, 2010-2011

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Introduction: Epidemiological surveillance data for emergency department (ED) visits by children are imperative to guide resource allocation and to develop health policies that advance pediatric emergency care. However, there are sparse population-based data on patient-level information (e.g., the number of children who present to the emergency department [ED]). In this context, we aimed to investigate both the patient- and visit-level rates of ED utilization by children.

Methods: This was a retrospective cohort study using population-based multipayer data – state ED databases (SEDD) and state inpatient databases (SID) – from six geographically-dispersed U.S. states (California, Florida, Iowa, Nebraska, New York, and Utah) in 2010 and 2011. We identified all children aged <18 years who presented to the ED and described the patient-level ED visit rate, visit-level ED visit rate, and proportion of all ED visits made by children. We conducted the analysis using the 2011 SEDD and SID data. We also repeated the analysis using the 2010 data to determine the consistency of the results across different years.

Results: In 2011, 2.9 million children with a patient identifier presented to EDs in the six U.S. states. At the patient-level, 15 out of every 100 children presented to an ED at least once per year. Of these children, 25% presented to EDs 2-3 times per year with an approximately 1.5-fold variation across the states (e.g., 19% in Utah vs. 28% in Florida). In addition, 5% presented to EDs ≥4 times per year. At the visit-level, 6.7 million ED visits were made by children in 2011 – 34 ED visits per 100 children annually. ED visits by children accounted for 22% of all ED visits (including both adults and children), with a relatively small variation across the states (e.g., 20% in New York vs. 24% in Nebraska). Analysis of the 2010 data gave similar results for the ED utilization by children.

Conclusion: By using large population-based data, we found a substantial burden of ED visits at both patient- and visit-levels. These findings provide a strong foundation for policy makers and professional organizations to strengthen emergency care for children. [West J Emerg Med. 2017;18(8)1042-1046.]

INTRODUCTION

Approximately 30 million emergency department (ED) visits are made by children in the U.S. annually.[1,2] ED visits by children increased 14.4% between 2001 and 2010.[3] The increased burden of ED visits by children underscores the importance of pediatric emergency care readiness.[4] Although substantial efforts have improved the pediatric readiness over years, the state of emergency care readiness for U.S. children remains insufficient and uneven due to resource and workforce disparities.[5] For example, recent U.S. surveillance data

reported that only 45% of EDs have a quality improvement plan addressing the needs of children[5] and that 17%-65% of EDs have a physician or nurse pediatric emergency care coordinator — who ensures that staffs are appropriately trained, that the ED is prepared with the appropriate equipment, and that the right kinds of policies are in place for caring for children.[4,6]

To guide appropriate resource allocation and advance pediatric emergency care, surveillance data of the current ED visits made by children are instrumental. A combination of the patient- and visit-level information on the ED visits provides a comprehensive view of ED utilization by children. Although prior reports have documented visit-level information for U.S. children (e.g., the number of ED visits and visit-level ED visit rate),[1,2] there are limited data on patient-level data (e.g., the number of children who present to the ED).[7-9] An analysis of the National Health Interview Survey reported that 12% of children living in the U.S. (8.8 million children) had an ED visit in the preceding 12 months in 2012; approximately half of these children (4.2 million children) had two or more ED visits.[7] However, this study is potentially limited by the low response rate (70%), lack of onsite verification, and recall bias.[7] Two other multicenter pediatric ED studies have reported that 36%-38% of children who visited the ED had multiple ED visits.[8,9] Yet, since 90% of children are brought to general EDs,[10] focusing on high-volume pediatric centers might cause selection bias.

To address the knowledge gap, we aimed to investigate both the patient- and visit-level rates of ED utilization by children in six geographically-dispersed U.S. states by using population-based multipayer datasets.

METHODS

We conducted a retrospective cohort study using 2010-2011 data from the Healthcare Cost and Utilization Project (HCUP) state emergency department databases (SEDD) and state inpatient databases (SID) from six U.S. states (California, Florida, Iowa, Nebraska, New York, and Utah). Details of the methods may be found in the supplemental material. The SEDD includes all treat-and-release and transfer ED visits from short-term, acute-care, nonfederal, community hospitals in participating states. The SID includes all inpatient discharges from short-term, acute-care, nonfederal, general, and other specialty hospitals in participating states, including those hospitalized from the ED. Taken together, we identified all ED visits regardless of disposition. Further information on SEDD and SID databases can be found elsewhere.[11] In the current study, these six states were selected for data availability, their geographic distribution, high data quality, and chiefly because their databases contain unique patient identifiers that enable follow-up of individual patients across years.

We identified all children aged <18 years who presented to the ED in the six states during 2010-2011. We investigated 1) the patient-level ED visit rate (i.e., the number of children who presented to EDs per 100 children), 2) the visit-level ED visit rate (i.e., the number of ED visits by children per 100 children), and 3) the proportion of ED visits made by children among all ED visits (including both children and adults). The denominators for ED visit rates were the population estimates obtained from the U.S. Census Bureau.[12] For the patient-level analysis, we excluded children with no record of a patient identifier. Descriptive statistics were performed using Stata version14.1 (StataCorp, College Station, TX). First, we conducted the analysis using data from the 2011 SEDD and SID. Next, we repeated this analysis using data from the 2010 data to determine the consistency of the results across the different years. The institutional review board of Massachusetts General Hospital approved this analysis.

RESULTS

In 2011, 2.9 million children with a patient identifier presented to EDs in the six U.S. states (Table 1). Children in California, Florida, and New York accounted for approximately 90% of these children. Overall, the median age was eight years, 39% were non-Hispanic White, and 52% were Medicaid beneficiaries at the first ED visit. Compared to children who presented to the ED once per year, those who presented to the ED multiple times per year were younger, and more likely to be female sex, non-Hispanic Black or Hispanic, Medicaid beneficiaries, and living in the area with lower median household income (all P<0.001; Table 1). At the patient-level, 15 out of every 100 children presented to an ED at least once per year. Of these children, 25% presented to EDs 2-3 times per year with an approximately 1.5-fold variation across states (e.g., 19 % in Utah vs. 28% in Florida). Additionally, 5% had ≥4 ED visits per year.

At the visit-level, 6.7 million ED visits were made by children in 2011 – 34 ED visits per 100 children annually (Table 2). There was an approximate two-fold variation across states (e.g., 19 visits in Utah vs. 43 visits in Florida, per 100 children annually). ED visits by children accounted for 22% of all ED visits (including both children and adults), with a relatively small variation across states (e.g., 20% in New York vs. 24% in Nebraska).

The analysis of the 2010 data gave similar results for the burden of ED visits by children (Supplemental Table 1). At the patient-level, 14 out of every 100 children presented to an ED at least once per year; of these, 24% presented to EDs 2-3 times per year, and 5% had ≥4 ED visits per year. At the visit-level, there were 33 ED visits per 100 children annually, an d ED visits by children accounted for 22% of all ED visits.

DISCUSSION

In this analysis of population-based multipayer data from the six U.S. states, at the patient-level one in seven children presented to the ED at least once per year. Additionally, 25% of these children had 2-3 ED visits and 5% had ≥4 ED visits. At the visit-level, children accounted for 22% of all ED visits, consistent with the estimates using nationally-representative databases — e.g., the Nationwide Emergency Department Sample ED visits by

Table 1. Baseline characteristics of children who presented to an emergency department, at first visit in 2011.

Characteristics	Children who presented to ED once per year[1]	Children who presented to ED 2-3 times per year[1]	Children who presented to ED ≥4 times per year[1]	p value*
Age (year), median (IQR)	9 (3-15)	7 (2-14)	5 (1-14)	<0.001
Male sex	1,054,016 (53%)	361,728 (51%)	69,205 (49%)	<0.001
Race/ethnicity				<0.001
Non-Hispanic white	762,134 (41%)	237,888 (36%)	46,064 (34%)	
Non-Hispanic black	376,225 (20%)	152,602 (23%)	33,461 (24%)	
Hispanics	555,099 (30%)	220,202 (33%)	46,945 (34%)	
Others	184,853 (10%)	58,407 (9%)	10,803 (8%)	
Primary health insurance				<0.001
Medicare	6,734 (1%)	2,364 (1%)	507 (1%)	
Medicaid	945,377 (50%)	428,473 (61%)	102,074 (71%)	
Private	791,610 (39%)	187,634 (27%)	24,696 (17%)	
Self-pay	191,148 (9%)	60,289 (9%)	10,969 (8%)	
Others	79,428 (4%)	26,383 (4%)	4,833 (3%)	
Quartiles for median household income				<0.001
1 (lowest)	676,327 (34%)	274,490 (39%)	61,807 (44%)	
2	530,429 (27%)	193,803 (28%)	39,844 (28%)	
3	443,820 (22%)	143,303 (21%)	26,652 (19%)	
4 (highest)	336,064 (17%)	84,309 (12%)	12,703 (9%)	
Patient residence				<0.001
Metropolitan area	1,824,303 (91%)	636,926 (90%)	128,921 (90%)	
Rural area	186,595 (9%)	67,711 (10%)	14,106 (10%)	

ED, emergency department; *IQR*, interquartile range.
[1]Children with a patient identifier.
*Comparison between children who presented to ED once per year and those who presented to ED ≥2 times per year.

children accounted for 20% of all ED visits in 2011.[13] Our population-based data corroborates the previous reports on the visit-level data, but our study then extends beyond them by investigating ED utilization at the patient-level.

In the U.S., EDs serve as a primary safety net, an acute diagnostic and treatment center, and a 24/7 portal for rapid hospitalization. The visit-level findings indicate that the burden of ED visits by children continued to be substantial, accounting for approximately 20% of all ED visits from 1997 to 2011.[1,2,14] Consistent with our findings, the previous patient-level analysis revealed that 12%-14% of U.S. children visited the ED at least once per year.[7] In contrast, the proportion of children with ≥2 ED visits within a year in this population-based study (i.e., 30%) was lower compared to studies using interview or multicenter registries – approximately 40% of children who visited the ED had repeat ED visits.[7,8,9] This discrepancy might be attributable to the difference in study design, population, data measurement, or any combination of these factors. Nevertheless, the validity of the current findings is supported by the use of population-based databases that captured all ED visits and patients across six U.S. states.

We also found the differences in demographics and socioeconomic status between children who presented to the ED once per year and those who presented multiple times per year. For example, children with multiple ED visits were more likely to be racial/ethnic minorities, Medicaid beneficiaries, and living in the area with lower median household income. Although further investigation is warranted, these findings suggest the potential relationship between socio-demographics and frequent ED utilization – e.g., lower socioeconomic status might be associated with the frequent ED utilization among children.

The observed large ED utilization by children necessitates the appropriate allocation of resources and improvement of guidelines-recommended pediatric readiness. The national guidelines of pediatric readiness target seven areas of focus[15]: 1) administration and coordination, 2) physicians, nurses, and other healthcare clinicians, 3) quality improvement, 4) patient safety, 5) policies, procedures, and protocols, 6)

Table 2. Annual child-related emergency department visits and rates in six U.S. states in 2011.

	Patient-level				Visit-level		
States (year 2011)	Total number of children who presented to ED, n[1]	Total number of children who presented to ED 2-3 times per year, n (%)	Total number of children who presented to ED ≥4 times per year, n (%)	Number of children who presented to ED per 100 person-years[2]	Total number of pediatric ED visits, n	Pediatric ED visit rate per 100 person-years[2]	Proportion of pediatric ED visits among all ED visits[3]
Overall	2,863,705	705,445 (25)	143,220 (5)	15	6,696,967	34	22%
California	847,646	205,088 (24)	39,412 (5)	9	2,752,545	30	23%
Florida	734,933	204,929 (28)	47,919 (7)	18	1,730,086	43	20%
Iowa	67,898	16,469 (24)	3,415 (5)	9	259,074	36	22%
Nebraska	97,781	21,089 (22)	3,580 (4)	22	130,396	28	24%
New York	1,071,372	249,535 (23)	47,364 (4)	25	1,654,211	39	20%
Utah	44,075	8,335 (19)	1,455 (3)	5	170,655	19	23%

ED, emergency department.
[1]Children with a patient identifier (39% of ED visits had no patient identifier).
[2]Denominators were pediatric population (age <18 years) in each state.
[3]Denominators were all adults and pediatric population in each state.

support services, and 7) equipment, supplies, and medications.[16] The first area of these focuses – the availability of pediatric emergency care coordinators – has been reported to be insufficient.[5] While the Institute of Medicine has recommended that all hospitals – regardless of the pediatric ED visit volume – should have pediatric emergency care coordinators,[4] studies have reported that 17%-65% of EDs do not have a physician or nurse pediatric emergency care coordinator.[4,6] As for physicians' training, particularly for emergency medicine residency training, the Accreditation Council for Graduate Medical Education set the requirement that 20% of all ED encounters should be dedicated to the care of pediatric patients.[17] This requirement is consistent with our observation that 20%-22% of overall ED visits are made by children.[13] By contrast, while mandatory pediatric emergency care competency evaluations are recommended in the aforementioned guidelines,[15] the competency evaluations are not often conducted either in midlevel staff (18.1%) or in physicians (38.7%).[5] In terms of the quality improvement in pediatric care, a previous survey demonstrated that only 45% of EDs reported having a quality improvement plan addressing the needs of children.[5] Additionally, almost 50% of EDs had barriers to guideline implementations due to the cost of training and the lack of educational resources.[5] Because of children's unique healthcare needs, our findings in conjunction with the literature[5] suggest that these critical chasms in the pediatric readiness in the ED should be the priority area for improvement efforts.[4]

LIMITATIONS

This study has several potential limitations. First, this study population was not a random sample of the entire U.S. The overall findings are largely attributable to the data from three large-population states (California, Florida, and New York) and there was a lack of information from some U.S. regions, such as the Pacific Northwest. Second, the lack of a patient identifier in some children may have led to an underestimation of the patient-level ED visit rate – that is, the current study indicates the "least" patient-level ED visit rates. Third, although the age cut-off to define pediatric population varies across studies,[18-20] we defined children as age ≤18 years to maintain consistency with the methods used in the national estimates of ED visits made by children.[13,21] Finally, this study focused on ED utilization in acute care hospitals; we recognize that many children who need emergency care might have presented to other settings (e.g., urgent care centers). Thus, observed findings do not represent the total burden of children who need unique care. Nevertheless, as we focused on the patient- and visit-level ED visits, our observations are highly relevant to millions of U.S. children visiting the ED and their families.

CONCLUSION

In summary, this study of the large population-based multipayer databases from six U.S. states found that one in seven children presented to the ED at least once per year, and that 30% of these children had multiple ED visits within a single year. This patient-level information provides detailed information that characterizes the children who present to the ED. The observed data also indicated that children accounted for 22% of all ED visits in these states. This visit-level information indicates the actual burden of ED use by children. In addition, the patient-level and visit-level ED visit rates varied widely across the study states. Given the large ED utilization by children, our data should

encourage healthcare providers, hospitals, professional organizations, policymakers, and other stakeholders involving emergency care for children to continue their efforts for improving pediatric readiness in the ED.

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Ultrasound-Guided Peripheral Intravenous Line Placement: A Narrative Review of Evidence-based Best Practices

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Peripheral intravenous line placement is a common procedure in emergency medicine. Ultrasound guidance has been demonstrated to improve success rates, as well as decrease complications and pain. This paper provides a narrative review of the literature focusing on best practices and techniques to improve performance with this procedure. We provide an evidence-based discussion of preparation for the procedure, vein and catheter selection, multiple techniques for placement, and line confirmation. [West J Emerg Med. 2017;18(6)1047-1054.]

BACKGROUND

After the first reported use of ultrasound for real-time central venous catheter (CVC) insertion was reported in 1984,[1] ultrasound-guidance progressively became the standard approach for placement, particularly when cannulating the internal jugular vein.[2,3] When used for CVC insertion, ultrasound guidance has led to increased placement success, decreased complication rates, and decreased insertion times.[4] As ultrasound technology and training have improved, researchers have studied whether the benefits of ultrasound in central venous access would translate to peripheral intravenous line (PIV) placement.

Peripheral intravenous access is the most commonly performed procedure in the emergency department (ED), with 150-200 million PIVs placed annually in North America.[5,6] Unfortunately, diseases frequently encountered in the ED, such as diabetes, intravenous drug abuse, and sickle cell disease, are often associated with difficulty of PIV placement.[5,7] Studies have demonstrated that as many as 8-23% of ED patients meet criteria for difficult venous access.[5,8] Historically, these patients have frequently required "rescue" techniques, such as the placement of an external jugular line or CVC insertion when PIVs could not be obtained by landmark guidance. However, CVCs are associated with much more serious complications when compared to PIVs.[9,10] Complications associated with CVC placement include infections, hemothorax, pneumothorax, arterial puncture, and hematoma formation.[9] Several studies have found that the incorporation of ultrasound-guided PIV can reduce the need for CVC placement in up to 80% of patients.[11-14]

Multiple studies of ultrasound-guided versus landmark-based PIV insertion have demonstrated that the use of ultrasound improves placement success, with the most pronounced effects occurring in those with difficult access.[15-25] While many PIV placements may not necessitate ultrasound, a significant number of patients may benefit from this approach by either reducing the number of PIV attempts or preventing the need for CVC insertion. Therefore, it is important that all providers be comfortable with this application.

This paper provides a narrative review of the literature on all components of ultrasound-guided PIV placement from preparation to confirmation with a focus on best practices and techniques for improved performance with this procedure.

CRITICAL APPRAISAL OF THE LITERATURE

We performed a search of PubMed for articles published from inception to June 16, 2017. Keywords included "ultrasound," "peripheral line," "peripheral iv," "venous access," and "vascular access." Bibliographies of all relevant articles were reviewed for additional studies. The search yielded 2,620 articles, of which 65 articles were deemed to be relevant for inclusion in this review. When supporting data was not available, recommendations were made based upon the authors' combined experience and opinions.

PREPARATION

Prior to beginning the procedure, all appropriate supplies should be gathered and any relevant contraindications should be evaluated (e.g., hemodialysis fistula, history of ipsilateral mastectomy or lymph node dissection, etc.). Similar to blind PIV placement, it is beneficial to ask the patient which arm has had a higher rate of successful cannulation in the past. It is important to recognize that there are innate risks related to peripheral vascular access with or without the use of ultrasound. These include infection, bleeding, and damage to adjacent structures (e.g., arteries and nerves). In a study performed by Adhikari et al., there was no increase in infection rates in ultrasound-guided peripheral lines when compared to traditionally placed peripheral lines.[26]

Frazee et al. demonstrated that methicillin-resistant *Staphylococcus aureus* (MRSA) and other clinically-significant organisms were effectively eliminated from the transducer with the use of a quaternary ammonia-based germicidal wipe.[27] Although chemical disinfectants have been shown to decrease the spread of pathogens, several barrier methods including probe covers and adhesive films (e.g., 3M Tegaderm™) are frequently used to further decrease infection risk. Current data is limited on the efficacy of adhesive films for decreasing the risk of infection, and further studies are needed.[28] Caution should be used with the application of an adhesive barrier, as some manufacturers recommend against its use based upon concern that it may damage the ultrasound probe's protective membrane.

To perform the procedure, several supplies are needed. These include a tourniquet, alcohol pads, gauze, normal saline flushes, PIV tubing, PIV catheters, adhesive to secure the line after placement, and sterile ultrasound transmission gel (or alternate sterile gel that can transmit ultrasound waves). The ultrasound machine should be placed on the contralateral side of the bed so that it is in the direct line of sight for the provider. Given the potential for infection transmission, it is important to use sterile ultrasound gel or lubricant during placement.[29] If available, guidewire-based catheters can be used to increase success of catheter advancement after the vessel is cannulated.[30] When applying the tourniquet, it should be applied as close to the axilla as possible to increase the degree of venodilation present. Sometimes the addition of a second tourniquet or a blood pressure cuff inflated to 150 mm Hg may be needed to ensure sufficient venous distension.[31]

BEST PRACTICE RECOMMENDATIONS

1. Standard PIV placement and cleaning procedures should be followed. Sterile ultrasound gel should be used during placement.
2. There is limited evidence with respect to the benefit of probe covers and adhesive barriers. Manufacturer recommendations should be followed when using adhesive barriers.

VEIN CHARACTERISTICS

The first step in placing an ultrasound-guided PIV is to find an appropriate vein to cannulate. With ultrasound guidance, the vein should initially be evaluated by using the probe to apply gentle pressure directly over the vessel (Figure 1, Video 1). Because both arteries and veins will collapse if significant pressure is applied, it is important to apply a small amount of pressure first to assess for pulsatility. If a vein has been confirmed by the above techniques, the provider should then apply full pressure to ensure that no clot is present within the vessel lumen. Providers may also use either color flow or pulsed wave Doppler to verify that the vessel in question is a vein and not an artery (Figure 2, Video 2). Once confirmed, proximal augmentation may be performed to assess for proximal clots that may prevent successful use of the PIV line. To perform proximal augmentation, the provider or patient should squeeze the arm proximal to the proposed PIV insertion site and evaluate for backflow of blood through the vein using color flow Doppler. If the flow is compromised, a different vein should be selected for cannulation. It is important to note that no studies have formally evaluated whether this technique aids in PIV insertion.

The vein should also be measured with respect to both the diameter and depth from the skin surface. Studies have demonstrated that moderate-depth vessels (0.3-1.5 cm from the surface) are significantly easier to cannulate than vessels that are less than 0.3 cm or greater than 1.5 cm from the surface.[32,33] Additionally, Witting et al. demonstrated that vessels greater than 0.4 cm in diameter had a much higher success rate than those less than 0.4 cm in diameter.[33] While vessel diameter has

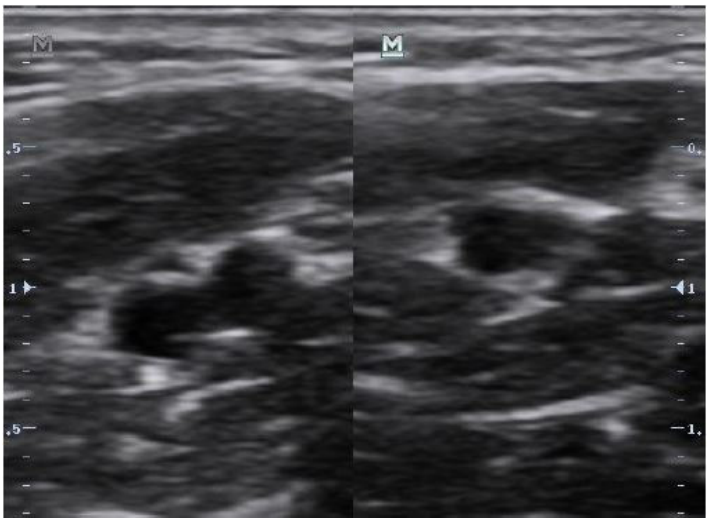

Figure 1. Differentiation of vein from artery using compression. The left image demonstrates both artery and vein. The right image demonstrates only an artery.

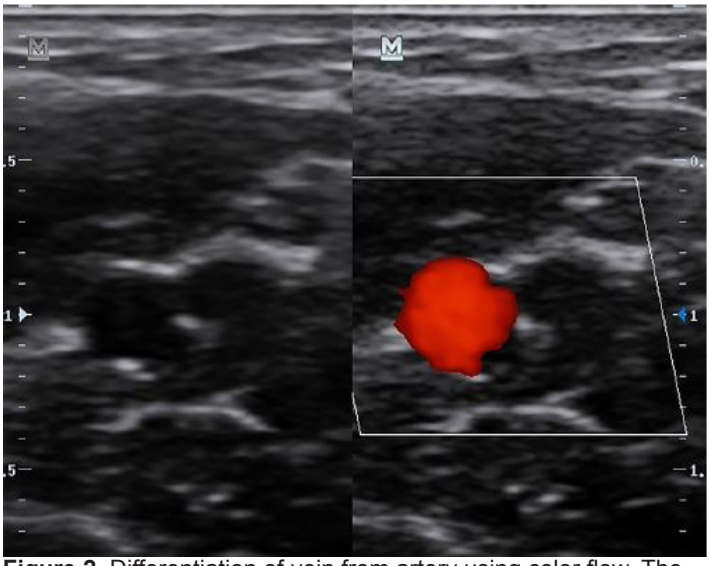

Figure 2. Differentiation of vein from artery using color flow. The right image demonstrates pulsations from the artery.

not been associated with length of PIV sustainability, vessels less than 1.2 cm from the surface have been correlated with significantly longer sustainability of the PIV.[34] These studies suggest that larger vessels closer to the surface will have the best chance of successful, continued access.

After measuring the diameter and depth of the vein, its course should then be traced with ultrasound to identify the path of the vessel in both short and long axis. Short axis will allow the vessel to be traced in order to identify the direction of the vein and ensure that it remains straight. Long axis will allow for assessment of the presence of valves in close proximity to where the catheter will be placed.[14] The vessel can be externally marked at the beginning and end of the anticipated catheterization path to assist in following the track of the vessel. However, external marking has not been shown to improve success rates.[35]

When choosing a catheter length, shorter catheters have been demonstrated to have a faster time to cannulation than longer catheters.[36] However, longer catheters have a lower risk of catheter failure.[36] Shorter catheters may not have a sufficient length within the actual vessel lumen, thus leading to easier catheter dislodgement and early failure of the PIV.[11] Longer catheters will allow a greater length of tubing to be within the vessel lumen, which should maintain the catheter within the vessel regardless of patient movement.

When determining which catheter length is necessary, one must consider the total distance that the catheter will travel to enter the vein, rather than just the distance from the vein to the skin surface. This distance is determined using the Pythagorean theorem. Assuming a depth of 1.0 cm with needle insertion at a 45-degree angle, so that the site of the vessel entry is 1.0 cm past the site of skin entry, the provider would actually need to travel 1.4 cm to reach the vein. Based upon existing PIV lengths, the provider should use a catheter that is 2.5 cm or longer to ensure that at least 1 cm of the catheter is securely within the vein.[11] The table provides a list of recommended catheter lengths based upon the distance from the skin surface to the vein. Of note, if the provider uses a shallower angle, a longer catheter length may be required. For example, if the same vein is 1.0 cm deep and a 30-degree angle is used, the distance to the vein will be 2.2 cm and a longer PIV would be required than in the first example.

There are several options for vein selection when placing an ultrasound-guided PIV. Often, providers use the basilic or deep brachial veins. The basilic vein offers the advantage of being more superficial and separated from the surrounding arteries and nerves. The deep brachial is almost universally present, but is much deeper and in close proximity to the artery and nerve. Consequently, when cannulating the deep brachial vessel, it is important to ensure that sufficient catheter is within the vein and advise patients to minimize arm movements after placement. One study demonstrated that the basilic vein was associated with an improved success rate compared with the deep brachial.[37] Another study found a significantly higher rate of extravasation in deep brachial veins than in other antecubital veins.[38] While the focus is often on upper-extremity veins, providers should also consider lower-extremity veins, such as the saphenous vein, which is relatively superficial and separated from surrounding nerves and arteries.[39]

Newer studies have suggested performing ultrasound-guided cannulation of the internal jugular vein using a peripheral intravenous catheter in patients with very limited access.[40-44]

Table. Recommended catheter lengths based upon depth of vein using a 45-degree insertion angle.

Depth of vein in cm	Horizontal distance from the vein for insertion in cm	Total distance to vein in cm	Recommended catheter length in cm (in)
0.5	0.5	0.7	1.9 (0.75)
1.0	1.0	1.4	2.5 (1.0)
1.5	1.5	2.1	3.12 (1.25)
2.0	2.0	2.8	4.4 (1.75)

While sterile technique (including sterile gloves and a probe cover) is recommended, the catheter is typically treated as a peripheral line after placement. This line has been suggested to be superior to central venous access due to speed of placement and lower risk of complications (e.g., needle injury, catheter malposition, etc.).[40-44] However, the peripheral internal jugular (PIJ) line also carries inherent risks. Given the proximity to central access, providers must be careful to avoid introducing an infection into the central bloodstream. Therefore, a bio-occlusive dressing should be used, and it is not recommended to perform wire exchange through the PIJ to convert it into a central line.[41] Similar to other PIV, infiltration is a risk with the PIJ and an appropriate catheter length should be chosen to reduce this risk.[41]

BEST PRACTICE RECOMMENDATIONS

1. Multiple techniques have been used to select a vein for cannulation. The authors recommend vessel compression as the primary technique with color flow Doppler, pulse wave Doppler, or proximal augmentation as supplemental techniques.
2. Veins should be selected that are 0.3-1.5 cm from the skin surface with a diameter greater than 0.4 cm.
3. Catheter length should be selected based upon anticipated distance to the vein to ensure that a sufficient portion of the catheter will remain in the vessel.
4. The deep brachial vein has a higher failure rate and should be avoided when more superficial veins are available.
5. There is limited evidence supporting the ultrasound-guided peripheral internal jugular vein line. Further studies are needed before routine use.

TECHNIQUE

The most common technique used for the placement of an ultrasound-guided PIV is the short-axis (e.g., transverse or out-of-plane) approach. In this view, the vein will be visualized in cross-section and the needle followed until it enters the vein. With this approach, it is essential that the transducer be advanced in sync with the needle tip, as both the needle tip and shaft may appear similar (Figure 3). While the short-axis approach has been suggested to be faster and easier than the long-axis approach (particularly among more novice sonographers), it may be associated with increased risk of injury to the posterior vessel wall.[45-47]

The second most common technique is the long-axis (e.g., in-plane) technique. With this approach, the entire length of the vessel and needle will be visualized (Figure 4). Prior to inserting the needle, one must ensure that the entire length of the vessel is visualized. In the long-axis view, veins may appear similar to arteries. Therefore, prior to needle insertion, one should confirm that the visualized vessel is a vein, using one of the aforementioned techniques. When advancing the needle, it is important that both the needle and vessel remain in the same plane. Because of this, it can be challenging for some sonographers to perform in real patients. The advantage

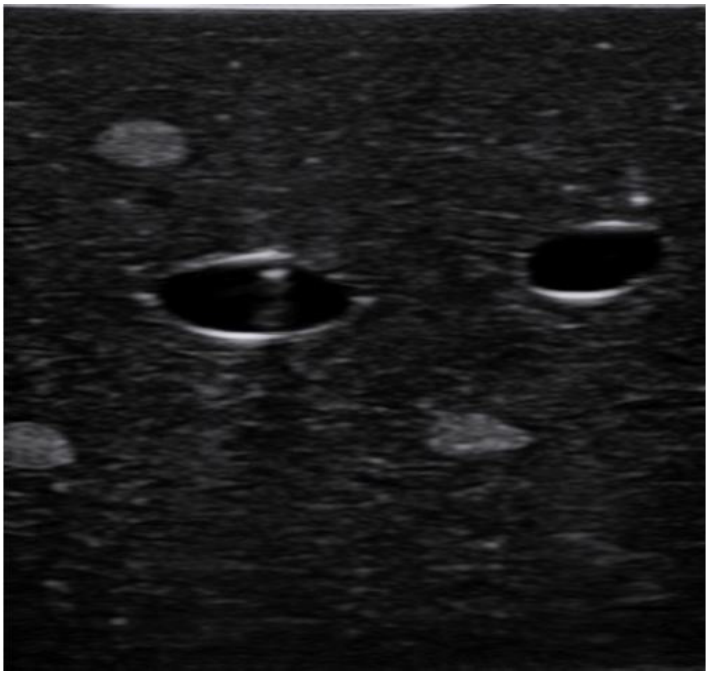

Figure 3A. Ultrasound image of needle shaft in short axis on a phantom model.

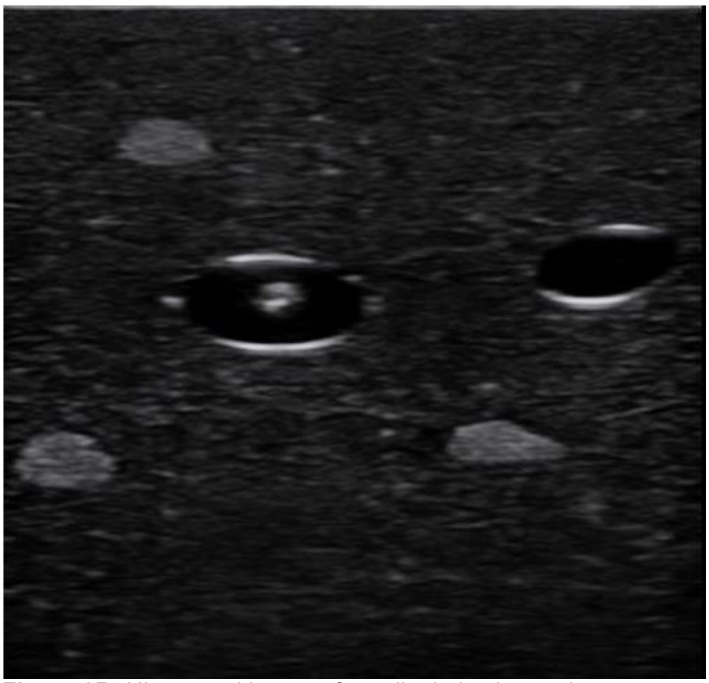

Figure 3B. Ultrasound image of needle tip in short axis on a phantom model. Note that the needle tip is slightly more echogenic than the needle shaft.

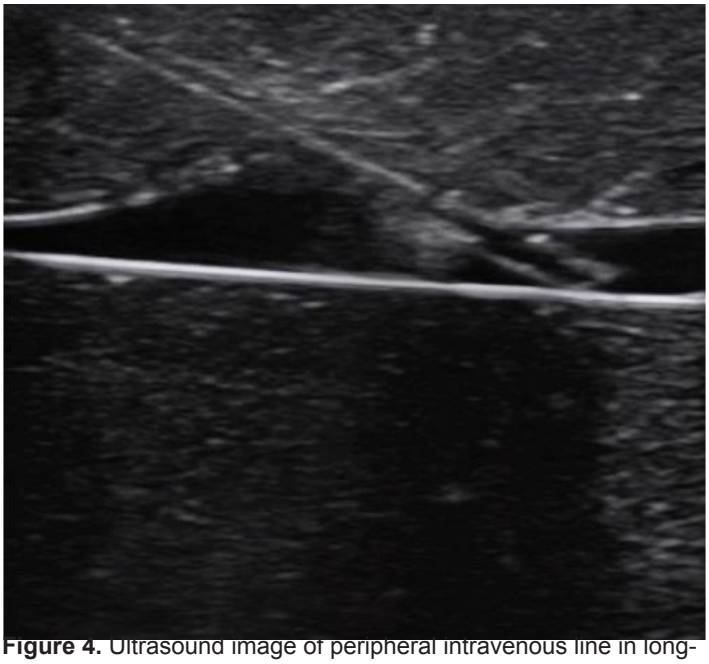

Figure 4. Ultrasound image of peripheral intravenous line in long-axis orientation on a phantom model.

of this technique is that the entire needle is visualized, thereby reducing the risk of posterior wall injury, while ensuring that sufficient length of catheter has entered the vein for successful advancement.

A newer technique derived from the central line literature is the oblique approach.[48-50] This is considered by some to be the best of both approaches.[48-50] This technique involves obtaining the short-axis view and then rotating the transducer 45 degrees into an oblique angle to increase the surface area (and, consequently, the visualization) of the needle. The user benefits from the ability to better visualize the location of the needle with respect to nearby structures, while also having improved needle visualization. Further studies are needed to assess this in PIV placement prior to routine use.

While novice sonographers often prefer the short-axis approach, the long-axis approach allows better needle tip visualization and less risk of posterior wall puncture.[45-47,51] Long axis is similarly favored in techniques such as nerve blocks, where accuracy of the needle tip carries similar importance.[52] To minimize damage to surrounding structures, the authors recommend identifying vessels in the short axis and then converting to long axis for needle insertion.

Regardless of which technique is used, it is important to avoid accidental compression of the vein during the placement attempt. As patients are often intravascularly depleted and veins are easily compressible, small amounts of pressure may compress or collapse the vein, making cannulation more difficult. This can be avoided by using the palm of the hand or an extended finger to apply pressure and stabilize the hand at a more distant location (Figure 5).

Another common challenge is advancement of the catheter in the short-axis approach. While providers can often obtain initial vessel access with the needle, subsequent threading of the catheter can pose problems. After entering the vessel, the provider should lower the angle of the needle and advance further, while keeping the needle tip in the center of the vessel on ultrasound (Figure 3B). This should be continued, alternating probe and catheter advancement while progressively lowering the angle of the catheter, until the entire length of the catheter is in the vessel and the catheter hub is abutting the skin (Video 3). Using this technique ensures that the maximal length of the catheter is safely inside the vessel, reducing the risk of catheter misplacement or dislodgement.[53]

An additional strategy is to use the Seldinger technique.[54-57] This technique is commonly used for central venous and arterial lines, though not commonly used for peripheral veins. Mahler et al. demonstrated high success rates using this modality in an ED setting.[56] In cases where a longer catheter with a guidewire is not available, Mills et al. describe a different technique by which initial access is obtained and then the PIV is replaced with a longer, more sustainable PIV, using a guidewire for catheter exchange.[57]

BEST PRACTICE RECOMMENDATIONS

1. The long-axis approach should be used, when possible, to reduce the risk of posterior vessel wall injury.
2. The authors recommend avoiding compression of the vein by applying pressure distally with the palm or fifth finger.

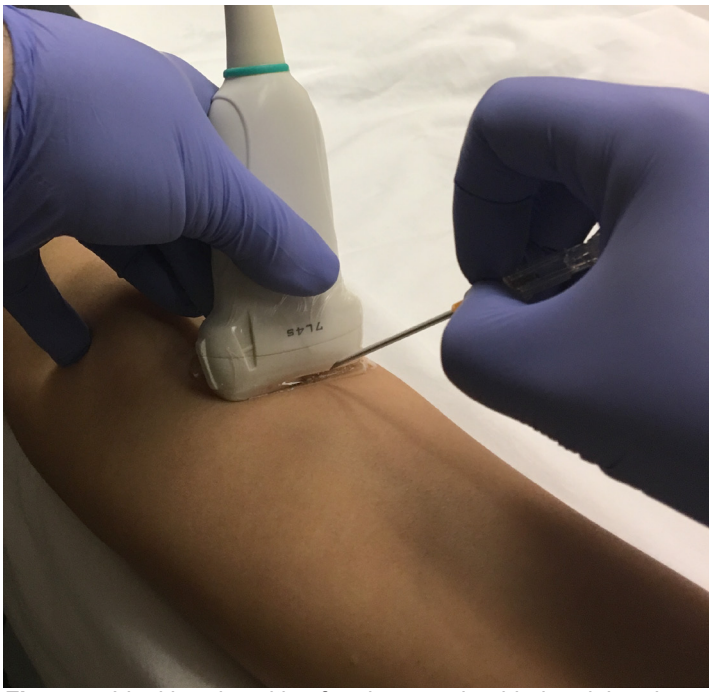

Figure 5. Ideal hand position for ultrasound-guided peripheral intravenous line placement.

3. The Seldinger technique may be used to facilitate placement.

CONFIRMATION

Once the PIV has been fully advanced, it is important to confirm placement. While many providers rely upon blood return and the ability to inject saline without palpable soft tissue swelling, ultrasound may be a valuable adjunct for confirming placement. One technique for confirming placement is to visualize the catheter in long axis, ensuring that the entire length of the catheter is within the vessel. This can be further assessed by infusing 5-10 mL of normal saline and visualizing the bubbles appearing within the vessel (e.g. "saline flush test") (Video 4).[58-61] Color flow can also be added to enhance visualization (Figure 6, Video 5).

BEST PRACTICE RECOMMENDATIONS

1. Placement may be confirmed by using the ultrasound to visualize the entire length of the catheter within the vessel.
2. Normal saline solution may be infused to further assess proper PIV placement.

CHALLENGES AND LIMITATIONS

As with most ultrasound procedures, there is operator variability in skill sets. Currently, there is no consensus on the number of observed placements required to determine competency, with studies ranging from 5 - 25 attempts.[14, 62-66] Witting et al. found that providers who had placed more than 20 ultrasound-guided PIV had higher success rates than those who had placed less than 20.[33] More data is needed to determine the number of ultrasound-guided PIVs to become competent in this modality.

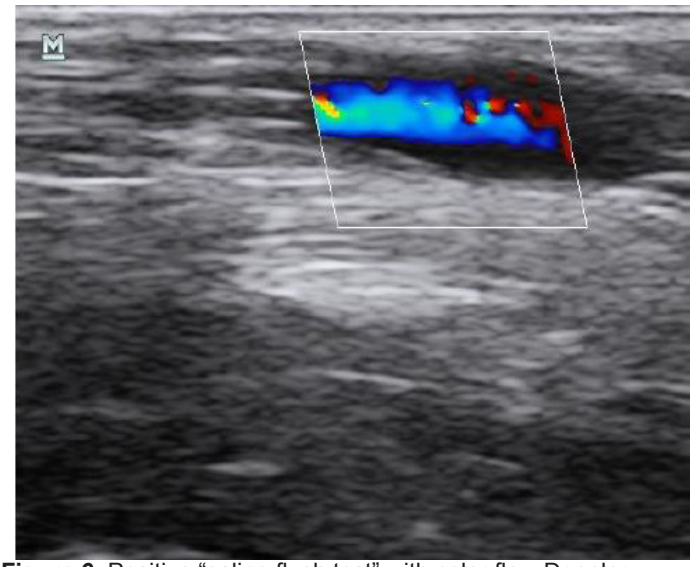

Figure 6. Positive "saline flush test" with color flow Doppler.

Additionally, similar to blind PIVs, if there is insufficient or minimal catheter within the vessel lumen, it may dislodge with arm movements, resulting in loss of venous access and extravasation of infused solution. This risk can be reduced by using longer PIVs and advancing the entire length of the PIV under ultrasound guidance, as discussed above. Finally, one should make sure to properly clean all involved areas and maintain sterility throughout the procedure. While studies have demonstrated no increased infection risks with the use of ultrasound, the addition of the ultrasound machine provides a further potential source for infection if not properly cleaned.

CONCLUSION

This paper provides a review of the existing data on ultrasound-guided PIV placement combined with suggestions to enhance successful placement and confirmation. After reading this paper, it is the authors' intention that the reader will have new strategies and troubleshooting techniques for his or her next ultrasound-guided PIV attempt.

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Video 1. Ultrasound video demonstrating vein compression.
Video 2. Ultrasound video demonstrating the use of color Doppler to differentiate a vein from an artery.
Video 3. Ultrasound video demonstrating needle advancement into a vein in an ultrasound phantom model.
Video 4. Ultrasound video demonstrating a positive saline flush test.
Video 5. Ultrasound video demonstrating a positive saline flush test with color Doppler.

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Characterizing New England Emergency Departments by Telemedicine Use

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Introduction: Telemedicine connects emergency departments (ED) with resources necessary for patient care; its use has not been characterized nationally, or even regionally. Our primary objective was to describe the prevalence of telemedicine use in New England EDs and the clinical applications of use. Secondarily, we aimed to determine if telemedicine use was associated with consultant availability and to identify ED characteristics associated with telemedicine use.

Methods: We analyzed data from the National Emergency Department Inventory-New England survey, which assessed basic ED characteristics in 2014. The survey queried directors of every ED (n=195) in the six New England states (excluding federal hospitals and college infirmaries). Descriptive statistics characterized ED telemedicine use; multivariable logistic regression identified independent predictors of use.

Results: Of the 169 responding EDs (87% response rate), 82 (49%) reported using telemedicine. Telemedicine EDs were more likely to be rural (18% of users vs. 7% of non-users, p=0.03); less likely to be academic (1% of users vs. 11% of non-users, p=0.01); and less likely to have 24/7 access to neurology (p<0.001), neurosurgery (p<0.001), orthopedics (p=0.01), plastic surgery (p=0.01), psychiatry (p<0.001), and hand surgery (p<0.001) consultants. Neuro/stroke (68%), pediatrics (11%), psychiatry (11%), and trauma (10%) were the most commonly reported applications. On multivariable analysis, telemedicine was more likely in rural EDs (odds ratio [OR] 4.39, 95% confidence interval [CI] 1.30-14.86), and less likely in EDs with 24/7 neurologist availability (OR 0.21, 95% CI [0.09-0.49]), and annual volume <20,000 (OR 0.24, 95% CI [0.08-0.68]).

Conclusion: Telemedicine is commonly used in New England EDs. In 2014, use was more common among rural EDs and EDs with limited neurology consultant availability. In contrast, telemedicine use was less common among very low-volume EDs. [West J Emerg Med. 2017;18(6)1055-1060.]

INTRODUCTION

Resource availability in U.S. emergency departments (EDs) varies substantially, particularly in rural areas with disparities in access[1] and in smaller EDs reporting decreased consultant availability.[2] Telemedicine (TM), the use of telecommunication for remote diagnosis or treatment, may be part of the solution to connect patients with the resources necessary for their care.[3] It is feasible and effective for clinical care in EDs,[4] may improve care coordination,[1] and its value has been well-established in emergency stroke care.[5]

The promise of TM has been underscored by the 21st Century Cures Act and the Expanding Capacity for Health Outcomes Act.[6,7] Yet the extent of TM adoption in U.S. EDs is not well known. As a first step, our primary objective was to describe the prevalence of TM use in New England EDs and the applications for which it is used. Secondarily, we aimed to identify independent predictors of ED TM use.

Population Health Research Capsule

What do we already know about this issue?
Telemedicine is a feasible and effective technology to use in EDs for remote diagnosis, treatment, and care coordination.

What was the research question?
What is the prevalence of telemedicine use in New England EDs and what are the applications for which it is used?

What was the major finding of the study?
About half of New England EDs report using telemedicine, most commonly for neuro/stroke, pediatrics, psychiatry, and trauma.

How does this improve population health?
Telemedicine may be a means to address disparities in access for patients in rural or underserved areas. These results begin to lay the groundwork for future research in emergency telemedicine.

METHODS

Study Design, Setting and Population

We conducted a survey of New England EDs as part of the National Emergency Department Inventory (NEDI). This institutional review board-approved study, called NEDI-NE, was coordinated by the Emergency Medicine Network.[8] We used the NEDI-USA 2012 database to obtain a comprehensive list of all EDs in New England (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont); the methods that underlie NEDI-USA have been reported.[9] Briefly, EDs are included if they are open 24/7 and available for use by the general public. This includes hospital-based EDs, and hospital-affiliated freestanding EDs. We excluded EDs at federal hospitals and college infirmaries.

Survey and Administration

We administered the survey (Appendix 1) in 2015, with modules to characterize the EDs in 2014 including basic characteristics, staffing, electronic resources, and timing of consultations. The survey content and wording were refined with feedback from colleagues, including the Massachusetts College of Emergency Physicians' Board of Directors, which includes both community and academic physicians. We mailed surveys to ED directors up to three times over a two-month period; a link to an online-version of the survey was included in each mailing. Follow-up to non-responsive sites, and those with partially completed surveys, was conducted through telephone calls and site visits. We entered and managed survey data using the REDCap electronic data capture tool.

Measurements

Our primary outcome was use of TM. For this study, we focused on the use of video consultation for patient evaluation, which excludes store-and-forward technology (e.g., teleradiology or dermatology). We determined TM use based on the survey item, "Does your ED obtain consultation via video conferencing equipment? (e.g., video transmission to outside experts for evaluation of an acute stroke patient in your ED)?" Respondents who selected "yes" received a free-text field to "specify" the type of consultation.

We also collected data regarding other key ED characteristics related to staffing, patient volume, bed size, and availability of specialists for consultation. We categorized EDs by annual volume (<20,000, 20,000-39,999, 40,000-59,999, and ≥60,000 visits per year). We classified EDs as urban or rural based on location in a core-based statistical area.[9] We defined academic EDs as any site affiliated with an emergency medicine residency program designated by the Society for Academic Emergency Medicine.[10]

Data Analysis

Descriptive statistics quantified ED TM use, and applications of its use are presented as proportions and medians (with interquartile ranges [IQR]). To better understand the relationship between TM use and multiple ED characteristics, we performed bivariate analyses using chi-square test, Fisher's exact test, and Wilcoxon rank-sum test, as appropriate. To identify independent predictors of TM use among New England EDs, we used multivariable logistic regression. Model covariates were specified

Table. New England emergency department characteristics by telemedicine use.

ED characteristics	Telemedicine non-users n=87	Telemedicine users n=82	p-value
Rural*†	6 (7)	15 (18)	0.03
Academic ED†	10 (11)	1 (1)	0.01
Freestanding ED†	2 (2)	3 (4)	0.60
Median annual total ED visits (IQR)	35,126 (17,500-59,112)	26,730 (14,925-40,000)	0.02
Annual total ED visits			0.03
<20,000	25 (29)	29 (35)	
20,000-39,999	22 (25)	31 (38)	
40,000-59,999	21 (24)	16 (20)	
≥60,000	19 (22)	6 (7)	
Median annual total ED visits by children (IQR)	3,600 (1,500-8,395)	3,425 (2,0005,000)	0.42
Median number of ED beds (IQR)	25 (13-39)	20 (9-29)	0.01
Percentage of uninsured/self-pay			0.25
<10%	30 (34)	35 (43)	
≥10%	46 (53)	33 (40)	
Unknown	11 (13)	14 (17)	
Number of critical care transfers			0.02
<250	64 (74)	43 (52)	
≥250	18 (21)	31 (38)	
Unknown	5 (6)	8 (10)	
Median number of full-time attending physicians (IQR)	11 (6-22)	9 (5-13)	0.04
24/7 Attending Physician on duty			1.00
No	5 (6)	5 (6)	
Yes	82 (94)	77 (94)	
24/7 Certified emergency nurse on duty			0.046
No	19 (23)	32 (40)	
Yes	52 (62)	36 (45)	
Don't know	13 (15)	12 (15)	
Specialist availability			
Anesthesiologist			
in-person	77 (89)	71 (87)	0.71
24/7	72 (83)	69 (84)	0.81
Cardiologist			
in-person	67 (77)	62 (76)	0.83
24/7	59 (68)	48 (59)	0.21
General surgeon			
in-person	79 (91)	77 (94)	0.45
24/7	76 (87)	65 (79)	0.16
Neurologist			
in-person	63 (72)	40 (49)	0.002
24/7	55 (63)	25 (30)	<0.001

ED, emergency department; *CBSA*, core-based statistical area; *IQR*, interquartile range; *24/7*, available 24 hours a day and 7 days a week. Data are no. (%) of EDs unless otherwise indicated. Percentages may not total to 100% due to rounding.
*Defined by location outside of a core-based statistical area.
†Acquired from 2013 NEDI-USA.

Table. Continued.

ED Characteristics	Telemedicine Non-Users n=87	Telemedicine Users n=82	p-value
Neurosurgeon			
in-person	39 (45)	16 (20)	<0.001
24/7	35 (40)	10 (12)	<0.001
Obstetrician/ gynecologist			
in-person	74 (85)	64 (78)	0.24
24/7	72 (83)	60 (73)	0.13
Orthopedist			
in-person	79 (91)	69 (84)	0.19
24/7	70 (80)	51 (62)	0.009
Pediatrician			
in-person	56 (64)	56 (68)	0.59
24/7	50 (57)	48 (59)	0.89
Plastic surgeon			
in-person	41 (47)	22 (27)	0.01
24/7	24 (28)	9 (11)	0.01
Psychiatrist			
in-person	54 (62)	35 (43)	0.01
24/7	40 (46)	16 (20)	<0.001
Hand Surgeon			
in-person	51 (59)	28 (34)	0.001
24/7	31 (36)	10 (12)	<0.001

24/7, available 24 hours a day and 7 days a week.

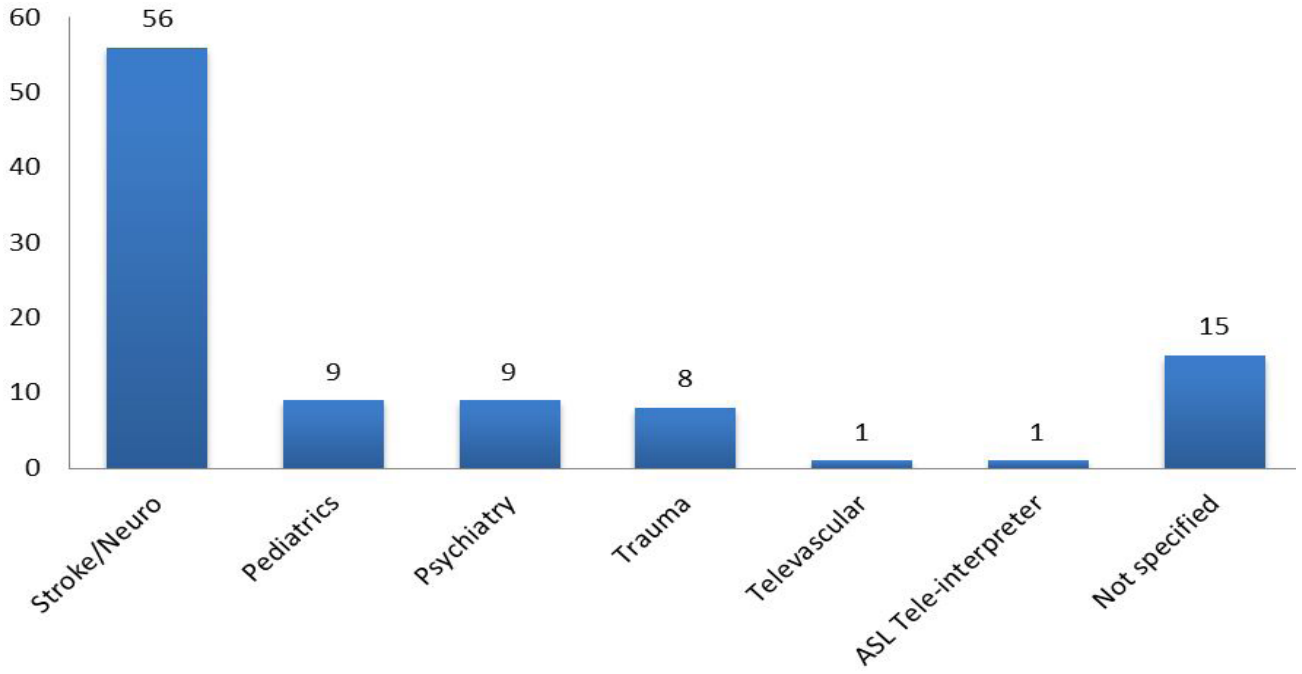

Figure. Free responses as reported by responding EDs converted to categorical variable. Type of telemedicine (TM) use reported by TM-using EDs, n=82.

a priori; given absence of literature on TM use in EDs, variables were selected based on our hypotheses and clinical experience. The final model adjusted for rural location, annual ED visit volume, percentage of uninsured/self-pay patients, number of critical care transfers, number of full-time attending physicians, and neurology consultant availability. Results are reported as odds ratios (ORs) with 95% confidence intervals (CI). We performed analyses with Stata 14.1 (Stata Corp, College Station, TX).

RESULTS

ED Responses and Characteristics

Of the 195 New England EDs surveyed, we received responses from 169 (87%). Responding and non-responding EDs were similar on several important variables (e.g., rural location, academic status, annual visit volume: Appendix 2). Among all responding EDs, 12% were rural and 7% academic (Table). The median number of ED visits in 2014 was 30,000 (IQR 16,000-51,000). The median number of ED beds was 22 (IQR 11-33).

Telemedicine Use in New England EDs

Of the 169 responding EDs, 82 (49%) reported using TM. The most commonly reported applications were stroke/neuro, pediatrics, psychiatry, and trauma (Figure). In bivariate analyses examining the association between TM use and ED characteristics (Table), TM-using EDs were more often rural and less often academic. TM-using EDs had a lower median annual ED volume, but did not vary by annual total children ED visits. TM-using EDs had fewer beds, reported fewer full-time attending physicians, and less frequently reported a 24/7 certified emergency nurse on duty, but there was no difference in the proportion of EDs with 24/7 attending physician coverage. Relative to EDs without TM, TM-using EDs had more critical care transfers during the study year.

TM-using EDs had less availability of consultants for some, but not all, specialties (Table). For example, 30% of TM-users reported 24/7 neurology availability, versus 63% of non-users. Compared to non-users, TM-users had less availability of neurologists, neurosurgeons, plastic surgeons, psychiatrists, hand-surgeons, and orthopedic surgeons.

Predictors of ED Telemedicine Use in Multivariable Model

In multivariable logistic regression modeling, rural EDs were more likely to use TM (OR 4.39 95% CI [1.30-14.86]), and EDs with 24/7 neurologist availability were less likely to use TM (OR 0.21, 95% CI [0.09-0.49]). Relative to EDs with an intermediate number of visits, smaller EDs (i.e., less than 20,000 annual visits) were less likely to use TM (OR 0.24, 95% CI [0.08-0.68]).

DISCUSSION

In this study, we found that nearly half of New England EDs use TM. The most commonly reported applications were stroke/neurology, pediatrics, psychiatry, and trauma. In multivariable modeling, ED TM use was associated with rural location, lack of 24/7 neurologist availability, and annual visit volume of 20,000 or more.

The relationship between annual ED volume and TM use warrants further consideration, and may be a consequence of the expense required for TM implementation. We do not believe that this finding was influenced by the association between rural location and TM use, as the relationship between volume and TM use did not significantly change when rural location was removed from the regression model (Appendix 3).

It is not surprising that stroke and pediatrics were two of the four most frequently reported applications, given substantial bodies of literature for the use of TM to improve acute stroke care delivery[5] and pediatric critical care.[11] TM has many other potential applications in EDs, for example, to augment care provided in EDs staffed by nurse practitioners and physician assistants, to reduce patient transfers, and even to maintain 24/7 ED staffing.[12-15] TM may also enable increased access to emergency psychiatry services[16] – an application of tremendous potential value to U.S. EDs that are strained by psychiatric emergencies and patient boarding.[17]

While the use of TM for particular applications in emergency medicine has been studied, we are not aware of any prior descriptions of the prevalence of TM use in U.S. EDs. This regional description is a valuable first step. Future work is needed to describe TM use in EDs nationally, to understand barriers and facilitators of TM implementation, to evaluate safety of TM, and to consider policy changes that may motivate adoption, in particular related to reimbursement for TM services.

LIMITATIONS

One potential limitation of this work is related to sampling. Of 195 New England EDs, 169 surveys were completed; this non-response could have influenced results. However, we believe the 87% response rate is sufficient to characterize TM use among New England EDs and do not have any reason to expect response bias with this particular question. Likewise, we do not have reason to believe that non-responders are systematically different in TM use than responders, as the primary focus of the survey was not on TM use, and we did not find differences between the groups in rural location or annual visit volume.

Secondly, this description of TM use in New England EDs may not be generalizable. New England has distinct characteristics that may influence our findings, such as closer distances between hospitals and fewer rural hospitals than some other U.S. regions; our definition of rural EDs may not accurately reflect distance from a referral hospital. Additionally, New England may have differences in the political and economic environment surrounding TM.

Another limitation is with respect to the outcome. We chose to focus on video conferencing for patient evaluation. Therefore, our findings are unlikely to reflect the more commoditized forms of TM applications such as

teleradiology. Finally, given the nature of our survey data we were unable to extract further information from EDs to characterize the nature of TM use or to explore explanatory models for our findings. Nevertheless, we believe these findings provide important preliminary results to inform future study of ED TM use.

CONCLUSION

Telemedicine is used in nearly half of New England EDs. It is more often used in EDs that are rural, EDs that do not have 24/7 neurologist availability, and EDs with annual volume of greater than or equal to 20,000 visits. TM may have value beyond its current applications in emergency medicine, such as for workforce and resource-related issues. As TM becomes more prominent in U.S. healthcare policy,[6,7] future research should characterize TM use in EDs nationally, as well as barriers and facilitators of its implementation.

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Heated Ultrasound Gel and Patient Satisfaction with Bedside Ultrasound Studies: The HUGS Trial

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Introduction: Our goal was to determine if heated gel for emergency department (ED) bedside ultrasonography improves patient satisfaction compared to room-temperature gel.

Methods: We randomized a convenience sample of ED patients determined by their treating physician to require a bedside ultrasound (US) study to either heated gel (102.0° F) or room-temperature gel (82.3° F). Investigators performed all US examinations. We informed all subjects that the study entailed investigation into various measures to improve patient satisfaction with ED US examinations but did not inform them of our specific focus on gel temperature. Investigators wore heat-resistant gloves while performing the examinations to blind themselves to the gel temperature. After completion of the US, subjects completed a survey including the primary outcome measure of patient satisfaction as measured on a 100-mm visual analogue scale (VAS). A secondary outcome was patient perceptions of sonographer professionalism measured by an ordinal scale (1-5).

Results: We enrolled 124 subjects; 120 completed all outcome measures. Of these, 59 underwent randomization to US studies with room-temperature gel and 61 underwent randomization to heated US gel. Patient 100-mm VAS satisfaction scores were 83.9 among patients undergoing studies with room-temperature gel versus 87.6 among subjects undergoing studies with heated gel (effect size 3.7, 95% confidence interval -1.3-8.6). There were similarly no differences between the two arms with regard to patient perceptions of sonographer professionalism.

Conclusion: The use of heated ultrasound gel appears to have no material impact on the satisfaction of ED patients undergoing bedside ultrasound studies. [West J Emerg Med. 2017;18(6)1061-1067.]

INTRODUCTION

Background

Patient satisfaction is an increasing outcome of interest for emergency department (ED) providers.[1-4] Hospital administrators increasingly scrutinize satisfaction scores and link results with physician reimbursement.[5] Moreover, there exists a correlation between ED visit satisfaction scores and the likelihood of patients filing complaints related to their care. In one study of over 2.4 million ED visits across eight different states, patients who responded in the lowest quartile

of satisfaction scores were twice as likely to file a complaint compared to the patients with satisfaction scores in the uppermost quartile.[6]

Bedside ultrasound (US) is a diagnostic tool rapidly increasing in use by ED providers.[7,8] In the hands of emergency physicians at the bedside, this modality has shown high sensitivity and specificity for the diagnosis of myriad common diseases encountered in the ED such as appendicitis,[9] cholecystitis,[10,11] and deep vein thrombosis.[12] There is further an association between the use of bedside ultrasonography and increased patient satisfaction scores.[13] However, to date there has been little research to elucidate those components of bedside ultrasonography with the strongest relationship to patient satisfaction.

US gel temperature represents one important component of bedside ultrasonography. Many US technicians routinely use heated US gel to enhance patient comfort. Several gel warmer class I medical devices exist, which may provide an effective and inexpensive mechanism to heat US gel for this purpose. However, our anecdotal experience is that many EDs do not routinely use these devices. To our knowledge, no studies exist that examine the impact of heated gel on satisfaction scores among patients undergoing US studies.

Population Health Research Capsule

What do we already know about this issue?
Bedside ultrasound is rapidly increasing in use by emergency department (ED) providers. Methods of performing these exams may impact patient satisfaction.

What was the research question?
How does heated versus room-temperature gel for ED bedside ultrasonography affect patients' satisfaction?

What was the major finding of the study?
ED ultrasonography gel temperature does not significantly impact patients' satisfaction with their ED visits.

How does this improve population health?
This negative result suggests that providers seeking to improve ED patient satisfaction should focus on alternative targets aside from ultrasound gel temperature.

Study Objectives

The primary objective of this investigation was to determine if heated gel for ED bedside ultrasonography improves patient satisfaction compared to room-temperature gel. The secondary objective was to determine the impact of heated US gel use on patient perceptions of ultrasonographer professionalism. We hypothesized that the use of heated gel during bedside US examinations would improve patient satisfaction scores and perceptions of provider professionalism.

METHODS

Study Design and Setting

We conducted a randomized controlled trial in the ED of an academic, urban, tertiary care hospital. The ED annual census is approximately 82,000 visits. The ED supports a three-year emergency medicine residency and fellowship programs in US and emergency medical services. Our institutional review board (IRB) approved the project. We registered the trial on ClinicalTrials.gov (NCT03135379), and documented subject participation in accordance with the CONSORT guidelines (Figure).[14]

Selection of Participants

We enrolled a convenience sample of adult ED patients. Inclusion criteria comprised patients determined by their treating provider to require a bedside US study delineated by the American College of Physicians as falling within the scope of practice for emergency physicians.[15] Exclusion criteria included age less than 18, age greater than 89, pregnancy, skin lesions precluding bedside US examination, or patients not fluent in English. We also excluded vulnerable patient populations, specifically patients with altered mental status, prisoners, and military basic trainees.

All subjects received an information sheet disclosing that they would participate in a study investigating alternative strategies to improve patient satisfaction related to US studies. While we could not blind subjects to gel temperature, we did not disclose to patients that the primary purpose of the study was to investigate the impact of US gel temperature on patient satisfaction. All subjects provided verbal consent for study participation. Our IRB approved this alteration of the consent process and waiver of documentation of informed consent as they determined the research was minimal risk to participants, did not adversely affect the rights of subjects, would not be practical without these provisions, and allowed for provision of pertinent information to participants when appropriate.[16]

Interventions

We randomized patients to either warm gel (102.0° F) or room-temperature gel for the bedside ultrasonography examinations. Prior to study start, investigators constructed a workstation in the ED with six standard gel-warming devices

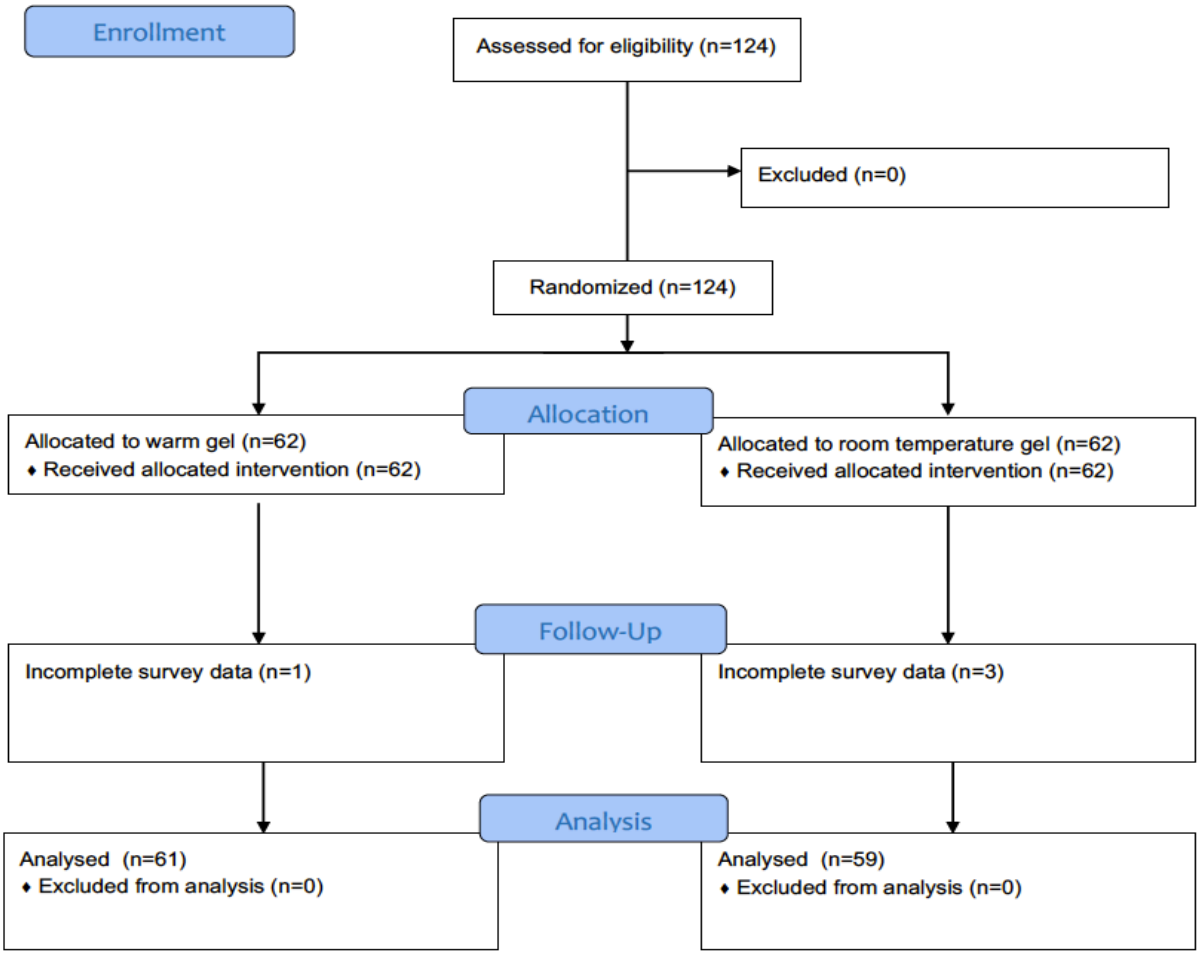

Figure. Consort 2010 Flow Chart. Patient trial participation in study examining patient satisfaction as related to temperature of ultrasound gel.

(Thermasonic® Gel Warmer, Parker Laboratories, Fairfield, NJ). We configured three of the six devices to heat the gel to 102.0° F. We turned the remaining three devices off, allowing the gel to remain at room temperature. We validated gel temperature through weekly quality assurance measurements throughout the study period. The mean of these temperature measurements for the heated ultrasound gel was 102.0° F, whereas that for the room temperature gel was 82.3° F. We obtained these measurements by a Suretemp® Plus 692 Thermometer (Welch Allyn Inc., Skaneateles Falls, NY). The ambient temperature maintained in our ED is 70.0° F. We assigned each of the six devices a unique identification number. The study packet for each participant included a card with the identification number of the gel warmer to which we allocated that particular subject. We used a simple randomization sequence to allocate subjects to each study arm.

Eight emergency medicine resident and US fellow investigators performed all ultrasonography examinations. They performed all US examinations using one of four identical Sonosite M-Turbo® ultrasound machines (Fujifilm Sonosite, Inc., Bothell, WA). Investigators would retrieve any of these four devices based on device availability for use during study procedures: there was no systematic allocation of devices according to study arm. We stored the US machines separately from the gel-warming devices.

We took several measures to blind investigators to the temperature of the gel used for each subject. First, we obscured the power indicator light on the gel-warming devices with non-transparent tape. In addition, the investigators wore a heat-resistant glove (ULine terry cloth glove, Pleasant Prairie, WI) during the entirety of the study procedures, starting with retrieval of the gel from the assigned warmer. During the US examinations, the investigators additionally wore a sterile non-latex glove (synthetic polyisoprene surgical gloves, Molnlycke Health Care Pty Ltd, Norcross, GA) over the heat-resistant glove for infection control purposes; at no time did the investigators remove the heat-resistant glove during the study procedures. These methods aimed to maintain

blinding even in the event that reapplication of gel during the US examination was necessary. The heat-resistant glove resists temperatures up to 250° Fahrenheit. We validated the efficacy of this glove for maintaining blinding to gel temperature prior to study start. Specifically, 10 volunteers not otherwise affiliated with the study donned the gloves while simulating bedside US procedures on a manikin model. We provided five of these volunteers warmed gel and five with room-temperature gel. None of the volunteers successfully identified the temperature of the gel.

Outcome Measurements

We measured study outcomes with hard-copy surveys upon conclusion of study procedures, which solicited patient demographics (age and gender). The survey administered to patients comprised three questions. The first was, "How satisfied are you with the experience of having a bedside ultrasound today?" The response to this first question comprised a 100-mm visual analogue scale (VAS) for satisfaction as used in previous studies.[17] This response comprised the primary outcome for the study. Responses to the remaining questions on the subject survey comprised secondary outcomes. These questions included, "Are you satisfied with the care you received today in the emergency department?" The response to this question was binary (yes or no). The final subject survey question read, "How professional was the provider who performed your bedside ultrasound?" The response to this final question comprised a Likert scale spanning 1 ("very unprofessional") to 5 ("very professional").

Upon completion of study procedures for each subject, we also administered a hard-copy survey to each investigator performing the study US examination. The purpose of this survey was to ascertain the effectiveness of our blinding methodology. Specifically, the survey question read, "What was the temperature of the ultrasound gel you used during the study?" Response options were "warm," "room temperature," or "I do not know."

Analysis

Our sample size estimate used an alpha of 0.05 and a beta of 0.2. Based on previous ED-based studies using a patient satisfaction VAS we powered our study to detect a minimally clinically significant difference of 11 mm.[18] We anticipated a standard deviation of 21 mm based on internal quality-improvement data. Our estimated required sample size to detect this effect size was 114 participants. With an additional estimated 10 subject withdrawals or dropouts, our total enrollment requirement was 124 participants.

We double-entered all hard-copy data forms into a secured Excel database (version 14, Microsoft, Redmond, WA). We then exported all data into SPSS (version 21, IBM, Armonk, NY) for statistical analysis. We excluded subjects with missing data for the primary outcome from all analyses. We compared our primary outcome of satisfaction VAS using a two-tailed independent samples student t-test. And we compared our secondary outcome of perceived professionalism with a Mann-Whitney U test. We planned comparison of our secondary outcome of overall satisfaction with ED care (binary variable) with a chi-squared test. Finally, we compared provider responses to the inquiry regarding whether the gel for each patient was room temperature, warmed, or uncertain using a chi-squared test.

RESULTS

Study Subject Characteristics

All 124 patients screened for enrollment were eligible for participation and verbally consented to the study. Half (62) of these subjects underwent allocation to room-temperature gel while the remaining subjects underwent allocation to heated gel. No patients withdrew from the study prior to completion. Survey data were incomplete for three subjects in the room-temperature arm and one subject in the heated-gel arm. This resulted in 59 subjects for analysis in the room-temperature arm and 61 subjects for analysis in the heated-gel arm (Figure).

Patient baseline characteristics including age and sex were comparable between the two groups (Table 1). Studies performed were diverse and included focused assessment with sonography in trauma and US studies of the kidneys, aorta, gallbladder, gastrointestinal tract (e.g., appendix, hernias), heart, eyes, skin, bones, and testicles.

Main Results

Mean patient 100-mm VAS satisfaction scores were 83.9 (standard deviation 15.5) among patients undergoing studies with room-temperature gel vs. 87.6 (standard deviation 10.5) among subjects undergoing studies with heated gel (effect size 3.7, 95% confidence interval -1.3-8.6, Table 2). All subjects in both arms reported satisfaction with regard to their ED visit. There were similarly no differences between the two groups with regard to the secondary outcome of perceived investigator professionalism.

Provider responses to the inquiry regarding whether the gel for each patient was room temperature, warmed, or uncertain indicated imperfect investigator blinding (Table 3). Investigators reported the correct gel temperature for 21 of 59 (36%) subjects undergoing US studies with room temperature gel. Investigators reported the correct gel temperature for 16 of 61 (26%) subjects undergoing US studies with warmed gel.

Table 1. Patient characteristics.

Variable	Room temperature (n=59)	Warmed (n=61)
Mean age, years (95% CI)	42.0 (37.2-47.1)	41.5 (37.2-45.9)
Male sex, % (95% CI)	46 (33-58)	69 (56-81)

CI, confidence interval.

Table 2. Outcomes of study examining impact of heated vs. room-temperature ultrasound gel on patient satisfaction.

Variable	Room temperature (n=59)	Warmed (n=61)	Effect size
Mean VAS satisfaction score (95% CI)	83.9 (79.4-87.6)	87.6 (84.8-90.1)	3.7 (-1.3-8.6)
Median professionalism score (IQR)	5 (5-5)	5 (5-5)	0 (0-0)

CI, confidence interval; *IQR*, interquartile range; *VAS*, visual analogue scale.

Table 3. Blinding efficacy.

	Actual gel temperature	
Investigator-reported gel temperature	Room temperature (n=59)*	Warmed (n=61)
Room temperature	21	1
Warmed	0	16
Unsure	37	44

*Data missing for one subject.

DISCUSSION

Use of bedside US imaging in the ED is on the rise.[7] Simultaneously, interest continues to grow in the emergency medicine literature with regard to investigations of interventions to improve patient satisfaction.[1-3] To our knowledge, ours is the first and only study to examine the impact of heated gel on patient satisfaction. Our results indicate that heated US gel has no material impact on the satisfaction of ED patients undergoing bedside US studies.

Our study provides high-quality evidence in support of this conclusion. Our randomized design should eliminate the impact of confounders on our results. While we did observe a trend toward slightly higher patient satisfaction with heated gel, the effect size did not reach the minimally clinically significant differences for patient satisfaction reported in the literature (7-11 mm).[18] Similarly, we observed no significant differences based on US gel temperature with regard to patient overall satisfaction with their ED visit, or patient perceptions of emergency physician professionalism.

These findings will likely be welcome to many ED administrators, given our anecdotal experience that few EDs use gel warmers. While gel warmer devices are relatively inexpensive, we surmise their limited use in ED settings largely relates to the dynamic nature of ED care. Whereas gel warmer devices generally require a power outlet and must generally remain in a static location, US machines in the ED are portable and frequently moved to various rooms throughout the department. Given the time demands placed upon the emergency physician, it is often impractical to return to a fixed location between examinations to retrieve warmed gel.

It is important to highlight that these results may not be generalizable outside of the ED setting. We expect the ED population to present with more acute illness, discomfort, and anxiety than patients in office-based practices. While our inclusion criteria required that patients not be so critically ill as to compromise their mental status to provide verbal consent, it is possible that their levels of pain and anxiety precluded them from focusing on the discomfort associated with the US gel temperature. Future studies repeating our study methodology in alternative patient populations may yield different results. It is also possible that future studies conducted with different internal climates resulting in different room temperature values would yield different results.

LIMITATIONS

Our study has several important limitations. First, the post-study procedures investigator survey responses suggested imperfect investigator blinding to the gel temperature. This occurred despite our efforts to maintain blinding by having investigators wear heat-resistant gloves during the entirety of the study procedures for each patient. The most likely reason for this finding is patient verbal or physical response following application of gel. Anecdotally, numerous patients flinched upon application of room-temperature gel to their skin. Conversely, other patients commented upon the pleasant sensation of the heated gel. Another possibility is that the decrease in gel viscosity following heating may potentially have allowed investigators to ascertain the temperature of the gel being used. However, given that all investigators were privy to the study hypothesis, this lack of blinding threatens a Type I error (false-positive study result), which we know did not occur given our negative study result.

Second, our study population is the product of convenience sampling. Consequently, our study may suffer from sampling bias. For example, investigators may have preferentially enrolled patients who appeared less

uncomfortable and more amenable to study participation. In so doing, we may have enrolled a study population likely to express satisfaction with study and ED procedures regardless of intervention, blunting our measured effect size for our primary outcome. Similarly, investigators may have preferentially enrolled patients with body compositions more amenable to ultrasonography. This form of sampling bias may have led to less overall discomfort associated with the US examinations among a relatively homogenous patient population.

A related limitation is the timing of survey completion. As investigators requested that subjects complete the survey immediately upon completion of the study procedures, patients may have felt compelled to offer more favorable survey responses given the temporal proximity to the US examination and physical presence of the investigator in the room. This approach to data collection could blunt any effect size measurements by leading to uniformly high satisfaction responses from subjects regardless of the intervention to which they were allocated. While more laborious and logistically challenging, future studies might avoid this potential problem by administering the surveys at the end of the ED stay without any study personnel present instead of right after completion of study procedures.

A fourth limitation is that we did not mandate a particular type of training scan for investigators to complete (e.g. gallbladder, ocular, etc.) Study type may be an important effect modifier for the impact of gel temperature on patient satisfaction given that some studies require more time or involve more sensitive areas of the body than others. A related limitation is our exclusion of pregnant women, many of whom undergo transvaginal US examinations in the ED for which gel temperature may have a greater impact on patient satisfaction. We also did not collect comprehensive data regarding patient characteristics (e.g., age, gender) or operator experience (e.g., years of post-graduate training, numbers of prior US studies). Future studies might consider repeating our study procedures with either larger patient numbers for stratified analyses or narrower inclusion/exclusion criteria and homogenous operators to ascertain whether gel temperature might be a more potent driver of patient satisfaction under various specific circumstances.

A fifth limitation is that our study only examined a single set of temperatures. Specifically, our quality assurance measurements found mean temperatures of 102.0° F for the warmed gel and 82.3° F for the room- temperature gel. It is possible that changes in these temperature values could result in different results than those found in our study. To the extent that there is a greater differential between the temperatures of warmed and non-warmed gel, we anticipate that gel temperature may have a greater impact on patient satisfaction.

Another important point is that our study outcome measure examines overall visit satisfaction. Consequently, we cannot speak to whether US gel temperature impacts satisfaction specifically with regards to ED US examinations. Our reasoning for instead focusing on overall visit satisfaction is that this represents a more definitive and terminal outcome. One might argue that should heated US gel increase patient satisfaction with ED US studies but not overall ED visit satisfaction that there is limited justification for implementing this intervention. Nevertheless, future studies might consider examining the impact of US gel temperature on the more proximal and immediate outcome of satisfaction with US examination.

A final limitation is a lack of reporting on several additional outcome measures of potential interest to emergency physicians. In particular, such outcome measures would include sonographer time at bedside and patient ED length of stay. Future investigations in this area should consider incorporation of these additional outcomes.

All these limitations notwithstanding, our results suggest that investment in ED gel-warming devices should be low priority. On the other hand, given that the expense is likely to have a minimal impact on overall operating budget, if future studies were to identify a beneficial effect of heated gel on patient satisfaction ED administrators should have a low threshold for obtaining these machines as they would likely have relatively low cost-to-benefit ratios.[19]

CONCLUSION

Although there is a trend towards increased patient satisfaction with heated ultrasound gel, the effect size appears to be insignificant. Researchers might consider focusing future investigations on more specific settings and ultrasound study types for which gel temperature is more likely to impact patient comfort and hence satisfaction. In the interim, emergency physicians looking to improve patient satisfaction are likely to have more success focusing on more traditional targets, such as decreasing patient wait times rather than using gel-warming devices.

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The Impact of an Emergency Department Front-End Redesign on Patient-Reported Satisfaction Survey Results

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Introduction: For emergency department (ED) patients, delays in care are associated with decreased satisfaction. Our department focused on implementing a front-end vertical patient flow model aimed to decrease delays in care, especially care initiation. The physical space for this new model was termed the Flexible Care Area (FCA). The purpose of this study was to quantify the impact of this intervention on patient satisfaction.

Methods: We conducted a retrospective study of patients discharged from our academic ED over a one-year period (7/1/2013-6/30/2014). Of the 34,083 patients discharged during that period, 14,075 were sent a Press-Ganey survey and 2,358 (16.8%) returned the survey. We subsequently compared these survey responses with clinical information available through our electronic health record (EHR). Responses from the Press-Ganey surveys were dichotomized as being "Very Good" (VG, the highest rating) or "Other" (for all other ratings). Data abstracted from the EHR included demographic information (age, gender) and operational information (e.g. – emergency severity index, length of stay, whether care was delivered entirely in the FCA, utilization of labs or radiology testing, or administration of opioid pain medications). We used Fisher's exact test to calculate statistical differences in proportions, while the Mantel-Haenszel method was used to report odds ratios.

Results: Of the returned surveys, 62% rated overall care for the visit as VG. However, fewer patients reported their care as VG if they were seen in FCA (53.4% versus 63.2%, p=0.027). Patients seen in FCA were less likely to have advanced imaging performed (12% versus 23.8%, p=0.001) or labs drawn (24.8% vs. 59.1%, p=0.001). Length of stay (FCA mean 159 ±103.5 minutes versus non-FCA 223 ±117 minutes) and acuity were lower for FCA patients than non-FCA patients (p=0.001). There was no statistically significant difference between patient-reported ratings of physicians or nurses when comparing patients seen in FCA vs. those not seen in FCA.

Conclusion: Patients seen through the FCA reported a lower overall rating of care compared to patients not seen in the FCA. This occurred despite a shorter overall length of stay for these patients, suggesting that other factors have a meaningful impact on patient satisfaction.[West J Emerg Med. 2017;18(6)1068-1074.]

INTRODUCTION

Emergency department (ED) volumes in the United States continue to grow, leading to crowding, delays in care, and increased wait times.[1] To address this growing crisis, EDs have used innovative methods, including initiatives such as physician triage, observation units, and fast-track areas.[2] A number of departments have used a model in the ED that focuses on "vertical patient flow," in which patients can be evaluated, managed, and rendered a disposition in the setting of the waiting room and without occupying a traditional ED bed.[3] Outside of the ED, other targets have included downstream processes such as facilitating hospital discharges and smoothing elective surgical scheduling.

At our ED, a Level I adult and pediatric trauma and burn center with an emergency medicine residency program, we have implemented a front-end redesign, which focuses on vertical patient flow as a means to minimize delays in care, particularly care initiation.

The physical space for this new flow paradigm was a sectioned-off part of the waiting room called the "Flexible Care Area" (FCA) and consisted of three rooms with an adjoining work area for the care team. This was staffed by an emergency physician, a nurse, and an emergency medical technician. The guiding principle for the staff in this area was to ensure a safe waiting room (i.e., briefly evaluate each patient to ensure no time-sensitive conditions were being missed), while also addressing bottlenecks in the diagnostic process; for example, laboratory tests, imaging tests, and even specialist consultation can be ordered from this area. Additionally, lower-acuity patients without the need for diagnostic tests or consultation, or whose diagnostic tests could be resulted rapidly, could have their entire episode of care completed by the FCA staff.

The explicit prioritization for this flow model, however, was to first address higher-acuity patients and expedite their workup prior to tackling the needs of lower-acuity patients. The team staffing the FCA was responsible for identifying patients who would benefit from evaluation and treatment in the FCA, diverting these patients from the waiting room to initiate their care. Previously, we have shown that using this flow model decreases overall length of stay (LOS) for all ED patients with emergency severity index (ESI) levels 3 and 4.[3] These data are in line with national trends showing that front-end changes, such as fast track and vertical flow, have decreased delays in care.[2,4]

In an ever-evolving patient-centered ED model, however, it is not enough to measure improvements simply by time-related metrics. The Centers for Medicare and Medicaid Services use patient satisfaction as a key marker of value. Since LOS and time to initiation of care are fundamental determinants of patient satisfaction with ED care,[5] we hypothesized that implementation of our FCA would lead to greater patient satisfaction for those seen in the FCA. Therefore, the purpose of this study was to quantify the impact of our FCA model on patient satisfaction by comparing the Press-Ganey scores of discharged patients seen entirely in FCA vs. those cared for primarily in the main ED, even if their care was begun in the FCA. Secondarily, we aimed to demonstrate the impact of individual components of care, including diagnostic and therapeutic interventions, on overall patient satisfaction.

Population Health Research Capsule

What do we already know about this issue?
ED length of stay (LOS) is viewed as a key driver of patient satisfaction. Interventions aimed at decreasing LOS theoretically improve satisfaction.

What was the research question?
Can an ED redesign that embraces vertical patient flow decrease LOS and increase satisfaction?

What was the major finding of the study?
Though vertical patient flow decreases ED LOS, it was not observed to impact patient satisfaction.

How does this improve population health?
Future studies of drivers of ED patient satisfaction should investigate factors beyond time metrics, possibly more focused on the physician-patient interaction.

METHODS

Study Design and Setting

This was a retrospective study of patients discharged from our ED from 7/1/2013 to 6/30/2014. The study was conducted at an academic, tertiary-care hospital with approximately 50,000 ED patient visits annually during the study period. This study was HIPAA-compliant and deemed exempt from review by our institutional review board.

Selection of Participants

We included in this study discharged patients who were seen in our ED during the study period and returned a Press-Ganey survey. Per hospital protocol, Press-Ganey surveys are sent one week after an ED visit to a representative sample of patients (every third adult patient and every other pediatric patient) discharged from the ED. Patient selection for survey participation was not part of this study.

Methods and Measurements

We reviewed the EHRs of included patients, including clinical documentation and bed tracking, to ascertain whether their entire episode of care occurred in the FCA (termed "FCA patients" for the purposes of this study). All other patients were considered "non-FCA" patients, including the cohort of patients who had their care initiated in the FCA area, but were subsequently transitioned to complete their care in the main ED. The FCA was open 4pm-12am

daily and though many patients had their care initiated in this setting, less than 10% had it completed there.

The primary data abstractor was a research assistant who was trained on a standardized data abstraction protocol by the principal investigator (PI). After abstracting 25 charts together, the PI also re-abstracted data from another 100 charts to verify data integrity. No significant discrepancies were identified during this process. Abstracted data included age, imaging tests performed, opioid pain medication received, laboratory tests ordered, whether the patient had all care rendered in the FCA area, ED LOS, time to being placed in a room, time from being placed in a room to seeing a physician, and ESI score. We tabulated all data in a Microsoft Excel 2013 spreadsheet (Microsoft Corporation, Redmond, WA).

Outcome Measures

We used Press-Ganey patient satisfaction surveys to evaluate patient's perceptions of care. Responses on survey items were reported on a five-point scale (Very Poor, Poor, Fair, Good, Very Good) but for the purpose of our primary analysis were dichotomized into "Very Good" (VG) and "Other," where "Other" represented all other possible ratings. The rationale for the dichotomization was that our institution, as well as many others, only use the top rating percentage when assessing system and provider performance. Our primary outcome was the response to the survey item related to "Overall rating of care received during your visit." Ratings were also abstracted for responses related to perceived quality of physician and nursing care. These questions included the following: "Courtesy of the doctors who cared for you;" "Degree to which these doctors took the time to listen to you;" "Concern these doctors showed to keep you informed about your treatment;" and "Concern these doctors showed for your comfort while treating you." A similar set of questions was asked about perceived quality of nursing care. As with the overall rating of care, we dichotimized the answers to these questions based on whether the response was VG or anything else.

Data Analysis

Our primary analysis was comparing the percentage of FCA patients who rated their overall care as VG vs. the percentage of all other patients who rated their care as VG, though we do also report the mean score for FCA vs. non-FCA patients by simply converting the survey responses to an ordinal scale (1-5). Secondarily, we performed univariate and multivariate regression analysis for each of the seven variables abstracted in chart review to ascertain the correlation between each variable and reporting of care as VG (reported as odds ratios [OR]). We also calculated the percentage of patients who rated their physician and nurse as VG in several domains; we again performed a regression analysis and report the OR for rating their overall care as VG based on each survey item in this set. We did not include missing survey responses in data analysis. We used Fisher's exact test to calculate statistical differences in proportions, while the Mantel-Haenszel method was used to calculate OR during regression analyses. We conducted statistical analysis using Statistical Analysis System (SAS) version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Study Population

During the study period, 50,358 patients were seen in our ED. Of these, 34,083 were discharged, 14,075 of whom were sent a Press-Ganey survey to complete. A total of 2,358 patients (16.8%) completed and returned the survey, which comprises our study sample. Of these, 133 patients (5.6%) had their entire episode of care conducted in the FCA only. Assuming an estimated 10 patients completed their care in FCA daily, then data from approximately 3.65% (133/3,650) of FCA patients are included in this analysis. The mean age of patients who returned a Press-Ganey survey was 47.9 (standard deviation 23.8) years. Table 1 displays characteristics of all patients in the study cohort and compares the characteristics of patients who rated their overall care as VG vs. those who did not.

Table 1. Characteristics of study patients who responded to Press-Ganey survey Results are reported for all patients as well as the subgroup who reported their overall care as "Very Good," or "Other," which included "Very Poor," "Poor," "Fair," and "Good." For each variable, the mean and standard deviations are reported.

Variable	Very good (n= 1437)	Other (n=877)	p-value	Overall
Age (years), SD	49.4 ±23.7	45.3 ±22.5	<0.001	47 ±23.8
Length of stay (minutes), SD	206.9 ±107.4	246.3 ±130.5	<0.001	222.6 ±118
Time to room (minutes), SD	7.8 ±21.2	19.0 ±35.40	<0.001	12.2 ±28
Time from room to first physician (minutes), SD	12.5 ±13.9	16.9 ±19.5	<0.001	14.3 ±16.4
Acuity (ESI score)			0.001	
1	0.1%	0.0%		0.04%
2	19.3%	12.9%		16%
3	61.5%	66.4%		61.2%
4	18.6%	19.3%		18.1%
5	0.6%	1.3%		0.8%

ESI, emergency severity index; *SD*, standard deviation.

Main Results

Across all patients in the study, 62.6% (1,388/2,218) rated their overall care for the visit as VG. Of FCA patients, 53.4% (71/133) reported their care as VG, compared with 63.2% (1,317/2,085) of discharged patients cared for in the main ED (p=0.027). The mean survey rating for patients seen in FCA was 4.26 (95% confidence interval [CI] [4.09-4.43]) while it was 4.41 (95% CI [4.37-4.45]) for non-FCA patients; the p-value for difference in scores was non-significant (p=0.09).

Secondary Analyses

Comparison of FCA Vs. Other Patients

We profiled the patients based on whether their entire care episode took place in the FCA vs. those who were seen primarily in the main ED, even if their care was begun in the FCA (Table 2). A smaller proportion of patients seen exclusively in the FCA had advanced imaging performed (12% versus 23.8%, p=0.001). This result was also seen in laboratory tests done (24.8% versus 59.1%, p=0.001). LOS (159.0 ±103.5 min versus 223.0 ±117.0 min, p=0.001) and acuity (median ESI 4 versus ESI 3, p=0.001) were lower for FCA patients than non-FCA patients. Patient age and time from being placed in a room to seeing a physician were not statistically different for these groups. Of note, time from being registered to being placed in a room was statistically higher for FCA patients compared to non-FCA patients (23.1 versus 10 minutes, p=0.001).

Effects of Physician and Nursing Care on Patient Satisfaction Score

There was no difference in physician and nurse ratings comparing those patients seen in FCA vs. those not seen in FCA. However, patients who reported physician care as VG were more likely to rate their overall care in the ED as VG, with OR ranging 21.8-23.5 (Table 3). Nursing care, however, had minimal or no impact on overall satisfaction, with OR ranging 1.11-1.23. Thus, while we found no statistical difference in survey results for questions concerning physician and nursing care between FCA and non-FCA patients, we did find a highly significant increased odds of overall patient satisfaction if respondents had a high opinion of physician care, but not of nursing care.

Univariate Logistic Regression

Patients were less likely to rate their overall care as VG if they were seen exclusively in the FCA (OR 0.67, 95% CI [0.47-0.95]). They were also less likely to rate their overall care as VG if they had opioid pain medicines administered (OR 0.73, 95% CI [0.6-0.9]). Further, the percentage of patients reporting their care as VG was not affected by having imaging tests performed (either radiograph or advanced imaging), having laboratory tests performed, or being signed out to another team (p-values ranging 0.08 to 0.86). See Table 4 for a complete listing of OR.

Multivariate Logistic Regression

When modeling the effect of all individual elements extracted from EHR review, being cared for in the FCA (OR 0.57, 95% CI [0.39-0.83], p=0.004) and increasing age (OR 0.99, 95% CI [0.986-0.993], p<0.001) were the two parameters associated with decreased overall patient satisfaction with care. Shorter LOS was statistically positively, but practically very weakly, associated with satisfaction (OR 1.004, 95% CI [1.003-1.005], p<0.001). All other variables did not affect patient satisfaction to a statistically significant level.

Table 2. Comparison of characteristics for patients seen in the Flexible Care Area (FCA) vs. non-FCA. The percentage of patients who had one of four different interventions are reported here as is the overall emergency department (ED) length of stay; time from ED arrival to being placed in a room; time from being placed in a room to seeing a physician; age; and triage acuity score.

Variable	FCA (n=133)	Non-FCA (n=2125)	p-value
Patient received a radiograph	48.1%	56.0%	0.08
Patient received an advanced imaging study	12.0%	23.8%	0.001
Patient received any opioid pain medication	18.8%	22.9%	0.33
Patient had laboratory testing performed	24.8%	59.1%	0.001
Length of stay (minutes)	159.0 ±103.5	223.0 ±117.0	0.001
Time to room (minutes)	23.1 ±33.7	10.0 ±24.9	0.001
Time from room to first physician (minutes)	11.9 ±9.1	14.1 ±15.7	0.65
Age (years)	48.5 ±18.4	47.6 ±27.3	0.68
Acuity (ESI score)			0.001
1	0.0%	0.1%	
2	2.3%	17.9%	
3	40.0%	64.7%	
4	53.9%	16.7%	
5	3.9%	0.7%	

ESI, emergency severity index.

Table 3. Ratings of physician and nurse care. Percentage of patients who rated their physician and nurse care as "Very Good" are shown for patients seen in the Flexible Care Area (FCA) vs. those not seen in the FCA. The reported p-value tests the difference between FCA and non-FCA patients reporting "Very Good" to each question. The last two columns report the odds (and confidence interval) of rating overall care as "Very Good" when the patient also reported "Very Good" for each statement.

Individual questions regarding provider care	FCA	Non-FCA	p-value	OR	95% CI
Doctors kept me informed about treatment	64.9%	62.1%	0.57	21.8	17.5-27.3
Doctors were courteous to me	66.2%	70.1%	0.38	22.03	17.4-27.8
Doctors took the time to listen to me	63.6%	65.9%	0.64	22.4	17.9-28.1
Doctors were concerned about my privacy	62.1%	63.5%	0.78	23.5	18.8-29.4
Nurses kept me informed about treatment	58.9%	65.7%	0.12	1.16	0.97-1.39
Nurses were courteous to me	67.7%	74.9%	0.08	1.23	1.02-1.5
Nurses took the time to listen to me	67.4%	71.2%	0.36	1.11	0.92-1.34
Nurses were concerned about my privacy	61.7%	70.1%	0.05	1.18	0.98-1.42
Nurses were attentive	64.3%	69.8%	0.2	1.14	0.95-1.37

CI, confidence interval; *OR*, odds ratio.

DISCUSSION

Responses on patient satisfaction surveys have been identified as a key marker of value in the patient care experience. In this retrospective evaluation of patient satisfaction with overall care in the ED, we found that operationalizing a vertical patient flow model, which we termed and housed in the Flexible Care Area, did not yield an improvement in the percentage of patients who rated their overall care as "Very Good." However, we were able to demonstrate that the primary objective of this new patient care paradigm was achieved: overall LOS was, in fact, shorter for patients seen in the FCA (159.0 ±103.5 min versus 223.0 ±117.0 min). It seems that while improving time-related metrics may decrease overall ED crowding, this may not equate to an improved patient experience.

Focusing on LOS alone as the primary driver of patient satisfaction appears to have missed the mark and is an oversimplification of what drives patients' needs from an ED visit. Though it is a relatively easy measure to trend, further study into the drivers of patient experience will surely show that many other factors are as important. For example, a significant, unexpected result through secondary analysis of the survey data suggests that while patient satisfaction with physician care is highly correlated with overall care rating, patient satisfaction with nursing care had minimal or no effect on overall patient satisfaction.

To uncover possible differences in measurable components of care for patients seen solely in FCA compared with all others, we assessed a number of interventions for the two groups. Though we did observe a difference in the number of interventions performed for FCA versus non-FCA patients, we found no difference in the odds of reporting satisfaction with overall care as VG if patients had these interventions performed. The one exception to this finding was if a patient received opioid pain medicines (whether in FCA or not) – almost paradoxically, those who did were less likely to report their care as VG, a finding that has been reported previously.[6] This may be confounded by the fact that FCA patients were both less likely to receive these pain medicines and less likely to report their overall care as VG. Informal querying of nursing staff in the FCA suggests the reason for decreased use of opioid pain medicines was two-fold. First, patients did not remain in the physical FCA area for the entirety of their stay – in the spirit of embracing the vertical patient flow philosophy, they were asked to return to the waiting room and therefore were not as likely to have their pain level assessed. Additionally, FCA nursing staff was reticent to administer opioid pain medicine in the FCA because of concerns of these patients later being unmonitored in the waiting room.

Prior studies have compared overall patient satisfaction after implementation of a fast-track area, demonstrating that overall satisfaction increases.[7] However, our FCA is different than a traditional fast-track system; prioritization was given to first address higher-acuity patients and expedite their workup prior to tackling the needs of lower-acuity patients, who are the usual target of fast-track systems. Despite this broader mission to decrease time to care initiation, our results demonstrated a different finding than that previously reported with fast tracks: patients seen in the FCA rated their overall care less favorably. This was in spite of overall LOS being shorter for those patients seen exclusively in FCA. Though such patients had lower ESI scores than the general ED population, they likely had to wait longer than traditional fast-track patients since higher-acuity patients, destined for the main ED, were prioritized to have their care initiated in the FCA before the lower acuity, fast track-type, patients. Additionally, those general ED patients who were initially seen in FCA benefited from decreased care delays afforded by FCA, but were not included in the FCA group for analysis purposes in this paper. These two departures from usual fast track-type systems may help to explain the difference in findings.

One of the factors that may negatively impact patient satisfaction is the inherent nature of a vertical patient flow setting like our FCA; many patients are not given their own private room for the duration of their stay. FCA patients are frequently brought to and from FCA rooms, and asked to return to the waiting room while their diagnostic studies are pending. These patients, once

Table 4. Odds ratios for various interventions. Odds of reporting overall care as "Very Good" when evaluated for each individual potential determinant of perceived care. Laboratory testing included any test (blood, urine, etc) that was sent to the hospital laboratory.

Variable	OR	95% CI
Patient signed out to another team	0.8	0.62-1.04
Had an X-ray performed	0.98	0.83-1.16
Had a CT or MRI performed	0.91	0.75-1.12
Received opioid pain medicines	0.73	0.6-0.9
Received intravenous opioid pain medicines	0.81	0.65-1.02
Had laboratory testing performed	1.01	0.86-1.2
Seen in the FCA only	0.67	0.47-0.95

CI, confidence interval; *CT*, computed tomography; *FCA*, flexible care area; *MRI*, magnetic resonance imaging; *OR*, odds ratio.

returned to the waiting room to await test results, are not given many of the amenities that a patient in a regular ED room is given while waiting, including private TVs and access to a nursing call button to help address immediate needs. Our findings are similar to previous studies, which have demonstrated that ED hallway-bed usage is associated with lower ED satisfaction and lower satisfaction with the overall hospitalization.[8] Similarly, because patients are not seen and treated in the traditional manner, many patients seen in FCA may have the perception that they are not receiving the same care as a patient seen in a traditional room.

It is important to note that patients' perceptions of care provided by the physician was not different when comparing the FCA group and non-FCA group. This is not surprising given that emergency physicians who staff the FCA are the same physicians who work in the main ED. Yet, there seems to be a disconnect between patients' perceived medical care and actual care. Several studies have shown that increased wait times and time to see a doctor can lead to adverse outcomes, including prolonged time to antibiotics in severe pneumonia[9] and time to thrombolytics in acute myocardial ischemia.[10] Studies have shown that patients seen in a fast-track setting are under-evaluated and undertreated for pain,[11] though we demonstrated no statistically significant difference in the percentage of patients receiving opioid pain medications in FCA versus the main ED. However, patients who received opioid pain medication were less likely to report their overall care as VG with an OR of 0.73 (95% CI [0.6-0.9]).

LIMITATIONS

This study has several limitations. First, this is a single-center, retrospective study of a relatively small patient population at an academic medical center, which limits the study's power and generalizability. (For example, compared with community hospitals, academic medical centers generally have longer baseline LOS; and the FCA was only open for eight hours a day [4pm-midnight]). The fact that it was retrospective, however, limits the potential for the Hawthorne effect and other forms of information bias. Second, only cursory demographic information was used to control for confounding in this study. It may be that there was a greater proportion of patients seen in FCA with chronic complaints, or complaints that result in an overall lower patient satisfaction score, no matter the setting in which they are seen. However, the same providers who staffed the FCA also staffed the main ED, which should limit confounding by provider type. Though we considered using each provider as his/her control as another potential confounder, it would be nearly impossible to disentangle the effect of a resident from that of the attending or if the care spanned more than one shift/physician team.

Also, patients who benefited from the FCA's early initiation of care but completed their care in the main ED would have been categorized as "non-FCA" by our study definitions. This fact likely diminished the observed impact of FCA on patient satisfaction. However, we also noted that throughput demands at times caused even some ESI level 2 patients (2.3% of the total cohort) to have their care completed in the FCA. Though the overall impact of FCA on LOS and patient satisfaction scores for those not seen in FCA was not part of this study, we previously reported that the implementation of the FCA did lead to decreased LOS for those patients.[3]

Further, use of Press-Ganey scores is dependent on the response rate, and patients in FCA who rated their overall care as VG may have responded to the survey at a lower rate than those patients seen in the main ED. The overall response rate was also low for a survey study, though in line with previously reported Press-Ganey response rates,[12] which limits our ability to make valid conclusions regarding respondents' opinions. However, given the penetrance of the Press-Ganey survey into the hospital patient-satisfaction industry, and despite its low overall response rate, we felt that its use for this study was acceptable.

CONCLUSION

Patients who had their entire episode of care conducted through our ED's front-end vertical patient flow redesign area reported a lower rating of overall care when compared to all other patients, despite a shorter overall length of stay. Clearly, factors beyond length of stay have a meaningful impact on patient satisfaction and must be taken into consideration as EDs work to balance throughput with patient satisfaction. As hospitals continue to optimize ED throughput,[13] it will be important to also evaluate how these unmet patient expectations contribute to patient satisfaction. Policymakers should also take note that patient experience can be negatively impacted by interventions aimed only at throughput metrics.

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Understanding the Intention-to-treat Principle in Randomized Controlled Trials

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Clinicians, institutions, and policy makers use results from randomized controlled trials to make decisions regarding therapeutic interventions for their patients and populations. Knowing the effect the intervention has on patients in clinical trials is critical for making both individual patient as well as population-based decisions. However, patients in clinical trials do not always adhere to the protocol. Excluding patients from the analysis who violated the research protocol (did not get their intended treatment) can have significant implications that impact the results and analysis of a study.

Intention-to-treat analysis is a method for analyzing results in a prospective randomized study where all participants who are randomized are included in the statistical analysis and analyzed according to the group they were originally assigned, regardless of what treatment (if any) they received. This method allows the investigator (or consumer of the medical literature) to draw accurate (unbiased) conclusions regarding the effectiveness of an intervention. This method preserves the benefits of randomization, which cannot be assumed when using other methods of analysis.

The risk of bias is increased whenever treatment groups are not analyzed according to the group to which they were originally assigned. If an intervention is truly effective (truth), an intention-to-treat analysis will provide an unbiased estimate of the efficacy of the intervention at the level of adherence in the study. This article will review the "intention-to-treat" principle and its converse, "per-protocol" analysis, and illustrate how using the wrong method of analysis can lead to a significantly biased assessment of the effectiveness of an intervention. [West J Emerg Med. 2017;18(6)1075-1078.]

The most effective way to establish a causal relationship between an intervention and outcome is through a randomized controlled trial (RCT) study design.[1-3] Randomization affords an unbiased comparison between groups as it controls for both known and unknown confounding variables. If done correctly, randomization yields groups that are balanced with regard to prognostic variables (variables that have an impact or an influence on developing the outcome under study). If two (or more) groups are prognostically balanced, with the exception of the intervention, and an investigator observes a difference in outcomes, a sound argument can be made attributing the difference in result to the intervention under study.

Although recognized as the "gold standard" study design for establishing a causal relationship between intervention and outcome, the process of randomization alone does not wholly guard against bias. Incorrect analysis of the data can introduce bias even in the setting of the correct implementation of a valid random allocation sequence. It is therefore important to preserve the integrity of randomization during the implementation of the study and in analysis. One such way investigators and consumers of the medical literature may arrive at an incorrect and biased assessment of results is by failing to evaluate patients according to the group to which they were originally assigned.

Anything that disrupts the prognostic balance afforded by randomization introduces bias into the study and analysis. Therefore, the goal of the investigator is to preserve this prognostic balance throughout the entire study, including the analysis phase after all data and outcomes have been recorded. The concept of analyzing patients according to which group they were originally assigned is called intention-to-treat analysis (or the intention-to-treat principle).[4,5] In this article, the author

presents and reviews a hypothetical example to illustrate how failure to apply this concept when interpreting results from a randomized trial can lead to misleading conclusions.

Example illustrating importance of intention-to-treat principle in an RCT

Imagine an investigator wants to evaluate whether adding a surgery to conventional medical therapy (medical management + surgery = intervention) is effective for preventing death (outcome) in patients with cardiovascular disease (Figure). Two hundred patients are enrolled in an RCT, 100 of whom are allocated to each arm. In this example, group A receives the intervention (medical management + surgery) and group B serves as the active control (medical management only). All outcomes are evaluated after 12 months.

In this example, there is a six-week waiting period between randomization and surgery. In group A, 30 total patients have died (the primary outcome of the trial) at the 12-month follow-up. Of these 30 patients, 15 died within three weeks after enrollment and the remaining 15 died between six weeks and 12 months. The patients in group B have a similar outcome: 30 total patients have died at the 12-month follow-up. Of these 30, 15 died within three weeks after enrollment and the remaining 15 died between six weeks and 12 months (Figure).

Let's also assume that the surgical intervention has no effectiveness, no impact on the primary outcome (death), and we will call this "truth." Investigators conduct randomized trials to discover the "truth" as to whether or not an intervention is effective. Our unbiased assessment of the study results (our search for truth) will depend on how we analyze the data. If analyzed correctly, we should come to the conclusion that the surgical intervention is ineffective, and if analyzed incorrectly, we will arrive at a spurious, biased conclusion that the surgery is effective.

PER-PROTOCOL ANALYSIS

We will begin our analysis according to who actually received the intervention assigned by the protocol. This method of analyzing the data is called per-protocol analysis, also referred to as efficacy, explanatory analysis, or analysis by treatment administered.[4] For the intervention group (A), 85 patients actually received the intervention, as 15 patients died before they had the opportunity to undergo surgery. The risk of death according to this method of analysis is 0.18 or 18% (15/85). For the control group (B), the risk of death is 0.3 or 30% (30/100) (Figure).

The risk of death in the intervention group (A) compared to the risk of death in the control group (B) is called the relative risk (RR). This is calculated by taking the ratio of the two risks, in this case 0.18/0.3. Doing the math yields a relative risk of 0.59 or 59%. The relative risk reduction of death can be calculated by subtracting the relative risk from 1 (when RR is expressed as a proportion). In this example, that would yield 0.41, or 41% (1 – 0.59).

So analyzing the data according to a per-protocol analysis would lead an investigator (or consumer of the medical literature) to spuriously conclude that the intervention (medical management + surgery) reduces the risk of death by 41% when compared to conventional therapy (medical management) alone. However, as discussed before, we know that surgery in this example has absolutely no effect on the outcome (truth). This method of analysis would result in a gross misinterpretation and inaccurate (biased) assessment of the effectiveness of the intervention.

Even more alarming would be the application of this inaccurate interpretation to clinical practice, where patients would be subject to an intervention with no benefit but with associated risks. A distinct but related type of analysis where patients are analyzed according to the treatment they actually received (regardless of their originally assigned group) also introduces bias into the analysis of a randomized study by disrupting the prognostic balance created by randomization. This method of evaluating patients according to which treatment they actually received is called as-treated analysis.[3] In this method, if a patient in the control group received surgery (regardless of the reason), they would be analyzed in the intervention group, and vice versa. Both per-protocol and as-treated analyses increase the risk of bias when evaluating the results of a RCT. Fortunately, for investigators and consumers of the medical literature, there is a method to analyze data from a randomized trial that will not lead to this type of spurious conclusion. This method is called intention-to-treat analysis.

INTENTION-TO-TREAT ANALYSIS

Intention-to-treat analysis analyzes the patients according to the groups to which they were originally assigned. A process that has once been described as "once randomized, always analyzed" reminds us to always analyze patients according to their original group assignment. This method of analysis preserves the prognostic balance afforded by randomization. In this example, the risk of death for the intervention group (A) is 0.3 or 30% (30/100). Using this method of analysis, the 15 patients who died (the primary outcome of the study) before they were to get the intervention are included in the calculation. For the control group (B), the risk of death is 0.3 or 30% (30/100).

The relative risk for death in patients receiving the intervention compared to the control group is 1 (0.3/0.3). And the relative risk reduction is 0 (1-1). So analyzing the data according to the intention-to-treat principle correctly concludes that the surgical intervention does not work. Some would argue, "Is it fair to include the 15 patients who died before receiving the intervention (medical management + surgery)?" Yes. Removing patients from either arm of the study disturbs the prognostic balance afforded by randomization. Although with few exceptions, excluding patients from a randomized trial will increase the risk of bias in a study.[6,7] Theoretically, the only way patients can be lost from a study and not increase the risk of bias

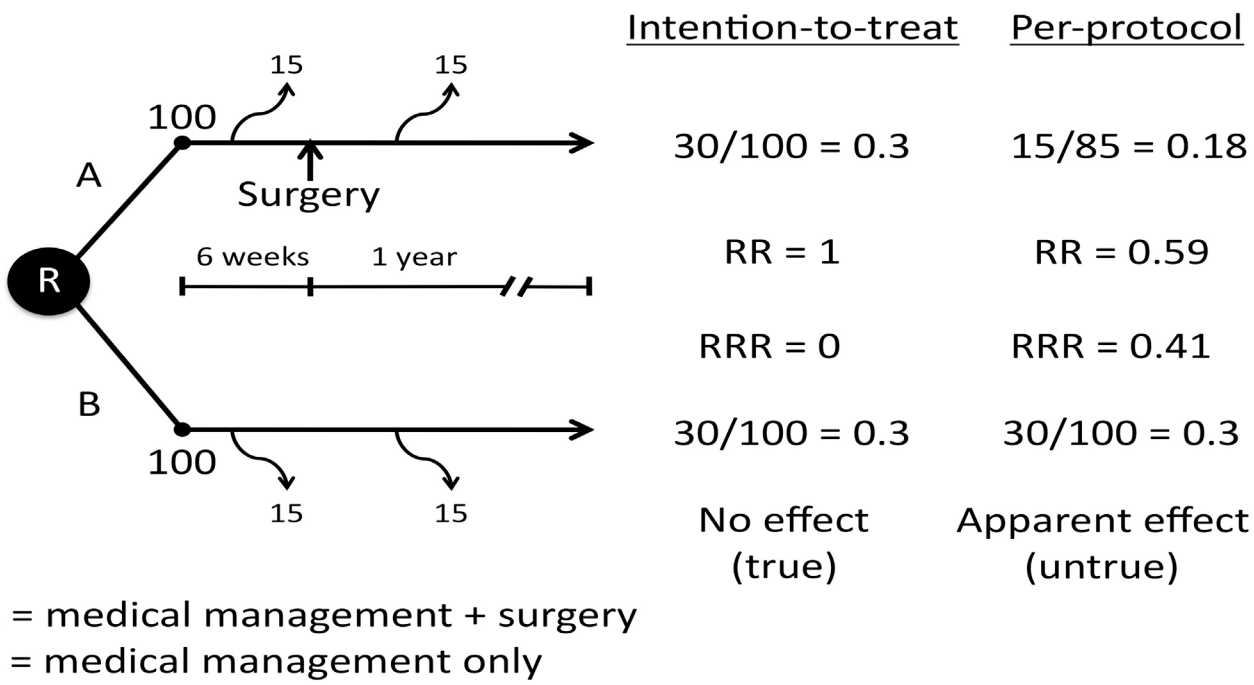

Figure. Hypothetical prospective randomized controlled trial evaluating effectiveness of intervention (A = medical management + surgery) vs. control (B = medical management only) in patients with cardiovascular disease.
R, randomization; *RR*, relative risk; *RRR*, relative risk reduction.

is if the patients who are lost are prognostically identical to the patients who remain.

However, research has shown that patients who do not adhere to the treatment assigned differ in ways more than just their adherence. Empirical evidence suggest that participants who adhere tend to do better than those who do not adhere, regardless of assignment to active treatment or placebo and even after adjustment for all known prognostic factors.[4,8,9] In a prospective placebo controlled trial evaluating the effectiveness of a lipid-lowering agent to reduce mortality in men suffering a myocardial infarction, the investigators observed a significant increase in mortality in nonadherent patients when compared to adherent patients, regardless of whether they received the intervention drug or placebo.[8] A meta-analysis evaluating the relationship between adherence to drug therapy and mortality concluded that adherence to drug therapy is associated with positive health outcomes.[9] The authors also report that the observed association between good adherence to placebo and decreased mortality supports the existence of the "healthy adherer" effect, whereby adherence to drug therapy may be a surrogate marker for overall health behavior.[9] The intention-to-treat analysis preserves the prognostic balance afforded by randomization, thereby minimizing any risk of bias that may be introduced by comparing groups that differ in prognostic variables.

Applying the intention-to-treat principles yields an unbiased estimate of the efficacy of the intervention on the primary study outcome at the level of adherence observed in the trial. So in the instance when the treatment under study is effective, but there is substantial nonadherence, the intention-to-treat analysis will underestimate the magnitude of the treatment effect that will occur in adherent patients. Although an underestimate of an effective therapy, it will be unbiased. This method of analysis results in a more accurate, unbiased estimate than that yielded from a per-protocol or as-treated type of analysis.

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Sex as a Biological Variable in Emergency Medicine Research and Clinical Practice: A Brief Narrative Review

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The National Institutes of Health recently highlighted the significant role of sex as a biological variable (SABV) in research design, outcome and reproducibility, mandating that this variable be accounted for in all its funded research studies. This move has resulted in a rapidly increasing body of literature on SABV with important implications for changing the clinical practice of emergency medicine (EM). Translation of this new knowledge to the bedside requires an understanding of how sex-based research will ultimately impact patient care. We use three case-based scenarios in acute myocardial infarction, acute ischemic stroke and important considerations in pharmacologic therapy administration to highlight available data on SABV in evidence-based research to provide the EM community with an important foundation for future integration of patient sex in the delivery of emergency care as gaps in research are filled. [West J Emerg Med. 2017;18(6)1079-1090.]

INTRODUCTION

Integration of potential sex effects into biomedical research is now a requirement. The U.S. National Institutes of Health (NIH) implemented a policy [NOT-OD-15-102] expecting research design, analysis and reporting to account for the role of sex as a biological variable (SABV) in vertebrate and human studies.

In anticipation of this, emergency medicine (EM) researchers developed consensus on a sex and gender specific agenda that would guide research in emergency care for the next decade. The proceedings demonstrated the expanding influence that sex (sex chromosomes XX or XY) and gender (psychosocial identity) have on disease presentation, performance of diagnostic testing, treatment responses and outcomes.[1] Additionally, provider behavior, healthcare utilization and disparities in delivery of medical care were also demonstrated to have effects linked to patient sex and gender.[1,2]

As the field of EM continues to align itself with national research priorities, new data continues to surface supporting significant differences of SABV in patient presentation, diagnostic workup, treatment and outcomes. This is a narrative review on the effect of SABV on three commonly seen EM conditions: acute myocardial infarction (AMI), acute ischemic stroke (AIS) and general administration of pharmacologic preparations. These examples are provided to briefly introduce the EM clinician and researcher to a sampling of the available SABV data, as well as to highlight the many gaps in knowledge that will need to be filled by future research endeavors in SABV in emergency care. Additionally, we discuss the cognitive steps required to bridge the gap between discovering the ever-increasing evidence that will result as SABV continues to be incorporated into EM research and the understanding of how to use this data to impact the clinical care of patients.

Due to the evolving terminology that now exists within the continuum of sex and gender, we have provided current definitions as an Appendix. Further discussion of the social construct of gender as well as the health-related issues of transgender patients are beyond the scope of this manuscript.

Cognitive Integration of Sex as A Biological Variable (SABV) by the Practicing Emergency Provider

Emergency physicians (EP) will need to learn how to incorporate evidence where SABV may affect clinical manifestation of disease as well as diagnostic and treatment decisions. Table 1 summarizes the cognitive steps EPs can use to assist the integration of this evidence depending upon the patient's sex. The most important first step toward integration and clinical care is to accurately identify each patient's biological sex. This may require clarification by the patient, as it does not always follow stereotypical norms, and the chromosomal sex (XX vs. XY) may be distinct from gender identity.

After performing the appropriate focused physical exam and assessment, it is important to recognize how the patient's sex may affect the clinical manifestation and presentation of the current illness. Routinely asking yourself, "How would the presentation, diagnostic workup or management of this patient change if they were the opposite sex?" is an important cognitive step in acknowledging this new science and aids in training ourselves to think differently.

When considering diagnostic workup, consider the potential limitations that may exist depending on patient sex. For instance, women are more likely to have non-obstructive cardiovascular disease compared to men.[3] Many of the diagnostic tools used to detect cardiovascular disease in the emergent setting have been based upon detection of macrovascular / obstructive coronary artery disease (CAD). This will leave microvascular / non-obstructive disease or a non-plaque mediated cause of ischemia often undetectable. These limitations should be understood and discussed with the patient.

As research that includes SABV continues, more sex-specific thresholds for biomarkers and laboratory value references will become increasingly available. For instance, sex-specific thresholds now exist for troponin.[4] Sex-specific laboratory value reference ranges are available for hemoglobin/hematocrit, calcium, creatinine, cholesterol and uric acid. The patient's biological sex, gender, and gender identity will need to be considered when interpreting these references ranges regarding sex-specific norms. Knowledge and accurate utilization of these ranges will increasingly become important.

Pharmacokinetics and pharmacodynamics are now known to be significantly different between women and men and have been demonstrated for many drugs including zolpidem,[5] propofol,[6] and rocuronium.[7] Additionally, indications for initiating medications can also differ by sex.[8] It is crucial that EPs are aware of these differences and remain open to new data as it is published to minimize risk and optimize benefits in the use of medications in the emergency setting.

To aid the emergency care provider in consuming newly released data, as well as achieving the aims of integration of SABV into clinical practice, an effective literature-search strategy is critical. The Texas Tech University Health Sciences Center Sex and Gender Specific Health PubMed Search Tool may help facilitate SABV-based literature assessment as well as clinical decision-making.[9]

ACUTE MYOCARDIAL INFARCTION

Case: A 40-year-old female with obesity, hypertension and one-pack-a-day smoking history was brought to the emergency department (ED) by ambulance for substernal chest discomfort at rest. Electrocardiogram (ECG) showed normal sinus rhythm with new T-wave inversions in I and AVL. Troponin came back at 0.10 (normal <0.05). Your diagnosis is non-ST elevation myocardial infarction (NSTEMI).

AMI is more common in men at a young age. However, young women with AMI are two times more likely than men to die during the hospitalization.[22] This sex-specific mortality disadvantage persists for women 30 days post discharge, and up to five years after the MI.[23] Some attribute this disparity to higher prevalence of comorbidities in women with AMI while others

Table 1. Cognitive steps to integrate SABV* into clinical practice with associated examples from current literature.

Cognitive Step	Examples
1.Identify patient sex	Male or Female
2. Understand sex differences in clinical manifestation of disease	Females more likely to have coronary microvascular disease than men[3]
3. Recognize potential limitations in diagnostic testing	Variable prognosis of exercise treadmill test in man versus woman[10]
4. Use any sex-specific thresholds for biomarkers or laboratory value references	Troponin,[11] Hemoglobin/Hematocrit, Calcium, Creatinine, Cholesterol and Uric Acid
5. When available, dose medications based upon sex-specific evidence	Sex-based dosing of analgesia,[12-15] antiemetics,[16] sedation medications,[17-19] neuromuscular blockade,[17,12] vasopressors or inotropes,[12,20], anticoagulants for treatment of myocardial infarction[21]
6. Use Sex and Gender Specific Health PubMed Search Tool	www.sexandgenderhealth.org

point to less aggressive management of women.[24,25] However, neither entirely explains the higher mortality seen in women – a cohort typically protected by estrogen. When MI occurs despite this protection, it is due to different disease pathology, anatomical differences or variable mechanisms of atherosclerosis.[26-28]

Table 2 outlines some of the sex differences in the pathophysiology of ischemic syndromes. One in eight women with AMI have a pathophysiology other than the classic thrombo-embolic mechanism that underlies typical AMI.[27] Women are also more likely to have single vessel disease (resulting in higher rates of false-negative stress tests).[29] Even in the presence of an abnormal stress test or positive troponin, women are less likely to have >50% obstruction of the coronary artery, a *sine qua non* of heart disease.[3,26] Ischemia in absence of CAD is most commonly attributed to coronary microvascular dysfunction (CMD). It refers to a group of mechanisms causing endothelial dysfunction of the small vessels (arterioles and prearterioles) that limit the ability of myocardium to increase blood flow in response to stress (coronary flow reserve) resulting in ischemic chest pain.

CMD is five times more common in women and presents a diagnostic challenge as routine testing for obstructive CAD is not sensitive in diagnosing CMD.[30-32] The EP often encounters these alternate mechanisms of ischemia while evaluating patients with recurrent chest pain, one of the leading causes of readmissions.[33] CMD is a known cause of recurrent chest pain and needs to be considered in the workup of patients with chest pain who are ruled out for CAD.[34-35]

Differences in pathophysiology also influence the presentation and risk stratification of AMI. Women, like men, present most commonly with chest pain when having an AMI.[36] However, they describe it more as *discomfort* than *pain* and are less likely to describe it as "classic" angina, i.e., as exertional substernal chest pain, which is more reliably predictive of obstructive CAD in men.[37] What also distinguishes the presentation is the number of associated symptoms: Women tend to describe a *cluster* of symptoms such as shortness of breath, fatigue, and radiation of pain, *in addition* to chest discomfort as opposed to men who focus primarily on chest pain.[38] The cluster of symptoms could therefore "dilute" the presentation when evaluating women with ischemia compared to men. This was seen in a sex-specific study of AMI from Canada,[38] and summarized in a recent consensus statement on AMI.[23] While more commonly seen in women, atypical symptoms such as shortness of breath, epigastric pain, nausea as the sole presentation of AMI constitute only 10-15% of all STEMI presentations and less than a third of all AMI presentations.[39,40] Young women with AMI may also present without any chest pain compared to men, potentially explaining the higher mortality seen in this age group.[41]

While assessment of cardiac risk factors in the ED has been questioned, data supports their use for cardiovascular risk stratification particularly in young patients.[42,43] Certain risk factors impart a differential risk by sex. Examples are included in Table 1 but the list of novel risk factors is rapidly evolving. The EP may inquire specifically about these risk factors based on patient sex and incorporate them in assigning the pretest probability for ischemia for that patient. For instance, the presence of diabetes in a young patient with chest pain would warrant some caution as diabetes has been known to equalize the cardiovascular risk protection typically seen in young women compared to similarly aged men.[44,45]

Several risk stratification tools currently exist to aid the EP in evaluating patients with chest pain. The more commonly used scores include the Thrombolysis in Myocardial Infarction (TIMI) score, the HEART (History, ECG, Age, Risk factors, Troponin) score or the Emergency Department Assessment of Chest Pain Score [EDACS]; all aim at identifying low-risk patients who could be safely discharged early from the ED.[46] While most of these scores considered sex/gender as a control variable in the original derivation cohorts, not many validated their performance independently among men and women. In the few studies that did evaluate these scores by sex, differential performance was seen despite similar discriminatory and calibration characteristics[47] of the scores.[48] Men were noted to have worse outcomes, suggesting that early discharge for low-risk men by HEART or TIMI scores may be less safe for men as compared to women with acute chest pain. This is likely due to the higher rates of major adverse outcomes (MACE) seen in men as compared to women with AMI, highlighting the need for sex-specific risk stratification scores.[49] The differential effect of sex was considered in the EDACS in its final model.[46] It performed well in its original validation cohort with 100% sensitivity and 59% specificity for low-risk patients. While the EDACS is a step forward by incorporating patient sex in considering cardiac risk, it still needs validation in studies evaluating its performance independently by sex.[49]

SABV can influence the interpretation of diagnostic tests for AMI.[11] Troponin testing is the cornerstone of diagnosing AMI in the ED. A European study of 1,126 patients with acute coronary syndrome (55% men and 45% women) used a conventional troponin assay to diagnose 19% men and 11% women with AMI.[11] The use of a high-sensitivity troponin assay added 4-5% AMI cases to each group. Most interestingly, when using a sex-specific threshold for troponin that has a lower cut-off for women (given their lower heart muscle mass), the diagnosis of MI doubled in women and did not vary significantly for men. Patients who were reclassified using the sex-specific cut-off had worse outcomes than patients with conventionally diagnosed MI.[11] High-sensitivity troponin assays were only recently approved by the FDA for use in the U.S. and therefore need validation in U.S. populations. However, the results are intriguing and may influence the future of cardiac marker analysis.[50]

Table 2. Sex differences in pathophysiology of cardiac ischemic syndromes.

Acute coronary syndromes	Women	Men
Anatomical area of coronary obstruction	Large and small vessels	Large vessels
Pathophysiology of ischemia	Plaque rupture	Plaque rupture[58]
	Plaque erosion	
	Alternate mechanisms: [23]	
	coronary artery spasm	
	spontaneous coronary artery dissection	
	embolization,	
	coronary microvascular dysfunction	
Presentation	Chest pain most common Often with cluster of associated symptoms[38]	Chest pain most common Fewer associated symptoms
Risk factors		
Traditional		
Smoking	2-fold higher,[59]	
Diabetes	2-fold higher[60]	
Hypertension	60% higher[43]	Higher[23]
Physical inactivity	Higher	
Novel risk factors	60% higher	
Depression	Higher[61]	
Lupus		
Hypercoagulable states		
Metabolic syndrome		
Pregnancy associated	Preeclampsia gestational diabetes, preterm labor and neonatal death double the risk for AMI. [62-5]	Not applicable
Diagnosis		
Troponin	Higher-sensitivity troponin using sex-adjusted cut-offs picked up twice as many with worse outcomes.[11]	High-sensitivity troponin made no significant change for diagnosing AMI compared to conventional troponin
Risk scores		Men with low-risk HEART and TIMI score have worse outcomes.[47,48]
Stress imaging	For intermediate-high risk, sensitivity can be increased with stress echo or nuclear stress with imaging.	ETT has higher sensitivity
Management		
STEMI	PCI preferred over thrombolytic therapy Door-to-balloon times longer[21]	PCI preferred over thrombolytic therapy
NSTEMI	Similar benefit Lower dose of anticoagulants	Similar benefit
Non-CAD ischemia	Conservative management with secondary prevention	
Prognosis		
Mortality	Higher at younger age[22]	Higher overall
Readmissions for chest pain	Higher	

AMI, acute myocardial infarction; *HEART*, HeartScore is a cardiovascular disease risk assessment and management tool developed by the European Society of Cardiology; *TIMI*, Thrombolytics in Myocardial Infarction, *ETT*, exercise tolerance test; *PCI*, percutaneous coronary intervention.

Table 3. Sex-specific considerations in acute ischemic stroke unique to women.

Risk Factors [66,68,70]
Hormonal therapy [66,68]
Migraines with aura in combination with tobacco [66]
Preeclampsia/eclampsia [66]
Peri-partum hypercoagulability [70]
Atrial fibrillation (incidence higher in women when age >75 y.o.) [66]
Presentation/diagnosis [71-4, 77, 79-80, 90]
Possible propensity for presenting with non-traditional symptoms [71-4]
Higher population incidence of conditions which may cause stroke mimic (i.e.: complex migraine, conversion disorder) [79-80]
More likely to arrive to emergency department via ambulance [77]
May have MRI rather than CT imaging (i.e.: pregnancy, young age) [90]
Treatment [78, 82, 83, 87]
Less likely to receive thrombolytic therapy [77]
Potential greater treatment effect of thrombolytic therapy in women [82, 83]
Smaller diameter vessels potentially effecting distal vessel thombectomy[87]

MRI, magnetic resonance imaging; *CT*, computed tomography.

Interpretation of stress tests may also vary depending on whether the patient is a man or a woman. For instance, an exercise tolerance test has 60% sensitivity in women (often with single vessel disease) as opposed to 71% sensitivity in men (often with multi-vessel disease).[10] Women are also less likely to achieve maximal heart rate crucial for correct interpretation and more likely to be converted to pharmacological testing. Sensitivity for a pharmacological nuclear scan in general is less (60%) compared to an exercise perfusion scan (85%).[10] Hence, women are more likely to have tests with lower sensitivity than men. Additional considerations, such as radiation risk in breast tissue with computed tomography (CT) angiography, further influence the optimal choice of test for men vs. women.

With a rapidly growing body of science on ischemic syndromes beyond CAD, an EP will be tasked to incorporate this knowledge into his/her assessment of chest pain patients to capture all cases of cardiac ischemia. Diagnosing non-CAD causes of ischemia can, however, be challenging. In contrast to CAD, CMD can present as angina induced by atypical triggers such as change in temperature or high stress.[34,51-53] Also, conventional tests such as troponin or stress test may be normal with CMD.[31] Our preliminary work indicates that up to 40% of ED patients with recurrent chest pain have CMD by advanced imaging.[34] Patients are suspected for CMD based on recurrent symptoms consistent with angina and lack of evidence for obstructive CAD. An EP may refer such patients for additional testing such as cardiac positron emission tomography (PET), magnetic resonance imaging (MRI) or even coronary reactivity testing by coronary angiogram so a definitive diagnosis of ischemia may be made.[51]

Current guidelines for treating MI are similar for men and women including benefits of anticoagulants, with some sex-specific nuances. For NSTEMI due to CAD, early invasive therapy is harmful for low-risk women and beneficial for all-risk men.[54] In addition, anticoagulants have to be weight-adjusted to reduce the risk of bleeding, more often seen in women.[21] For STEMI, newer therapies based on plaque composition such as aspiration thrombectomy and catheter-directed lytic therapy without implantation of stents are on the horizon.[23] A small study of these non-stent therapies indicates that the outcomes may be comparable to conventional therapies.[55] The biggest changes on the horizon are with regard to the treatment guidelines for non-CAD related causes of ischemia. Revascularization is not indicated for some causes of AMI (such as coronary artery dissection) or applicable (coronary artery vasospasm). Additional therapies may need to be adapted to the underlying cause, for instance calcium channel blockers for vasospasm, early use of statins and ACE inhibitors for non-plaque AMI,[56] or no anticoagulants for coronary artery dissection. For treatment of CMD and recurrent angina, at minimum patients require cardioprotective medications such as aspirin, statins and an aggressive symptom-management plan that may include ACE-inhibitors and statins, while nitrates and beta-blockers appear ineffective.[57] Given the effect of SABV in rapidly changing the landscape of ischemic heart disease, this review is meant to serve as a primer for a practicing physician.

ACUTE ISCHEMIC STROKE

Case: A 39-year-old female two weeks post-Cesarean section with rheumatic heart disease and paroxysmal atrial fibrillation (anticoagulation held) developed an acute right MCA stroke syndrome (NIH Stroke Scale (NIHSS) score of 19; left

side flaccid and plegic in arm and leg). Intravenous (IV) tissue plasminogen activator (TPA) had no improvement; the patient underwent mechanical thrombectomy 5.5 hours after symptom onset. A week later symptoms had nearly resolved.

Women face a higher lifetime risk of stroke having ~55,000 more strokes than men each year,[66] and have a higher annual stroke death rate (fifth cause of death for men; fourth for women). Overall, when age adjusted the incidence of all cerebrovascular disease is higher in men than women at younger ages but not older ages.[67] From 1980 to 2005 there was a greater age-adjusted decline in stroke death rates in men than in women.[67] There are roughly 6.8 million stroke survivors in the United States living after having had a stroke, including 3.8 million women and 3 million men.[21] Overall, one in five women will have a stroke at some point in their lives.[68] Regarding strokes in young people—in some studies men appear to have a higher rate in the 35- to 44-year-old age group, while other population-based analyses reveal a higher incidence among women under 30 years old.[70]

Sex-specific considerations in AIS are summarized in Table 3. Although the absolute risk of stroke is low, there are several sex-specific risk factors unique to women that increase the relative risk of stroke—hormone therapy (HT), migraine headaches with aura in combination with tobacco use, and preeclampsia/eclampsia.[66] Of note, atrial fibrillation is more common in women contrasted to men over the age of 75 while rates below this age are equivocal. The specific combination of hypertension and HT further increases the risk of stroke,[68] and the post-partum hypercoagulability phase may now extend out to 12 weeks post-delivery.[70] Recently, the American Stroke Association (ASA) published guidelines for prevention of stroke in women.[66] However, there is still opportunity for future progress, including addressing sex and gender differences in other phases of stroke care.

Several key sex differences have been evaluated in secondary analyses of large registries and other investigations. Population-based data on sex differences in the acute phase of presentation indicate conflicting results. Some studies report that women have a higher propensity for presenting with non-traditional stroke symptoms (i.e., altered mental status)[77-2] contrasted to their male counterparts who have higher odds of presenting with specific symptoms (i.e., focal findings such as paresthesia, ataxia, and diplopia) in combination with non-specific symptoms (i.e., pain, disorientation, generalized weakness, fatigue).[73-4] Others studies have not observed a consistent sex difference in the prevalence of traditional vs. non-traditional symptoms "making it difficult to craft a public health message about gender differences in early warning signs of stroke."[75] It is possible that the above investigations may be prone to length bias due to delayed presentations to the ED. One study observed that the risk of delay in hospital arrival was three times greater for women with acute strokes contrasted to men.[76] However, other literature, while not focusing overall on time to presentation, has demonstrated women are more likely to arrive via ambulance compared to men[77] while being less likely to receive TPA. Further investigation in this area is necessary to evaluate these differences.

For stroke etiology, some studies suggest women may be more likely to have large territory strokes contrasted to lacunar/small embolic syndromes more prevalent in men.[78] But interpretation is limited as other studies posit that women are more likely to have cardioembolic strokes contrasted to men.[75] Such studies do not specifically differentiate risks in different age categories as the etiology of stroke varies in young to geriatric patients. To further complicate matters for the EP, patients presenting with stroke mimics,such as complex migraine tend to be younger and are more likely to be female.[79-80] Navigating this paradox—the simultaneous existence of atypical presentations and observed differences in treatment rates—is a difficult task for the EP. One solution is to have a system that can rapidly recruit the aid of a stroke specialist (i.e., via telemedicine) and in some cases perform definitive diagnostic testing (i.e., hyperacute MRI) in cases where diagnostic uncertainty exists. While the current literature does not demonstrate sex differences in the rates of missed strokes, further investigation in this area merits consideration.[81]

A concerning observation as cited above is that women are less likely to receive IV TPA. This could be especially deleterious to outcomes, as other pooled analyses of clinical trials suggest

Table 4. Examples of sex-based differences in response to pharmacologic therapies in the emergency department.

Response	Example
Pharmacokinetic differences[12,95-6,98]	Female patients may require higher doses of lipophilic medications like propofol[17-19]
Volume of distribution	Female patients may require lower doses of water-soluble drugs like rocuronium[7,12]
Protein binding of drugs	
Metabolism and transport of drugs	
Pharmacodynamic differences[12,95-6,98]	Females are at increased risk of drug-induced torsades de pointes from QTc-prolonging medications such as ondansetron[105,107-9]; Female patients have increased risk of side effects such as CNS or respiratory depression from morphine[12-15,104]
Number of receptors & receptor binding	
Variability in ion channels	

QTc, QT interval corrected for heart rate; *CNS*, central nervous system.

a larger treatment effect of TPA in women including a NINDS/ATLANTIS/ECASS II pooled analysis,[82] and PROACT-2.[83] Of note, among patients receiving placebo, the former pooled analysis also observed worse outcomes in women compared to men. While these differences may partially be explained by factors such as age, initial NIHSS, delays in presentation, co-morbidities, the possibility of a stroke mimic, and the possible association of non-traditional symptoms, future investigation is necessary.[84] Some studies have found that sex differences were equalized after treatment.[85] In this new era of mechanical thrombectomy there is limited knowledge regarding sex differences; however, it is known that women are less likely to undergo cerebral angiography[86] and that women have smaller diameter cerebral vessels.[87] The influence on patient selection and treatment effect is unknown.

For stroke systems research, a national registry analysis revealed women are less likely than their male counterparts to receive defect-free care across the age spectrum. Defect-free care is defined as a health system attaining all of the AHA/ASA quality benchmarks in different phases of stroke care (i.e., consideration of IV TPA, anticoagulation for atrial fibrillation, dysphagia screening, etc).[88] The magnitude of such observations on overall clinical outcomes is unknown. However, other studies evaluating outcomes reveal women are more likely to have poor functional outcomes after AIS at 90 days and one year, and are institutionalized more often compared with men.[84]

In pregnancy, AIS is rare with an overall incidence ranging from 9-34 per 100,000[89] and has neither randomized controlled data nor registry data to inform decisions, given this population is commonly excluded from trials. Management requires a systems approach involving providers from multiple disciplines (i.e., high-risk obstetrics, neurology), and typically relies upon extrapolation from existing guidelines. For eligible patients meeting criteria for thrombolytic therapy risks and benefits should be evaluated on a case-by-case basis with the involvement of high-risk obstetrics and neurology, as well as the patient and family.[90] Endovascular therapy merits strong consideration for patients with large vessel occlusions and is potentially the most optimal intervention per some stroke experts.[91]

Sex-Based Pharmacology Considerations in the Emergency Department

Case: A 58-year-old male trauma patient presents to the ED. The EP notes he requires analgesia, antiemetics, procedural sedation, rapid sequence intubation and vasopressor support.

The provider should be aware of the available data on sex-based dosing of analgesia, antiemetics, sedation medications, neuromuscular blockade, vasopressors, and inotropes. The available research in SABV in response to pharmacologic therapies used in EM is limited to basic science studies, animal studies, and limited clinical studies, with a remarkable paucity of studies focused on clinical EM. Further research is needed to elucidate next steps in the translation of available data into safe and effective clinical practice.

As in the management of this trauma patient, EPs frequently manage patients with pharmacotherapies. Physiological, hormonal, and genetic differences between male and female patients affect both drug response and rate of adverse drug reactions (ADR), with female patients experiencing higher drug concentrations and more ADRs, even after accounting for weight-based dosing.[28,92-7] Examples of sex-based differences in response to pharmacologic therapies in the ED are summarized in Table 4. Historically, females have been excluded from pharmaceutical development research and sex-based dosing recommendations are rarely made.[12,28] Sex alters both pharmacokinetics and pharmacodynamics.[95,98] Sex differences have been reported in plasma volume, protein concentration, gastric emptying and gut transit times, drug metabolism and clearance, drug transporter function, drug receptor concentration and rates of polypharmacy.[28,92,95,98-102]

EPs providing opioid pain control should note that morphine causes lower rates of respiratory depression and has more rapid onset and offset in males.[12-13,103] Female patients are more sensitive to pain in experimentally-induced pain studies; have increased willingness to report pain in studies of pain tolerance; have higher rates of chronic painful conditions in epidemiological studies studying pain in multiple body sites; and may require higher doses of opioids to obtain pain relief, which may place female patients at increased risk for adverse events, particularly given an increased risk of opioid-induced respiratory depression compared to males.[12-15,104] Given the available data, careful dose titration and close monitoring for both effectiveness and opioid-induced side effects is warranted even when using standard weight-based dosing of morphine. In the case above, the provider may note that male patients may be able to tolerate higher doses of morphine, may be less likely to report pain, and are at decreased risk for adverse effects from opioids compared to females.

Underlying QTc prolongation and drug-induced torsades de pointes (TdP) from many antiemetics, antipsychotics, antiarrhythmics, and antimicrobials commonly administered in the ED is more common in females and may vary within the menstrual cycle.[105-8] Underlying mechanisms may be related to protective effects of testosterone in males, pro-arrhythmic effects of estrogens in females, and sex-based differences in drug pharmacokinetics and ion channel expression.[92,105-6,109-10] As an example, if this male trauma patient is treated with the antiemetic ondansetron, baseline QTc prolongation and therefore drug-induced TdP is less likely than in a female patient. A baseline ECG to assess QTc interval could be performed prior to administering QTc prolonging medications in patients at higher risk for TdP, such as female patients, patients with congenital long QT, or patients with concomitant use of another QT-prolonging medication.[109]

Given the same dose of a neuromuscular blocking agent like rocuronium or vecuronium, male patients will have a lower

serum drug concentration, slower onset, and shorter duration of action compared to females.[7,12] In the case of this male patient, the provider may note that paralytic effect during rapid sequence intubation may be shorter in duration than it would be for a female patient receiving standard doses of rocuronium. Such sex differences have not been found with succinylcholine.

When serial bolus dosing of propofol is used to titrate conscious sedation to effect, male patients require lower and fewer doses of propofol to maintain the same blood concentrations of drug as female patients, and often wake up more slowly than female patients.[17-19] Percentage body fat is higher in females, which lowers the blood concentration of lipid soluble drugs such as propofol.[89] Should this male patient require deep sedation using propofol, the EP may note that the patient may wake up more slowly, and require lower doses within the standard dosing range for propofol when compared to a female patient.[28]

Male patients metabolize vasopressor and inotropic agents commonly administered in the ED such as norepinephrine, epinephrine, and dopamine at higher rates than female patients due to 25% higher catabolic enzyme activity.[12,20] If the resuscitation of this male trauma patient warrants the titration of a vasopressor or inotrope to effect, the clinician may find that this male patient requires doses on the higher end of the normal dosing range for a vasopressor or inotrope.

Given that many of the medications provided in the ED are already dosed in ranges and titrated to effect, providers should be aware that female patients may be more susceptible to side effects from standard dosing of morphine; more sensitive to standard doses of inotropes, vasopressors, and non-depolarizing paralytics such as rocuronium; and less sensitive to standard doses of propofol than male patients. An awareness of these differences that have been reported in the literature can help clinicians be cognizant of sex-based differences that may occur in response to medication administration within dosing ranges commonly used within the standard practice of EM. Finally, given these sex-based differences in drug response and adverse outcomes, SABV should be considered in all phases of the development of new drugs designed to be used in the ED.[92,106]

LIMITATIONS

Despite the importance of both variables, sex and gender, in research and the important considerations they impart in the clinical care of women and men, this brief narrative review focused on SABV in research as it relates to ED clinical care. The ability to accurately measure and access the impact of gender identity on the delivery of medical care is complex and currently without well agreed-upon validated measurement tools. Despite this, the authors feel it is important to initially assess each patient's biological sex and current gender identity, as it will begin the process of realizing the fact that these two variables may not always be congruent.

The authors also discovered a paucity of SABV being included within EM clinical practice guidelines and available research, highlighting this as an area for future research and inclusion.

CONCLUSION

With the new NIH requirement to integrate SABV into research design, analysis and reporting, the evidence for the role of patient sex in medical care is growing. As these three clinical scenarios demonstrate, evidence for incorporating SABV in clinical care has immediate implications for the ED patient. The cognitive steps outlined in the manuscript are designed to prepare EM clinicians to identify their patients based upon biological sex, and to become more cognizant of sex-based variability in presentation of disease, appropriateness of diagnostic testing and interpretation of results. Additionally, better incorporation of SABV will allow for safe and effective sex-based treatment in EM. An awareness of known SABV factors in the field of EM will prepare the clinician to consume emerging data in this area. We encourage the utilization of the validated PubMed search tool described to assist the emergency physician in extracting new evidence through the lens of this important biological variable.

Translation of new knowledge of SABV to the bedside requires an awareness of both the available literature and the knowledge gaps that exist in understanding of how sex-based research will ultimately impact patient care. This manuscript details three specific clinical scenarios in which sex based care is imperative, however, much information is still needed to better dissect the role of SABV in all aspects of emergency care. It is incumbent on the astute emergency care provider to consciously embrace emerging evidence in order to provide the best clinical care to their patients. Sex is not simply a descriptor, but a biologic variable that has consequences on risk stratification, utilization of diagnostic tests, and appropriateness of pharmacologics ordered.

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Knowledge Translation of the PERC Rule for Suspected Pulmonary Embolism: A Blueprint for Reducing the Number of CT Pulmonary Angiograms

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Introduction: Computerized decision support decreases the number of computed tomography pulmonary angiograms (CTPA) for pulmonary embolism (PE) ordered in emergency departments, but it is not always well accepted by emergency physicians. We studied a department-endorsed, evidence-based clinical protocol that included the PE rule-out criteria (PERC) rule, multi-modal education using principles of knowledge translation (KT), and clinical decision support embedded in our order entry system, to decrease the number of unnecessary CTPA ordered.

Methods: We performed a historically controlled observational before-after study for one year pre- and post-implementation of a departmentally-endorsed protocol. We included patients > 18 in whom providers suspected PE and who did not have a contraindication to CTPA. Providers entered clinical information into a diagnostic pathway via computerized order entry. Prior to protocol implementation, we provided education to ordering providers. The primary outcome measure was the number of CTPA ordered per 1,000 visits one year before vs. after implementation.

Results: CTPA declined from 1,033 scans for 98,028 annual visits (10.53 per 1,000 patient visits (95% CI [9.9-11.2]) to 892 scans for 101,172 annual visits (8.81 per 1,000 patient visits (95% CI [8.3-9.4]) p<0.001. The absolute reduction in PACT ordered was 1.72 per 1,000 visits (a 16% reduction). Patient characteristics were similar for both periods.

Conclusion: Knowledge translation clinical decision support using the PERC rule significantly reduced the number of CTPA ordered. [West J Emerg Med. 2017;18(6)1091-1097.]

INTRODUCTION

Background

In recent years the pursuit of the diagnosis of pulmonary embolism (PE) has been the focus of much discussion in the medical literature. PE is common, difficult to diagnose, and potentially lethal if missed.[1] Computed tomography

pulmonary angiogram (CTPA) is currently the preferred test to diagnose PE. However, excessive testing in the pursuit of the diagnosis of PE has long been an area of concern.[2]

To enable clinicians to confidently rule out PE while reducing the number of unnecessary CTPAs, several clinical rules have been developed and validated. These include the Wells criteria and the Pulmonary Embolism Rule-Out Criteria (PERC).[3,4] A low-probability Wells score, along with a negative D-dimer[5] or a negative PERC score, can rule out a PE with a high enough degree of certainty that the number of patients who would benefit from further testing to increase that certainty would be less than the number harmed by the side effects of the testing itself and the harmful consequences of false-positive results, including needless anticoagulation.[6] Despite clear evidence that the use of validated clinical rules can effectively be used to rule out the diagnosis of PE, anecdotally they are not universally or even commonly applied.

Previous studies have described the use of computerized clinical decision support (CDS) rules whereby clinicians are reminded of relevant clinical rules during the ordering process. However, the effectiveness of this approach has been inconsistent. Raja et al. reported success in reducing the number of CTPA ordered and increase in yield, whereas Drescher et al. reported that CDS was unsuccessful in reducing the number of CTPA ordered and was not accepted by the clinicians ordering the tests.[7,8] In the former study, some limited physician education was done prior to implementing the CDS, whereas in the latter none is described. In addition, these studies used CDS based on Wells criteria for risk assessment of PE along with the use of D-dimer testing. PERC is an established clinical rule by which low-risk patients can be safely ruled out for the diagnosis of PE without the use of any ancillary testing. Our CDS was designed to incorporate this validated clinical rule along with Wells criteria and D-dimer testing as needed. To our knowledge, this is the first reported incorporation of PERC into a computerized CDS system.

Knowledge translation (KT) is a field of endeavor defined by the Canadian Institutes of Health as "a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically sound application of knowledge to improve health, provide more effective health services and products, and strengthen the health care system."[9] This definition recognizes the fact that knowledge creation and dissemination is not sufficient to affect clinical care and decision-making. We designed an explicit KT-based educational process to accompany the introduction of our CDS tool. We hypothesized that the combination of a CDS tool, a targeted education effort, and regular feedback to providers on their utilization rates would reduce the number of unnecessary CTPA ordered.

Population Health Research Capsule

What do we already know about this issue
Despite clear evidence that validated clinical decision rules can be used to rule out pulmonary embolism (PE), they are not universally or even commonly applied.

What was the research question?
We hypothesized that a clinical decision support tool, education effort, and regular fee dback to providers would reduce the number of unnecessary computed tomography pulmonary angiograms (CTPA) ordered.

What was the major finding of the study?
The number of CTPA per 1,000 patients decreased from 10.53 to 8.81, a 16% relative reduction.

How does this improve population health?
This study addressed indiscriminate CTPA testing for PE in pursuit of a diagnosis, which could result in over-diagnosis, harm patients and divert resources from other health care needs.

Importance

Excessive use of CTPA in the emergency department (ED) is associated with risks and costs to patients and systems of care. Although the increased risk of cancer to an individual patient from a single CTPA is low, the stochastic effects of ionizing radiation from CTs increase the population incidence of neoplastic disease.[10] In addition, the use of CTPA involves contrast medium, which can be nephrotoxic and lead to allergic reactions. Severe, life-threatening reactions including anaphylaxis occur in 0.1% of people receiving contrast media.[11] Recently, an increase in major adverse advents associated with CT contrast-induced nephropathy has been reported.[12] Testing for PE also carries implications for cost, throughput, patient satisfaction and resource allocation, as well as the risks of long-term anticoagulation in patients with false-positive or clinically insignificant positive findings.

Goals of this Investigation

We hypothesized that a coordinated KT effort involving the adoption of a department-endorsed, evidence-based clinical protocol, a multi-modal educational program, and CDS embedded in our computerized order entry system, would lead to a decrease in the number of CTPA ordered.

METHODS

Study Design and Setting

This was an observational before-after study in which data were collected prospectively over 12 months starting on October 15, 2012, and compared to the previous 12 months. The study took place in the ED of an urban tertiary referral center with a large emergency medicine (EM) residency program and with an annual census of 100,000 visits.

Patient Population

Our study population included all non-pregnant patients over the age of 18 in whom the providers suspected a diagnosis of PE and who did not have a contraindication to CTPA, including renal insufficiency and allergy to contrast material.

Intervention Protocol

A departmental protocol was instituted so that to obtain a CTPA for possible PE, providers were required to enter clinical information into a departmentally-approved diagnostic pathway based on recommendations of the American College of Emergency Medicine guidelines[1] regarding the evaluation of adult patients in the ED for PE. This diagnostic pathway was embedded into the computerized order entry system (Figure). The protocol required that a Wells score be calculated for all patients suspected of having a PE.

Low-risk patients then had their PERC score calculated. Patients with a negative PERC score were considered ruled out for PE with no further testing. Those patients deemed low risk by Wells score who did not meet the PERC criteria had D-dimer testing. Intermediate-risk patients had D-dimer testing, and high-risk patients had a CTPA ordered. Those patients who had negative D-dimer results were considered ruled out for PE and had no further testing. The computerized algorithm displayed the protocol pathway and guided providers according to their responses. However, to allow the ultimate decision to remain with the clinician at the bedside, providers were able to override the protocol and order a CTPA even if not indicated by the protocol. In these cases we sent an email to the ordering provider inquiring as to their reasoning for ordering CTPA despite the negative evaluation. We did not require or tally responses to these emails.

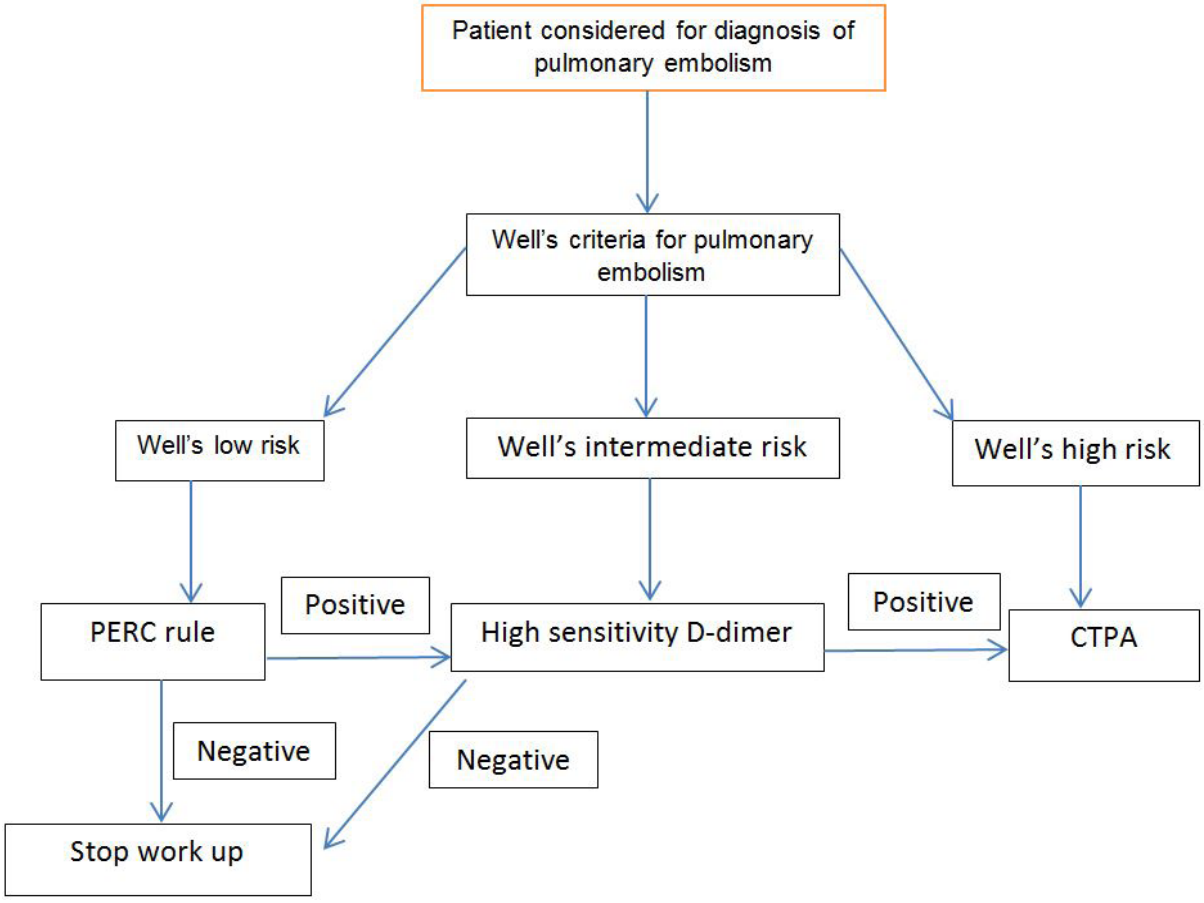

Figure. Diagnostic pathway embedded into computerized order entry system.

Knowledge Translation Implementation

Prior to implementation of the protocol, education was provided to ordering providers (attending and resident physicians, physician assistants, and advanced practice registered nurses) in the ED about the clinical rules and how to complete the ordering process. Discussion was invited at departmental meetings. An authority in the field of KT and the rational diagnosis of PE was invited to give a grand rounds talk on the topic. Subsequent to protocol implementation, providers who ordered CTPA outside the protocol parameters were reminded of the protocol by email and queried as to the reason for the violation. In addition, a quarterly utilization report was generated, distributed by email, and displayed during monthly staff meetings so that attending physicians could see their utilization of CTPA relative to that of their peers. Included in the process were 17 clinical EM faculty and 36 EM residents.

Data Collection

We identified all CTPAs performed during the study period through a query of the clinical system (Allscripts ED, Chicago, IL). Trained abstractors reviewed each record and recorded basic demographics, D-dimer and CTPA results, whether the CT was ordered according the departmental guidelines, and in cases of non-compliance, which specific item(s) were not adhered to. Educational sessions were held for the research assistants prior to the start of data collection, and one of the investigators (JF) audited 20% of all the charts to ensure data accuracy. Discrepancies were reconciled by referring to the source documentation. Data collection for the baseline period was performed retrospectively while data collection following implementation of the protocol was performed prospectively. We collected and managed study data using REDCap[13] electronic data capture tools hosted by the Hartford HealthCare Research Program. The study was approved by the hospital institutional review board.

Outcome Measures

The primary outcome measure was a reduction in the number of CTPA ordered per 1,000 patient visits in the year after the guideline was implemented compared to the year before. Secondary outcome measures were yield of CTPA ordered (percentage of positive tests) and compliance with the CTPA ordering guideline.

Analysis

The primary analyses for this study were comparison of CTPAs per 1,000 patient visits and the positive yield for PE between the periods of time before and after the implementation of the guideline and training. We calculated the rate of CTs performed for this purpose as the number of CTs performed per 1,000 ED visits before and after protocol implementation. Descriptive statistics for the cohort are expressed as means with standard deviations (SD) and proportions. Inferential statistics are expressed as point estimates with 95% confidence intervals (CI). We analyzed differences in means and proportions with *t* tests or chi-square analysis, as appropriate.

We conducted additional analyses for the post-implementation period only, due to availability of data. These focused on whether the guidelines were followed or a violation occurred, specifically whether a D-dimer was ordered and positive, and whether Wells or PERC criteria were followed. We created comparison groups based on the findings for these violations and compared them for the final diagnostic accuracy, again using chi-square tests of proportion. We performed all analyses with MedCalc version 13.1.2 (MedCalc Software, Ostend, Belgium) or with SPSS version 21 (SPSS, Inc., Chicago, IL).

RESULTS

There were no significant differences in the age or gender of the patients receiving CTPA in the periods before and after the interventional protocol was adopted. The average age was 59 in the period before and 59.4 in the period after. The proportion of males in the period before was 40.1% and 42.9% in the period after.

The total number of CTPAs declined from 1,033 scans for 98,028 annual visits to 892 scans for 101,172 annual visits. The number of CTPAs per 1,000 patient visits decreased from 10.53 (95% CI [9.9 to 11.2]) for the year before the guideline was enacted to 8.81 (95% CI [8.3 to 9.4]) for the year after (absolute difference 1.72, $p<0.001$). This difference represents a 16% reduction in CTPA utilization. The secondary outcome measure of PE yield showed no significant change, from 15.9% positive CTPA for PE in the year prior to 15.2% positive for PE in the year after (p=NS). The protocol was followed 66% of the time. When the protocol was followed (n=589) the positive PE yield was 18.4%; when it was not (n=303), the yield was 9.2% ($p < 0.001$). Types of protocol violations were subdivided, with multiple violations occurring in some cases (Table).

D-dimer was ordered in 34.4% of cases before and 65.7% of cases after protocol implementation ($p = 0.001$).

Table. Type of protocol violation regarding lack of adherence to clinical decision support pathway for diagnosis of pulmonary embolism.

Type of protocol violation	Percentage of cases
D-dimer not done or CTPA done despite negative result	15.1
Wells Score not calculated	18.2
Pulmonary embolism ruleout criteria not assessed	5.5
Other violation	3.5

CTPA, computed tomography pulmonary angiograms.

For those patients who had a D-dimer ordered there was a significant increase in the proportion of elevated (>250 ng/ml not age adjusted) D-dimers from 91.8% before to 95.9% after ($p = 0.009$).

DISCUSSION

The diagnosis of PE in the ED is of paramount importance. It is a disease with a frightening combination of being common, difficult to diagnose and potentially lethal if missed. On the other hand, indiscriminate pursuit of the diagnosis using CTPA harms patients and wastes resources. Diagnosis of clinically inconsequential PE or false- positive CTPA may also lead to unnecessary anticoagulation and increased ordering of subsequent CTPA , as well as increased and needless patient anxiety.

Our study was ultimately an attempt to address the challenges of unnecessary testing and overdiagnosis in the context of diagnosing PE. Five of the medical specialty societies participating in the *Choosing Wisely* campaign, including the American College of Emergency Physicians, have listed avoiding unnecessary imaging for PE among their main recommendations.[15] Similarly, avoiding PE overdiagnosis is included in the *British Medical Journal*'s *Too Much Medicine* campaign.[16]

The term overdiagnosis can be used in a broad sense to refer to several related concepts: overdetection of disease, overmedicalization of common human conditions, overutilization of resources, and overtreatment.[17] As diagnostic modalities have improved and illness definitions expanded, overdiagnosis has become a global problem for modern medical practice. The adverse consequences of overdiagnosis have been described for conditions as diverse as asthma, attention deficit hyperactivity disorder, breast cancer, hypertension, and PE.

Radiation and cost concerns aside, applying a highly sensitive test (CTPA) to a population with low PE prevalence leads to two distinct problems: diagnosing small PEs that will not harm the patient (overdetection) and diagnosing PEs that are not there (false positives), decreasing the specificity of the test. Either case will lead to unnecessary anticoagulation with all its attendant risks and costs. Effective KT can help clinicians avoid finding these PEs that should not be found, and in the process save money while providing the safest care for patients.

Consequently, much research has been devoted to developing a risk-stratification strategy that has been shown to safely rule out the diagnosis of PE in a significant subgroup of patients without the use of CTPA. To maximize the benefits to patients of such an evidence-based strategy it needs to be implemented in a systematic way. The principles of KT (also known as dissemination and implementation) provide a framework for doing this. Different formal frameworks have been described. There are differences between the frameworks, but they all retain some common characteristics: an evidence-based intervention with demonstrated effectiveness, guided implementation and innovation, evaluation, sustainability, and stakeholder input.[18]

The protocol has been shown to be sustainable in our department as it has been implemented and retained as the standard method for ordering CTPA to rule out PE. Our protocol followed the principles of KT in bringing evidence-based knowledge to bear and successfully affecting patient care at the departmental level. We followed a path of provider education, getting the buy-in of decision-makers, establishing a department standard and reiterating the expectations through a feedback loop.

The pursuit of the diagnosis of PE is well suited to this pathway. The stakes are high both for patient outcomes and resource utilization, The evidence for influencing practice is well established in the literature, and the clinical rules are well known and lend themselves to incorporation into computerized order entry algorithms. The need for translation of this knowledge into practice is demonstrated by the seminar workshop given yearly by the largest EM conference in the world entitled "Stop the Madness I: Reducing Unnecessary Radiation in Suspected Pulmonary Embolism." [19] Nonetheless, to date we are not aware of a published study showing the feasibility and results of implementation of KT of PERC in the diagnosis of PE.

Importantly, we did not measure the number of missed PE in adopting our protocol. The safety of the protocol, including the use of the PERC rule as part of the algorithm, has been previously established in the literature and endorsed in guidelines by major medical professional organizations.[20] We therefore did not see the need to re-evaluate the safety and accuracy profiles of the components of our intervention; rather, we set out to assess the effectiveness of implementation in practice, as an established, evidence-based pathway.

The present study demonstrated a significant decrease in utilization of CTPA when the principles of KT, in which a dynamic and iterative process that includes the synthesis, dissemination, exchange and ethically-sound application of knowledge, were applied to the diagnosis of PE using a novel CDS, which included PERC criteria to risk stratify along with Wells criteria for PE and D-dimer testing.

LIMITATIONS

The main limitations of this study are due to its observational design. One would expect that with the decrease in utilization observed in our study, there would be a concomitant increase in yield, if the prevalence of PE were unchanged. We did not find an overall increase in yield despite a decrease in utilization. This raises the question of whether the protocol resulted in more missed PEs along with the decrease in utilization of CTPA. However, we did find an increase in yield when the protocol was followed and a significant decrease in yield when the protocol was violated. This is consistent with the evidence on which this study is based, showing that patients who are risk stratified by clinical rules prior to decision-making on whether to order CTPA will have fewer negative tests than those who are not. In addition, it is possible that in using the protocol, patients with clinically

insignificant PE were scanned at a lower rate. A higher rate of small, clinically insignificant PE would have increased the total yield in the pre-protocol group reducing the change in yield seen after protocol implementation. We did not tally protocol violations by provider. It is possible that if providers who were risk averse were disproportionate violators of protocol, this would further lower positive yield in this group.

There is a necessary threshold for considering PE in the differential diagnosis for a given patient. It is possible that in the pre-protocol period, where there was no structured risk stratification, that the threshold for consideration of PE was higher than after protocol implementation. The threshold for considering patients for entry into the protocol could not be known. It is possible that a larger group of patients at low risk for PE were included than otherwise would have been, thus decreasing the diagnostic yield in the post-implementation period.

It is possible that a secular trend occurred over the time our intervention was implemented and that, for example, patients during the intervention period presented with fewer risk factors and signs of PE than during the pre-intervention period, which may have led to fewer scans ordered even without our implementation of the clinical protocol. We have no reason to suspect this or any other secular trend. We did not follow the clinical course of our patients to determine if there were any missed PEs before or after the protocol implementation.

An additional potential criticism of our study is that because we used multiple interventions (grand rounds, faculty meeting discussions, individual provider audit and feedback, electronic medical records,) we were not able to delineate the value of these interventions individually on our results. This was deemed impractical for two reasons. First, our main goal was to reduce the number of CTPAs ordered, and we pursued multiple avenues to achieve that mission. Second, individual clinicians are not influenced by differing interventions uniformly. While some may be more swayed to change behavior based on updated clinical evidence presented at grand rounds, others may be more influenced by the change in ordering procedure found in the EMR; and the individuals themselves often have little insight into their own thought processes.[14] So while we did not explicitly study the level of acceptance by providers of the protocol after implementation, we do not view this as a true limitation of the study since the true imCTPA on patients is in the outcome measured, that is rate of CTPA ordered, by the protocol implementation as a whole. We did not assess the impact of the protocol for increase or decrease in compliance over time.

CONCLUSION

Application of the principles of knowledge translation to an evidence-based, ED-mandated ordering process that includes the PERC rule significantly reduced the number of CTPAs ordered.

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A Sepsis-related Diagnosis Impacts Interventions and Predicts Outcomes for Emergency Patients with Severe Sepsis

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Introduction: Many patients meeting criteria for severe sepsis are not given a sepsis-related diagnosis by emergency physicians (EP). This study 1) compares emergency department (ED) interventions and in-hospital outcomes among patients with severe sepsis, based on the presence or absence of sepsis-related diagnosis, and 2) assesses how adverse outcomes relate to three-hour sepsis bundle completion among patients fulfilling severe sepsis criteria but not given a sepsis-related diagnosis.

Methods: We performed a retrospective cohort study using patients meeting criteria for severe sepsis at two urban, academic tertiary care centers from March 2015 through May 2015. We included all ED patients with the following: 1) the 1992 Consensus definition of severe sepsis, including two or more systemic inflammatory response syndrome criteria and evidence of organ dysfunction; or 2) physician diagnosis of severe sepsis or septic shock. We excluded patients transferred to or from another hospital and those <18 years old. Patients with an EP-assigned sepsis diagnosis created the "Physician Diagnosis" group; the remaining patients composed the "Consensus Criteria" group. The primary outcome was in-hospital mortality. Secondary outcomes included completed elements of the current three-hour sepsis bundle; non-elective intubation; vasopressor administration; intensive care unit (ICU) admission from the ED; and transfer to the ICU in < 24 hours. We compared proportions of each outcome between groups using the chi-square test, and we also performed a stratified analysis using chi square to assess the association between failure to complete the three-hour bundle and adverse outcomes in each group.

Results: Of 418 patients identified with severe sepsis we excluded 54, leaving 364 patients for analysis: 121 "Physician Diagnosis" and 243 "Consensus Criteria." The "Physician Diagnosis" group had a higher in-hospital mortality (12.4% vs 3.3%, P < 0.01) and compliance with the three-hour sepsis bundle (52.1% vs 20.2%, P < 0.01) compared with the "Consensus Criteria" group. An incomplete three-hour sepsis bundle was not associated with a higher incidence of death, intubation, vasopressor use, ICU admission or transfer to the ICU in <24 hours in patients without a sepsis diagnosis.

Conclusion: "Physician Diagnosis" patients more frequently received sepsis-specific interventions and had a higher incidence of mortality. "Consensus Criteria" patients had infrequent adverse outcomes regardless of three-hour bundle compliance. EPs' sepsis diagnoses reflect risk-stratification beyond the severe sepsis criteria. [West J Emerg Med. 2017;18(6)1098-1107.]

INTRODUCTION

Sepsis is defined as life-threatening organ dysfunction caused by a dysregulated host response to infection.[1] In response to the high morbidity, mortality,[2,3] and cost[1,4] associated with sepsis, clinical recommendations have been developed to promote the early recognition and aggressive treatment of sepsis.[5] In 2015 these recommendations were integrated into the Center for Medicare and Medicaid Services (CMS) sepsis quality measure, NQF# 0500, which mandates three- and six-hour care bundles for patients with severe sepsis. This measure includes all patients with an *International Classification of Diseases, Tenth Revision, Clinical Managemen*t (*ICD-10*) diagnosis of "severe sepsis" or "septic shock," as well as "sepsis," if patients demonstrate two or more systemic inflammatory response syndrome (SIRS) criteria, new sepsis-related organ dysfunction, and suspected infection—the definition of severe sepsis in the 1992 Consensus guidelines.[6,7]

More patients meet criteria for sepsis than those who are assigned a categorical sepsis diagnosis by emergency physicians (EP).[8] This discrepancy raises the possibility that EPs under-identify patients who could benefit from early and aggressive treatment, delaying time-sensitive care for these critically ill patients, and negatively affect patient outcomes in sepsis.[8] However, it is also possible that these under-identified patients compose a lower risk strata within the cohort of severe sepsis patients, mitigating the benefits of aggressive care.

This study of patients meeting criteria for severe sepsis compares differences in the primary outcome of mortality, and secondary outcomes of adverse events and sepsis-specific ED interventions, based on the presence or absence of an EP-assigned sepsis-related diagnosis. Furthermore, it evaluates the association between completing the CMS-prescribed three-hour sepsis bundle and adverse outcomes among patients who met severe sepsis criteria but were not given a sepsis-related diagnosis.

Population Research Health Capsule

What do we already know about this issue?
Patients who meet 1992 criteria for severe sepsis often do not receive an ED-documented sepsis diagnosis.

What was the research question?
Does this discrepancy represent under-recognition and an opportunity to expand sepsis-related care?

What was the major finding of the study?
Severe sepsis patients not given a sepsis-related diagnosis had low rates of adverse outcomes despite less aggressive care.

How does this improve population health?
Emergency physicians risk stratify sepsis patients beyond consensus criteria; broadly implementing aggressive care based on the presence of sepsis criteria alone may not improve outcomes.

METHODS

Study Design

This was a retrospective, observational study of emergency department (ED) patients meeting criteria for severe sepsis by the 1992 Consensus guidelines. We conducted the study over three months at two urban, academic EDs with 90,000 combined annual visits. This study was approved by the Human Subjects Committee of our institutional review board with a waiver from informed consent, and conformed to previously established guidelines for retrospective chart reviews.[9]

Study Subjects

This study included all patients during the study period who potentially could have met CMS NQF#0500 SEP-1 inclusion criteria for having severe sepsis in the ED. We included patients that met all of the 1992 Consensus criteria to define severe sepsis in the ED, which required having two or more SIRS criteria, new sepsis-related organ dysfunction, and suspected infection.[6] Consistent with the 1992 Consensus criteria,[7] new sepsis-related organ dysfunction was defined as creatinine > 2.0 mg/dL, bilirubin > 2.0 mg/dL, INR > 1.5, platelets <100,000 cells/mm^3, lactate > 2.0 mmol/L, or systolic blood pressure (SBP) < 90mm Hg during the ED stay. Patients with an EP-diagnosis of "severe sepsis" or "septic shock" were likewise included, similar to the current CMS NQF#0500 SEP-1 identification process, even if patients did not strictly meet the 1992 Consensus criteria. We excluded patients who were < 18 years old, transferred from another facility, and those transferred from a study ED to another facility.

We used our institutional electronic health record to screen all patients who were seen in the ED for the presence of two or more SIRS criteria, new sepsis-related organ dysfunction, and the presence of infection during the ED stay during the period from March 1, 2015, to May 31, 2015. All vital signs were documented electronically by the nurses. We used these vital signs and laboratory studies from the ED stay to identify SIRS criteria and new organ dysfunction that occurred at any point from triage to in-hospital transfer or initiation of boarding status. Subsequently, patients with two

or more SIRS criteria and evidence of organ dysfunction were manually reviewed to determine whether organ dysfunction was new, and if an infection was the perceived cause of meeting SIRS criteria in the ED. This review used data obtained after admission to the hospital if these data were felt to be relevant to the ED presentation (i.e., blood culture results). Each subject had a diagnostic review performed by one of two board-certified, attending EPs, and we used a 10% overlapped sample to assess inter-rater reliability (kappa = 0.86, 95% CI: 0.77 – 0.94). This high kappa value justified using a single review for each subject, and for the few diagnostic disagreements in the 10% overlapping sample, the principal investigator's (PI) adjudication was used. Next, we reviewed all patients who presented to the ED during the study period and had an *ICD-10* discharge diagnosis of "sepsis," "severe sepsis," or "septic shock," "present on arrival"—indicating that the conditions treated during hospitalization were present when the patient arrived at the hospital. All of the patients with EP diagnosis of "severe sepsis" or "septic shock" were included, even if they did not strictly meet the 1992 Consensus definition of severe sepsis, similar to the CMS NQF#0500 SEP-1 guidelines for identifying patients with severe sepsis.

Data Collection

In accordance with previously published guidelines for retrospective chart reviews,[10] all data abstractors were trained and directly supervised by the study PI. Abstractors used data abstraction forms with clear definitions of the abstracted variables. Abstractors were blind to the study hypothesis. Interrater reliability for abstracted data was not performed, although in the spirit of direct supervision, abstractors were able and encouraged to seek clarification regarding the data they abstracted.

Elements of the past medical history and medications were manually abstracted by two research assistants who were trained and supervised by the PI. Patient outcomes, including the administration and timing of vasopressors, non-elective intubation, and death, were abstracted by a third-year emergency medicine resident physician. Likewise, elements of the three-hour sepsis bundle (CMS-approved antibiotics, blood cultures before antibiotics, measurement of serum lactate levels, and intravenous [IV] fluid bolus of 30 cc/kg within three hours of presentation for lactate ≥ 4.0 mmol/L or SBP < 90 mmHg),[7] and the presence of shock in the ED were manually abstracted by the resident physician. Shock was defined as persistent hypotension (systolic blood pressure < 90 mmHg) despite the 30 cc/kg IV fluid bolus, elevated lactate (≥ 4.0 mmol/L), or vasopressor administration. ED vital signs, hospital disposition, hospital and intensive care unit (ICU) length of stay, and timing of transfers to the ICU were electronically abstracted for each visit from the electronic hospital database.

Outcomes

The primary outcome was in-hospital mortality. Secondary outcomes were ICU admission, transfer to ICU in less than 24 hours, vasopressor administration, non-elective intubation, and completed elements of the NQF#0500 SEP-1 three-hour sepsis bundle.

Data Analysis

We grouped patients based on the documented EP diagnosis: "Physician Diagnosis" or "Consensus Criteria." All patients were manually screened to determine if an EP diagnosed the patient with sepsis, severe sepsis, or septic shock. The "Physician Diagnosis" group included all patients within this cohort given a sepsis-related diagnosis by the EP. The "Consensus Criteria" group met all criteria for severe sepsis[6] without being given a sepsis-related diagnosis by the EP. Although, the physician diagnoses of infection (i.e., pneumonia) and organ dysfunction (i.e., hypotension) may indicate the presence of severe sepsis, we limited the "Physician Diagnosis" group to patients explicitly given a sepsis diagnosis to be consistent with the CMS guidelines and avoid confusion based on interpretation (i.e., acute renal failure if creatinine change did not meet CMS criteria for the diagnosis).

We used Student's t-test or Wilcoxon rank-sum test as appropriate to compare continuous variables between groups. We compared binary covariates, including baseline characteristics of the two cohorts, between groups using the chi-square test. The rates of the primary and secondary outcomes were compared between groups using the chi-square test as well. We compared the mortality between patients who met all CMS three-hour bundle criteria, stratified by the diagnostic group ("Physician Diagnosis" or "Consensus Criteria") to determine whether completing the NQF#0500 SEP-1 recommended three-hour bundle in either group was associated with adverse patient outcomes. We performed data analysis using SAS v9.3 statistical software (SAS Institute Inc., Cary, NC).

RESULTS

During the three-month study period, 23,551 patients presented to the study EDs, of which 418 were identified as having severe sepsis either by physician diagnosis, or by the 1992 Consensus guidelines. We excluded 54 patients (50 transferred from another hospital, three transferred to another hospital, and one patient < 18 years old), leaving 364 patients for analysis (Figure). Of these patients, 121 (33.2%) were assigned a sepsis-related diagnosis by a treating EP ("Physician Diagnosis") and 243 (66.8%) were identified by the 1992 Consensus guidelines without an EP diagnosis of sepsis, severe sepsis, or septic shock ("Consensus Criteria").

Table 1 displays the baseline characteristics and source of infection for each group. The "Physician Diagnosis" group was more likely to have bacteremia, while the "Consensus

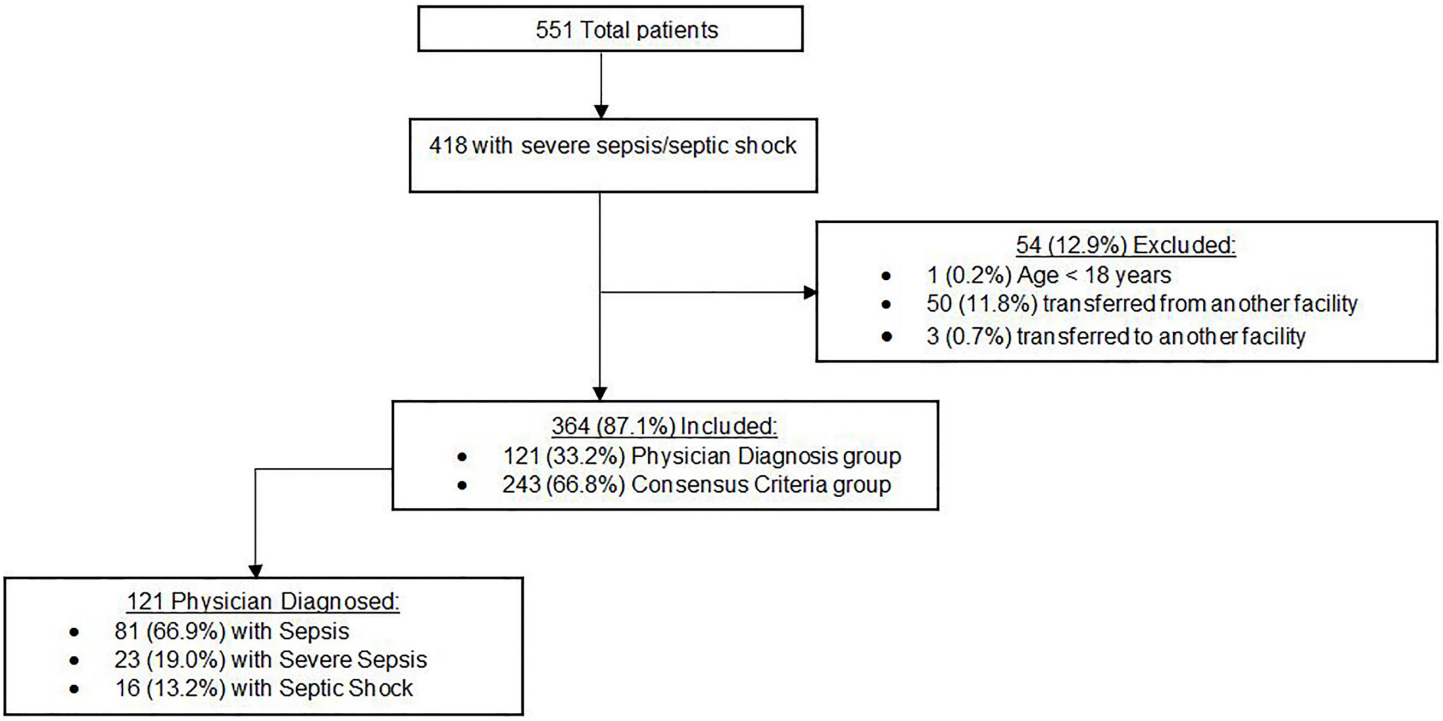

Figure. Study flow diagram of the total number of patients in this study of sepsis-related diagnosis, including the number of included and excluded patients.

Criteria" group was more likely to have an uncommon infection source. The "Physician Diagnosis" group was generally younger, yet more likely to have dementia or an indwelling urinary catheter; otherwise, the rates of comorbidities were similar between groups.

On average, patients identified as severe sepsis by physician diagnosis demonstrated higher presenting heart rate and temperature (Table 2). The mean minimum SBP in the "Physician Diagnosis" patients was lower than the "Consensus Criteria" patients (93.7 mm Hg vs 101.5 mm Hg, $P < 0.01$), and their average minimum respiratory rate was higher (18 per minute vs 16.4 per minute, $P < 0.01$) compared to the "Consensus Criteria" group (Table 2). Certain aspects of the clinical presentation were associated with the physician assigning a sepsis-related diagnosis among patients who met criteria for severe sepsis. Notably, the "Physician Diagnosis" group was more likely to have hypotension, elevated lactate or shock, established independent predictors of mortality in patients with presumed sepsis,[11-15] and the "Consensus Criteria" patients were more likely to have thrombocytopenia or hyperbilirubinemia.

Table 3 shows that the patients in the "Physician Diagnosis" group had a higher rate of organ dysfunction ($P < 0.01$), including more frequent incidence of elevated lactate ($P < 0.01$), and hypotension ($P < 0.01$). They were also more likely to have do-not-resuscitate orders documented in the ED, which may reflect a higher rate of comorbidities in this group ($P = 0.01$) (Table 1). Furthermore, the patients in the "Physician Diagnosis" group were more likely to have shock in the ED (Table 4).

Interventions

The "Physician Diagnosis" group more frequently received care that satisfied all elements of the three-hour bundle in the ED compared to the "Consensus Criteria" group (52.1% vs 20.2%, $P < 0.01$) (Table 5). Similarly, each individual component of the three-hour sepsis package was performed more frequently in the "Physician Diagnosis" group.

Outcomes

"Physician Diagnosis" patients had significantly higher rates of the primary outcome of mortality compared to the "Consensus Criteria" group (12.4% vs 3.3%, $P < 0.01$) (Table 6). Non-elective intubation, vasopressor administration, and ICU admission likewise occurred more frequently in the "Physician Diagnosis" group compared to the "Consensus Criteria" patients. Lastly, "Physician Diagnosis" patients were more likely to be transferred from the ward to the ICU within 24 hours (6.6% vs 1.7%, $P = 0.02$).

To evaluate the association between the NQF#0500 SEP-1 three-hour bundle and adverse outcomes, we performed a stratified analysis by group to assess whether the mortality

Table 1. Demographics, comorbidities, and infectious source by group.

Characteristic	Physician diagnosis	Consensus criteria	p-value
N	121	243	
Age, mean in years (SD)	51.4 (17.4)	55.8 (17.4)	0.03*
Do not resuscitate # (%)	19 (16)	18 (7)	0.01*
Comorbidities # (%)			
None	8 (7)	21 (9)	0.5
Alcohol abuse	15 (12)	27 (11)	0.72
Urinary catheter	11 (9)	5 (2)	< 0.01*
Vascular catheter	5 (4)	7 (3)	0.53
Congestive heart failure	14 (12)	29 (12)	0.92
Coronary artery disease	15 (12)	22 (9)	0.32
Myocardial infarction	5 (4)	13 (5)	0.61
Chronic obstructive pulmonary disease	20 (17)	48 (20)	0.46
Other lung disease	13 (11)	20 (8)	0.43
Dementia	6 (5)	3 (1)	0.03*
Diabetes mellitus	36 (30)	58 (24)	0.23
Hypertension	55 (46)	85 (35)	0.05
Intravenous drug use	13 (11)	36 (15)	0.28
End stage liver disease	7 (6)	25 (10)	0.15
Chronic renal insufficiency	25 (21)	34 (14)	0.1
Hemodialysis	4 (3)	6 (3)	0.65
Stroke/transient ischemic attack	10 (8)	18 (7)	0.77
Solid malignancy	22 (18)	62 (26)	0.12
Hematologic malignancy	8 (7)	26 (11)	0.21
Human immunodeficiency virus	3 (3)	5 (2)	0.8
Metastatic cancer	7 (6)	18 (7)	0.56
Transplant	4 (3)	12 (5)	0.47
Infection source			
Urine	23 (19.0)	35 (14.4)	0.26
Pulmonary	46 (38.0)	77 (31.7)	0.23
Skin/soft tissue	26 (21.5)	48 (19.8)	0.7
Abdominal	11 (9.1)	39 (16.1)	0.07
Viral	5 (4.1)	18 (7.4)	0.23
Blood	21 (17.4)	17 (7.0)	< 0.01*
Other	15 (12.4)	56 (23.1)	0.02

SD, standard deviation.
Patients may have more than one infectious source identified during their stay.
*denotes statistical significance of $p < 0.05$.

seen in either group was associated with failure to complete the three-hour sepsis bundle (Table 7). In the "Physician Diagnosis" group, those receiving the complete three-hour bundle had higher rates of non-elective intubation, vasopressor administration, ICU admission, and death. However, these differences were not statistically significant. For patients in the "Consensus Criteria" group, the rates of non-elective intubation and ICU admission were higher in those receiving the complete three-hour bundle. The rates of death were low overall in the "Consensus Criteria" group, and were not statistically different between those who received the complete three-hour bundle and those who did not.

Table 2. Vital signs of included patients.

	Physician diagnosis	Consensus criteria	
Vital sign	Mean (SD)	Mean (SD)	p-value
Initial SBP (mm Hg)	118.2 (28.2)	123.1 (26.2)	0.10
Initial DBP (mm Hg)	71.3 (20.2)	74.2 (18.2)	0.16
Initial temperature (°C)	37.4 (1.4)	37.1 (1.0)	0.01*
Initial HR (beats/minute)	110.7 (22.4)	105.8 (18.6)	0.03*
Initial RR (breaths/minute)	20.5 (5.6)	20.2 (7.2)	0.64
Initial oxygen saturation (%)	95.4 (6.3)	95.9 (4.8)	0.45
Maximum temperature (°C)	38.3 (1.5)	37.7 (1.2)	< 0.01*
Minimum temperature (°C)	36.6 (1.0)	36.5 (2.3)	0.53
Maximum HR (beats/minute)	112.8 (23.2)	114.9 (20.6)	0.38
Minimum HR (beats/minute)	93.8 (22.8)	86.9 (17.3)	< 0.01*
Maximum SBP (mm Hg)	135.4 (25.8)	136.9 (24.2)	0.59
Minimum SBP (mm Hg)	93.7 (20.2)	101.5 (21.1)	< 0.01*
Maximum RR (breaths/minute)	23.6 (7.1)	24.1 (9.3)	0.66
Minimum RR (breaths/minute)	18.0 (5.1)	16.4 (3.5)	< 0.01*

HR, heart rate; *DBP*, diastolic blood pressure; *RR*, respiratory rate; *SBP*, systolic blood pressure; *SD,* standard deviation.
*denotes statistical significance of p < 0.05.

Table 3. Frequency of organ dysfunction (OD) between the two groups of severe sepsis patients.

Organ dysfunction parameter	Physician diagnosis	Consensus criteria	p-value
Number of OD			< 0.01*
0	9 (7.4)	0 (0.0)	
1	54 (44.6)	158 (65.0)	
2	34 (28.1)	54 (22.2)	
3	12 (9.9)	22 (9.1)	
4	9 (7.4)	8 (3.3)	
5	2 (1.7)	0 (0.0)	
6	1 (0.8)	1 (0.4)	
Lactate > 2.0 mmol/L	82 (67.8)	125 (51.4)	< 0.01*
SBP < 90/MAP < 65 mmHg	59 (48.8)	67 (27.6)	< 0.01*
Creatinine > 2.0 mg/dL	28 (23.1)	42 (17.3)	0.18
Total bilirubin > 2.0 mg/dL	9 (7.4)	39 (16.1)	0.02*
Platelet < 100,000/uL	14 (11.6)	59 (24.3)	< 0.01*
INR > 1.5	18 (14.9)	38 (15.6)	0.85

SBP, systolic blood pressure; *MAP*, mean arterial pressure, *INR*, international normalized ratio.
*denotes statistical significance of p < 0.05.

DISCUSSION

This study suggests that, among patients meeting severe sepsis criteria, EPs assign a sepsis-related diagnosis and provide more sepsis-related care to patients with a higher severity of illness. Despite a higher compliance rate with the three-hour bundle completion, patients within the "Physician Diagnosis" group had a higher rate of in-hospital mortality, vasopressor administration, ICU admission from the ED, and transfer to the ICU from the hospital ward. These results suggest that physicians

Table 4. Determinants of shock in the emergency department.

Shock determinant	Physician diagnosis; number (%)	Consensus criteria; number (%)	p-value
Vasopressor administration	18 (14.9)	4 (1.7)	< 0.01*
Lactate > 4.0 mmol/L	11 (9.1)	11 (4.5)	0.09
SBP < 90 mmHg after 2L IVF	40 (33.1)	28 (11.5)	< 0.01*
Total with shock	52 (43.0)	38 (15.6)	< 0.01*

IVF, intravenous fluids; *SBP*, systolic blood pressure.
Note that patients may exhibit more than one criteria for shock.
*denotes statistical significance of p < 0.05.

recognize a higher risk population among those meeting criteria for severe sepsis, potentially based in part on the 1992 Consensus definitions, and this risk stratification leads to more aggressive interventions in the ED.

Within the "Consensus Criteria" cohort, mortality and all secondary outcomes occurred more frequently in patients who received a completed three-hour sepsis bundle. Again, the association between adverse outcomes and completion of the three-hour bundle in this group suggests that clinicians are identifying and aggressively treating those with more severe disease among patients meeting severe sepsis criteria. Patients in the "Consensus Criteria" group who received less aggressive care had lower rates of morbidity and mortality in comparison and, similarly, suffered lower mortality rates compared to prior study populations with severe sepsis.[16] In light of the risks of antibiotic overuse,[17] aggressive volume resuscitation[18] and the need for resource stewardship,[19] encouraging more nuanced sepsis care may be more appropriate, as opposed to broadly initiating standard bundles across this heterogeneous cohort of patients.

A previous study by Nguyen et al. noted a discrepancy between the frequency and severity of sepsis diagnoses when comparing EP diagnoses and the 1992 Consensus definitions.[8] In this study, the authors were concerned that under-diagnosis represented under-recognition of high-risk patients, potentially leading to delays in early, critical treatments. In our study, the "Consensus Criteria" cohort did receive fewer individual three-hour bundle interventions and received the entire three-hour bundle significantly less frequently than those given a sepsis diagnosis. Yet, among these "under-identified" and "under-treated" patients, the infrequency of adverse outcomes calls into question the potential gains available if aggressive sepsis care were mandated for all patients meeting severe sepsis criteria. Future iterations of the CMS guidelines may improve resource utilization by integrating physician gestalt into the process of identifying patients, especially in the ED setting where risk-stratification is intrinsic to the EP's role. Furthermore, emergency clinicians may temper the temptation to administer care according to the CMS guidelines across the spectrum of severe sepsis, when the care is driven solely to meet guidelines and not based on the sense of clinical utility.

LIMITATIONS

There are several limitations inherent in our study. It was performed at two large, academic referral centers both located in the same urban setting, potentially limiting geographic generalizability. Similarly, the patient

Table 5. Three-hour bundle interventions received, by group.

Intervention	Physician diagnosis; number (%)	Consensus criteria; number (%)	p-value
Lactate checked	111 (91.7)	163 (67.1)	< 0.01*
Blood cultures before antibiotics	95 (78.5)	128 (52.7)	< 0.01*
Appropriate antibiotics given	72 (59.5)	74 (30.5)	< 0.01*
2L IVF given	72 (59.5)	73 (30.0)	< 0.01*
IVF not applicable	30 (24.8)	118 (48.6)	< 0.01*
Completed entire 3-hour bundle	63 (52.1)	49 (20.2)	< 0.01*

IVF, intravenous fluids.
*denotes statistical significance of p < 0.05.
**Includes patients where the three-hour bundle did not require IVF administration.

Table 6. The frequency and timing of adverse outcomes

Adverse event	Physician diagnosis; number (%)	Consensus criteria; number (%)	p-value
In-hospital mortality			
ED	0 (0.0)	2 (0.8)	0.32
Within 24 hrs	4 (3.3)	0 (0.0)	0.01*
24-72 hrs	4 (3.3)	3 (1.2)	0.18
>72 hrs	7 (5.8)	4 (1.7)	0.03*
Total	15 (12.4)	8 (3.3)	0.01*
Non-elective intubation			
ED	14 (11.6)	12 (4.9)	0.02*
Within 24 hrs	2 (1.7)	3 (1.2)	0.75
24-72 hrs	2 (1.7)	2 (0.8)	0.47
> 72 hrs	1 (0.8)	4 (1.7)	0.53
Total	19 (15.7)	21 (8.6)	0.04*
Vasopressor administration			
ED	19 (15.7)	4 (1.7)	< 0.01*
Within 24 hrs	4 (3.3)	10 (4.1)	0.71
24-72 hrs	3 (2.5)	1 (0.4)	0.07
>72 hrs	1 (0.8)	2 (0.8)	1.0
Total	27 (22.3)	17 (7.0)	< 0.01*
ICU admission			
From ED	53 (43.8)	43 (17.7)	< 0.01*
Within 24 hrs	8 (6.6)	4 (1.7)	0.02 *
24-72 hours	5 (4.1)	2 (0.8)	0.04 *
After 72 hours	1 (0.8)	6 (2.5)	0.43
Never	54 (44.6)	188 (77.4)	< 0.01 *

ED, emergency department; *ICU*, intensive care unit.
*denotes statistical significance of $p < 0.05$.

population studied may not adequately represent patients seen in rural or community settings. Our population was comprised of patients who presented during the spring months, and the study may not represent variations in the presentation of septic patients or potential efficacy of sepsis treatments for seasonal diseases. While the act of designating a sepsis-diagnosis and initiating sepsis treatment could vary seasonally at academic institutions based on resident training, all patient care and diagnoses were supervised by an attending physician, making temporal trends in diagnosis and treatment unlikely.

In addition, our study was observational, retrospective, and based on a chart review. These charts were written by a variety of medical providers (resident and attending physicians, physician assistants, and nurse practitioners) with a possibility of misclassification bias. Furthermore, a physician's medical decision-making process may incorporate consensus guidelines, and different providers may have used these consensus guidelines to a variable degree based on their training. Lastly, there may be inaccuracies in obtaining information related to patients' medical comorbidities, and timing of interventions (blood cultures before antibiotics, IV fluids within three hours, etc.) as this information was obtained from what was recorded in the chart. However, it is unlikely that these errors would be systematic in a way that would bias the overall results of the study.

CONCLUSION

EP-assigned sepsis diagnoses reflect more severe illness, with increased in-hospital mortality and adverse outcomes, compared to ED patients meeting severe sepsis criteria but not specifically diagnosed as such. Patients of ED clinicians who are not specifically identified as septic by diagnosis in the ED chart, and who do not receive a completed three-hour bundle, nevertheless have lower rates of adverse outcomes, suggesting a less-ill cohort.

Table 7. Adverse outcomes, stratified by group, based on the completion of the entire 3-hour sepsis bundle.

Adverse oucome	Physician diagnosis; number (%)	p-value	Consensus criteria; number (%)	p-value
Death				
Completed 3hr bundle	10/63 (15.9)	0.23	3/49 (6.1)	0.21
Did not complete 3hr bundle	5/58 (8.6)		5/194 (2.6)	
Vasopressor administration				
Completed 3hr bundle	17/63 (27.0)	0.20	9/49 (18.4)	<0.01*
Did not complete 3hr bundle	10/58 (17.2)		8/194 (4.1)	
Non-elective intubation				
Completed 3hr bundle	13/63 (20.6)	0.12	8/49 (16.3)	0.03*
Did not complete 3hr bundle	6/58 (10.3)		13/194 (6.7)	
ICU admission				
Completed 3hr bundle	40/63 (63.5)	0.06	17/49 (34.7)	0.02*
Did not complete 3hr bundle	27/58 (46.6)		38/194 (19.6)	

ICU, intensive care unit.
*denotes statistical significance of $p < 0.05$.

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GLASS Clinical Decision Rule Applied to Thoracolumbar Spinal Fractures in Patients Involved in Motor Vehicle Crashes

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Introduction: There are established and validated clinical decision tools for cervical spine clearance. Almost all the rules include spinal tenderness on exam as an indication for imaging. Our goal was to apply GLASS, a previously derived clinical decision tool for cervical spine clearance, to thoracolumbar injuries. GLass intact Assures Safe Spine (GLASS) is a simple, objective method to evaluate those patients involved in motor vehicle collisions and determine which are at low risk for thoracolumbar injuries.

Methods: We performed a retrospective cohort study using the National Accident Sampling System-Crashworthiness Data System (NASS-CDS) over an 11-year period (1998-2008). Sampled occupant cases selected in this study included patients age 16-60 who were belt-restrained, front- seat occupants involved in a crash with no airbag deployment, and no glass damage prior to the crash.

Results: We evaluated 14,191 occupants involved in motor vehicle collisions in this analysis. GLASS had a sensitivity of 94.4% (95% CI [86.3-98.4%]), specificity of 54.1% (95% CI [53.2-54.9%]), and negative predictive value of 99.9% (95% CI [99.8-99.9%]) for thoracic injuries, and a sensitivity of 90.3% (95% CI [82.8-95.2%]), specificity of 54.2% (95% CI [53.3-54.9%]), and negative predictive value of 99.9% (95% CI [99.7-99.9%]) for lumbar injuries.

Conclusion: The GLASS rule represents the possibility of a novel, more-objective thoracolumbar spine clearance tool. Prospective evaluation would be required to further evaluate the validity of this clinical decision rule. [West J Emerg Med. 2017;18(6)1108–1113.]

INTRODUCTION

Effective diagnosis of spinal column injuries continues to present a diagnostic challenge to clinicians both in the pre-hospital and in-hospital environment. Risks of motion or force exacerbating potential spinal injuries have been historically overstated but have led to the challenge of deciding who needs radiography to exclude significant injury to the spinal column after blunt trauma. The most well-known decision tools are the NEXUS and the Canadian cervical spine rules. Both of these well-known studies deal with cervical spine injuries, while thoracolumbar (TL) spine fractures from blunt trauma have not garnered the same attention.

Despite the lack of attention in the literature, prevalence of TL fractures is actually higher than cervical spine fractures. One study demonstrated the prevalence of TL injuries in blunt trauma patients undergoing radiographic imaging to be 6.3%[1] compared with described prevalence of approximately 2.4% for cervical spine injuries.[2]

Several studies have attempted to identify which factors accurately identify patients who should undergo radiographic

imaging.[3,4] O'Connor and Walsham conducted a literature review evaluating the indications for TL imaging in blunt trauma patients.[3] They reviewed 17 studies and came up with the following indications for imaging that would yield an anticipated sensitivity of 99.1%:

- High-risk mechanism of injury, defined as motor vehicle collision (MVC) ≥ 45mph, fall of ≥ 10 feet, ejection from motor vehicle or motorcycle, or any mechanism of injury outside of these criteria that could cause TL fracture;
- Painful distracting injury, defined as painful torso or long-bone injury sufficient to distract the patient from the pain of the TL injury;
- New neurological signs, or back pain or tenderness;
- Cognitive impairment, defined by Glasgow Coma Scale (GCS) < 15, abnormal mentation or clinical intoxication;
- Known cervical spine injury.

The indications for imaging of the cervical and TL spine in blunt trauma are similar. Neurological signs and symptoms, spinal column pain or distracting injuries, altered mental status or intoxication are commonly cited as an indication for imaging. Mechanism remains a component of many rules to identify the high-risk cohort and requires imaging even in the absence of physical findings.

The GLASS decision tool was derived in an attempt to identify those individuals involved in low-energy MVCs for whom cervical spine imaging could be excluded by looking at objective criteria at the scene of the accident rather than the subjective complaints of the patient.[5] Given the excellent characteristics of this decision tool for cervical spine injuries (sensitivity 95%, negative predictive value 99.2%, specificity 54%) we sought to evaluate if it could also be applied to determine those patients who are at low risk of TL spine fractures in low-mechanism MVCs. This could potentially eliminate unnecessary spinal immobilization of patients who have complaints of back pain but are at extremely low risk of a TL spine fracture that would require surgical intervention. Additionally, it may decrease radiography use in the emergency department for patients with findings such as pain or intoxication, which may otherwise prompt imaging.

Our study sought to determine if the previously derived GLASS decision tool could be applied to adequately exclude TL spine fractures after MVC. The GLASS criteria are as follows:

- Patient age 16-60 years
- No damage to any of the vehicle's windows
- No airbags deployed
- Patient was a front-seat occupant.
- Patient was restrained by a lap and shoulder belt.

Population Health Research Capsule

What do we already know about this issue?
The current clinical decision tools to determine which patients are at low risk of thoracolumbar injury in a motor vehicle accident have not been as robustly studied as those for cervical spine injuries. The current criteria for evaluating thoracolumbar injuries focus on mechanism of injury, painful distracting injuries, new neurological signs, back pain or tenderness, cervical spine injury, and cognitive impairment. Some of these patients may have back pain and tenderness, and thus could not be clinically cleared and require radiographic imaging.

What was the research question?
Can the previously derived GLASS (GLass intact Assures Safe Spine) Criteria be applied to patients involved in a motor vehicle accident to determine if they are at low risk for a thoracolumbar injury?

What was the major finding of the study?
Those patients who met the GLASS Criteria were found to be at low risk for any significant thoracolumbar injuries.

How does this improve population health?
Spinal injury remains a significant concern in motor vehicle collisions. The GLASS rule, if validated, may decrease unnecessary immobilization and decrease the expense and risks associated with unnecessary radiographic imaging.

Study Design

We conducted a retrospective cohort study to evaluate the association between a low-energy MVC and the likelihood of the vehicle occupant sustaining a TL spine injury that required surgical intervention or treatment with immobilization using the GLASS criteria. We used the National Highway Traffic Safety Administration National Automotive Sampling System Crashworthiness Data System (NASS-CDS) to test the GLASS clinical decision tool. This is the same database that was used to derive the GLASS cervical spine rule. The institutional review board exempted this study from its review.

Setting

We used data from NASS-CDS to enroll cases for the cohort study.[6] The NASS-CDS database provides nationally representative data regarding MVCs based on a weighted annual sample of approximately 5,000 police-reported collisions.[7] To be recorded in the database, at least one of the vehicles involved in the accident must have been damaged enough to require it being towed from the scene. NASS-CDS includes researcher-determined detailed information for each individual crash, including vehicle properties, damage to the vehicle, crash conditions, occupant characteristics and the injury outcome sustained by each vehicle occupant. A NASS field investigator measures over 200 different data points on each vehicle enrolled in the database. This includes investigating and documenting the status of all the glass on a vehicle including all windows, mirrors, etc., as well as the status of the airbag deployment. The injury severity assessment for each NASS-CDS case is done based on the Abbreviated Injury Scale (AIS) scoring system; in addition, injury description, severity rating, and identification of injury source are performed based on medical records and field investigation.[8]

Sample Selection

We selected motor vehicle occupants between the ages of 16 - 60 involved in a collision and reported in the NASS-CDS during the years 1998 to 2008 as sample cases in the study. The selection criteria further required that the occupant had to be seated in the front driver or passenger position, with lap and shoulder belt restraint, and the vehicle had to be equipped with functional, frontal driver and passenger airbags, which did not deploy during the event of the crash. The vehicle type considered in the study was limited to passenger cars, sport utility vehicles, light trucks and vans. To adequately evaluate post-crash window integrity as an exposure measure, vehicles were pre-screened to include the ones that had intact windows and all adjustable windows in completely closed position (windows up) prior to the MVC. We excluded from the study cases of vehicle fire, water submersion and other non-representative cases (sample weighting factors in excess of one million).

Exposure Outcomes And Measures

The exposure measure used in this analysis was the post-crash integrity of the vehicle windows. For each case selected in the sample, it was determined whether the windshield, door windows or the rear window had been damaged as a result of the crash impact. The cause of window damage could have been due either to occupant contact or contact from external sources in the crash environment. The outcome measure of the analysis was the incidence of a clinically important TL spine injury with an AIS severity magnitude of two and higher (AIS 2+) as reported in NASS-CDS. Clinically important TL spine injuries, as defined in this study, include cord contusion, cord laceration and vertebral body injury, which may include fracture, herniation, or dislocation.

Data Analysis

Using a 2 x 2 contingency table, we analyzed the measure of association between the post-crash integrity of the vehicle windows and the outcome event of an occupant in this vehicle to sustain an AIS 2 or more severe TL spine injury . In the analysis we computed chi-square statistic to compare the probability of sustaining a TL injury for the two exposure groups considered in the study, and we reported the association measure in terms of relative risk with 95% confidence intervals (CI). The performance characteristic of a rule, which states that post-crash integrity of vehicle windows is indicative of the absence of TL spine injuries, was evaluated with 95% CI for sensitivity, specificity and negative predictive value. We performed all analyses with the SAS statistical software, version 9.1 (SAS Institute, Inc., Cary, NC).

RESULTS

We examined a total of 14,191 occupant cases that when weighted represented over 10 million front-seat occupants involved in crashes during the study period. The vehicles involved were mostly passenger cars (62%), followed by SUVs (22%) and vans (7%). The demographics of these occupants involved in a MVC included a mean age of 34 years with 54% female ratio and 81% of them seated in the driver position (Table 1).

Thoracic spine injuries

There were a total of 7,639 crash victims with intact windows. Four of these cases had an AIS 2 or greater thoracic spine injury. Table 2 details the injury outcome of the four subjects with thoracic spine injury who would have been missed by the rule. One of the four patients, age 55, also suffered significant injuries including an aortic injury with hemorrhage, bilateral flail chest, splenic laceration, lung laceration, liver injury, and a cerebellar injury. Other injuries not listed included extremity contusions, small lacerations, and a finger fracture. There were a total of 6,552 cases with window damage, of which 68 sustained thoracic spine injury. GLASS had a sensitivity of 94.4% (95% CI [86.3-98.4%]), specificity of 54.1%(95% CI [53.2-54.9%]) , and negative predictive value of 99.9% (95% CI [99.8-99.9%]).

Lumbar spine injuries

There were 7,639 cases with intact windows. Ten subjects in these vehicles suffered lumbar injuries of AIS 2 or greater. Table 3 details the injury outcome of those 10 subjects. The 20-year-old patient suffered a cervical strain, chest wall contusion, and subgaleal hematoma, and was given an AIS code of being unconscious for less than one hour. The 39-year-old patient had unconsciousness of unknown duration, facial skin contusion, chest wall contusion, upper extremity contusion, and lower

Table 1. Descriptive summary of selected cases of front-seat occupants involved in motor vehicle collisions.

	N=14,191	
	N (or mean)	% (or SD)
Occupant		
Age (years)	34.1	12.61
Sex (male)	6582.0	46.38
Stature (cm)	170.6	10.78
Mass (kg)	76.4	19.09
Seating position (driver)	11476.0	80.87
Vehicle		
Passenger car (yes)	8767.0	61.78
SUV (yes)	3164.0	22.30
Van (including minivans) (yes)	1002.0	7.06
Light truck (yes)	74.0	0.05
Injury		
Fatality (yes)	180.0	1.27
Maximum known abbreviated injury scale (AIS)	46.43	
1	5664.0	40.21
2	678.0	4.81
3	372.0	2.64
4	154.0	1.09
5	107.0	0.76
6	22.0	0.16
Unknown	549.0	3.90

SD, standard deviation; *SUV*, sport (or suburban) utility vehicle.

Table 2. Injury outcomes in GLASS*-negative patients with thoracic Injuries (number of fracture type).

Age	Thoracic injury
37	Thoracic spine fractures with or without dislocation but no cord involvement (3).
32	Vertebral body fracture with minor compression and less than 20% loss of anterior height (2).
47	Transverse process fracture.
55	Thoracic vertebral body fracture not further specified ("burst fracture").

GLASS, GLass intact Assures Safe Spine clinical decision tool.

extremity contusions. The 41-year-old patient also had cervical spine sprain. One of the 45-year-old patients suffered a cervical spine disc herniation not further specified, while the other 45-year-old patient suffered a facial skin laceration and abrasion. Of the 6,552 cases with window damage, 93 had a lumbar injury. GLASS had a sensitivity of 90.3%(95% CI [82.8-95.2%]) , specificity of 54.2%(95% CI [53.3-54.9%]), and negative predictive value (NPV) of 99.9% (95% CI [99.7-99.9%]).

Thoracic and Lumbar combined

The study characteristics when combining all thoracic and lumbar injuries with intact glass were as follows: sensitivity 92.0% (95% CI [86.9-95.5%]); specificity 54.1% (95% CI [53.5-54.7%]); and NPV of 99.9% (95% CI [98.8-99.9%]). Table 4 details a 2 x 2 contingency table for both thoracic and lumbar injuries.

DISCUSSION

If prospectively validated, the GLASS rule would be a useful adjunct to clinical exam, which is unreliable for TL,[9] for emergency physicians making imaging decisions for injured patients. Moreover, in combination with a validated GLASS cervical spine rule, this data could reduce the number of patients immobilized in the pre-hospital setting for spinal "precautions." The assessment of vehicle windows and airbags is simple and rapid and typically already done by EMS providers, making the GLASS rule an ideal candidate for a prehospital clinical decision rule. More complex clinical decision rules such as the Maine Protocol have been derived and well-validated for proper use by prehospital personnel.[10] Decreasing immobilization leaves more time to focus on clinically important care, decreases risk to providers by allowing them to move patients from dangerous traffic or scene conditions more rapidly, and increases patient comfort while reducing well-documented harms of immobilization.

This is particularly useful for emergency physicians as well because there are currently no validated rules with both good sensitivity and specificity for TL spinal injuries.[11] Practice patterns widely vary among institution and clinicians for this reason.[12] This mechanism-based tool would provide good confidence to providers choosing to forgo radiation from computed tomography or plain radiography after a low-risk MVC, although its poor positive predictive value would not mandate high suspicion in the absence of physical findings. A prospective study is ongoing, and if GLASS is validated it would be the first such tool for these injuries.

LIMITATIONS

A primary limitation of the study is that we performed a retrospective cohort analysis using a national database. A prospective study would further clarify some of the injuries we found in our study group that we suspect were inaccurately reported in the database. It must be realized that the analysis performed for rule performance is not population-based and includes a random selection of police-reported cases involving tow-away crashes. This may have resulted in the slightly lower sensitivity recorded for GLASS, when compared to NEXUS and the Canadian C-Spine Rule, because we are not

Table 3. Lumbar injuries among GLASS*-negative patients (number of that fracture type).

Age	Lumbar injury
20	Transverse process fractures (2).
23	Lumbar vertebral body fracture with major compression greater than 20% loss of anterior height.
24	Lumbar vertebral body fracture with minor compression less than 20% loss of anterior height.
32	Lumbar vertebral body fracture with minor compression less than 20% loss of anterior height (2). Transverse process fractures (4).
39	Vertebral body fractures not further specified (2).
40	Lumbar strain. Lumbar disc herniation not further specified.
41	Lumbar vertebral body fracture with minor compression less than 20% loss of anterior height.
45	Lumbar disc herniation not further specified.
45	Lumbar vertebral body fracture with minor compression less than 20% loss of anterior height.
54	Spinous process fractures (2).

GLASS, GLass intact Assures Safe Spine clinical decision tool.

Table 4. 2 x 2 contingency table analyzing the association between the post-crash integrity of vehicle windows and thoracolumbar spine injuries in front-seat occupants restrained by seatbelts.

Raw counts	T-spine injury AIS 2+	No T-Spine Injury AIS 2+
GLASS positive	68	6,484
GLASS negative	4	7,635
	L-spine Injury AIS 2+	No L-Spine Injury AIS 2+
GLASS positive	93	6,459
GLASS negative	10	7,629

GLASS, GLass intact Assures Safe Spine clinical decision tool.

capturing occupants involved in accidents in which neither vehicle required towing. Although the NASS-CDS includes weighting information to extrapolate the risk measures at the national level, inaccuracies associated with the weighting scheme to appropriately address specific injury outcomes and glass-damage exposure may lead to misleading results. The NASS-CDS data used was from 1998-2008, including older-model vehicles, which may have affected the data compared to modern vehicles as crashworthiness continues to improve. It is unknown whether window breakage would increase or decrease with this; however, other factors such as development of side curtain airbags may exclude more individuals from application of this rule.

CONCLUSION

The GLASS decision tool holds the promise to be an effective tool to safely rule out serious thoracic or lumbar spinal injury after an MVC based solely on objective criteria. In this retrospective cohort analysis, patients involved in accidents in which none of the GLASS criteria were met were very unlikely to have suffered a clinically significant spinal injury. This decision tool needs to be prospectively validated to further clarify the actual characteristics of the rule with regard to sensitivity and specificity, as well as ease of implementation, and potential cost savings. If validated, it has the potential to decrease both unnecessary immobilization and exposure to radiography.

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ALiEM Blog and Podcast Watch: Toxicology

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Introduction: The WestJEM Blog and Podcast Watch presents high-quality open-access educational blogs and podcasts in emergency medicine based on the ongoing Academic Life in Emergency Medicine (ALiEM) Approved Instructional Resources (AIR) and AIR-Professional (Pro) series. Both series critically appraise open-access educational blogs and podcasts in EM using an objective scoring instrument. This installment of the blog and podcast watch series curated and scored relevant posts in the specific topic of toxicology emergencies from the AIR-Pro Series.

Methods: The AIR-Pro Series is a continuously building curriculum covering a new subject area every two months. For each area, eight EM chief residents identify 3-5 advanced clinical questions. Using FOAMsearch.net and FOAMSearcher to search blogs and podcasts, relevant posts are scored by eight reviewers from the AIR-Pro editorial board, which is comprised of EM faculty and chief residents at various institutions across North America. The scoring instrument contains five measurement outcomes based on seven-point Likert scales: recency, accuracy, educational utility, evidence based, and references. The AIR-Pro label is awarded to posts with a score of ≥28 (out of 35) points. An "honorable mention" label is awarded if board members collectively felt that the blogs were valuable and the scores were > 25.

Results: A total of 31 blog posts and podcasts were included. Key educational pearls from the six high-quality AIR-Pro posts and four honorable mentions are summarized.

Conclusion: The WestJEM ALiEM 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, crowdsourced approach towards critically appraising educational social media content for EM clinicians. This installment focuses on toxicology emergencies. [West J Emerg Med. 2017;18(6)1114-1119.]

INTRODUCTION

Despite the rapid rise in social media educational content on blogs and podcasts, especially in emergency medicine (EM),[1] there has only been preliminary progress in helping educators and learners identify quality resources.[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 (III).[5] Residency

programs, however, were often unsure how to identify quality online resources specifically for asynchronous learning and III credit.

To address this need, the Approved Instructional Resources (AIR) Series[6] and AIR-Professional (Pro) Series were created in 2014 and 2015, respectively, by Academic Life in Emergency Medicine (ALiEM) to help EM residency programs identify quality online content specifically on social media. Using an expert-based, crowdsourced approach, these two programs identify trustworthy, high-quality educational blog and podcast content. The intended audience for the AIR series is EM junior residents, and for the AIR-Pro Series is the EM advanced practitioner. This blog and podcast watch series on *WestJEM* presents annotated summaries from the AIR and AIR-Pro Series.

This installment from the AIR-Pro Series summarizes the best scoring social media educational resources on specific topics within toxicology emergencies.

METHODS

Question Identification

The AIR-Pro Series is a continuously building curriculum covering a new subject area every two months. For each area, eight EM chief residents from different U.S. residency programs on the ALiEM-Pro editorial board identify 3-5 focused, advanced-level clinical queries within the featured subject area. The topics for this installment included the following:

1. Flumazenil in benzodiazepine overdose
2. Acetaminophen – drawing and timing of levels
3. Opioid overdoses
4. Acetaminophen toxicity related to liver transplant
5. Salicylates and hemodialysis

Inclusion and exclusion criteria

All available blog posts and podcasts on these five topics were identified using two custom EM search engines: FOAMsearch.net and FOAMSearcher. Blog posts and podcasts written in English and identified by key search terms were included for our scoring by our expert panel. Journal articles were excluded from the list.

Scoring

Extracted posts were scored by eight reviewers from the AIR-Pro editorial board, which is comprised of EM core faculty and chief residents from various U.S. institutions. The eight reviewers included five chief residents from the AIR-Pro editorial board as well as three EM faculty educators. The scoring instrument contains five measurement outcomes using seven-point Likert scales: recency, accuracy, educational utility, evidence based, and references (Table 1).

Data Analysis

An AIR-Pro endorsement is given to posts with a score of ≥28 (out of 35) points. Depending on the redundancy of the highest scoring posts, the best of these are then selected to address each pre-selected topic. An "honorable mention" label is also given to posts specifically felt to be worthwhile, accurate, unbiased, and educationally valuable for advanced clinicians by consensus of the AIR-Pro board. These posts must have scored ≥25 (out of 35) points.

RESULTS

A total of 31 blog posts and podcasts were initially included. Key educational pearls from the six high-quality, AIR-Pro posts and four honorable mentions are summarized (Table 2).

AIR-Pro Content

1. Awad N. Flumazenil: Friend or Foe? EM PharmMD. (November 7, 2013) http://empharmd.blogspot.ca/2013/11/flumazenil-friend-or-foe.html

This blog post discusses the incidence of seizures associated with the use of flumazenil in benzodiazepine overdose. It provides evidence that questions the long-held belief regarding the risk of seizures associated with the use of flumazenil.

Take home points

The post acknowledges that earlier studies documented a 13% incidence of seizures associated with the use of flumazenil; however, a number of recent studies put that rate at about 1%. Although the true incidence of seizures with the use of flumazenil cannot be precisely ascertained, it should be used with caution. The use of flumazenil is warranted for the following specific emergent situations in non-chronic benzodiazepine users: pediatric ingestions, iatrogenic toxicity, and a paradoxical response associated with a pure benzodiazepine overdose.

2. Hayes B. Utility of Pre-4-Hour Acetaminophen Levels in Acute Overdose. *ALiEM*. (August 5th, 2015) https://www.aliem.com/2015/utility-of-pre-4-hour-acetaminophen-levels-in-overdoses/

Through a review of multiple studies addressing the utility of pre-four hour levels, the timing of acetaminophen levels are examined including the interpretation of these levels.

Take-home points

Undetectable levels drawn after one hour of ingestion suggest that it is unlikely that the four-hour level will be clinically significant. The Rumack-Matthew nomogram, however, can only be used with an adequate negative predictive value when acetaminophen levels are drawn four hours after ingestion. Emergency physicians should

Table 1. AIR-Pro scoring instrument for blog and podcast content (maximum score = 35 points).

Tier 1: recency	Score	Tier 2: content accuracy	Score	Tier 3: educational utility	Score	Tier 4: evidence based- medicine	Score	Tier 5: referenced	Score
When was the blog post or podcast published?		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) and thus lack bias?		Are the authors and literature clearly cited?	
≥6 years ago or unknown	1	Yes, many concerns from many inaccuracies	1	Low value: No valuable pearls	1	Not EBM based, only expert opinion	1	No	1
5-6 years ago	2		2		2		2		2
4-5 years ago	3	Yes, a major concern about few inaccuracies	3	Yes, but there are only a few (1-2) valuable or multiple (>=3) less-valuable educational pearls	3	Minimally EBM based	3		3
3-4 years ago	4		4		4		4	Yes, authors and general references are listed (but no in-line references)	4
2-3 years ago	5	Minimal concerns over minor inaccuracies	5	Yes, there are several (>=3) valuable educational pearls, or a few (1-2) KEY educational pearls that every resident should know before graduating	5	Mostly EBM based	5		5
1-2 years ago	6		6		6		6		6
<1 year ago	7	No concerns over inaccuracies	7	Yes, there are multiple KEY educational pearls that residents should know before graduating	7	Yes exclusively EBM based (unbiased)	7	Yes, authors and in-line references are provided	7

continue to aim to draw levels after four hours of ingestion, but especially within seven hours if possible to ensure timely treatment with N-acetylcysteine if necessary.

3. Carley S. Opiate Overdose in the ED. *St.Emlyn's*. (February 27, 2015) http://stemlynsblog.org/opiate-overdose-in-the-ed-st-emlyns/

This 23-minute podcast, with a subsequent blog summary, covers the approach to patients with an opioid overdose. It emphasizes cautious reversal and continuous monitoring to ensure patient safety.

Take home points

Consider opioid ingestion in patients with toxidrome findings of miosis, central nervous system depression, respiratory depression, and consequences of prolonged hypoxia (seizures, dysrhythmias, brain injury). Do not give high doses of naloxone out of concern for precipitating

Table 2. Blog posts and podcasts receiving an AIR-Pro endorsement or honorable mention on the topic of toxicology.

Article title	Authors	Date	Title	Website URL
Flumazenil: Friend or Foe?	Nadia Awad	Nov 7, 2013	AIR-PRO	http://empharmd.blogspot.ca/2013/11/flumazenil-friend-or-foe.html
Utility of Pre-4-Hour Acetaminophen Levels in Acute Overdose	Bryan Hayes	Aug 5, 2015	AIR-PRO	https://www.aliem.com/2015/utility-of-pre-4-hour-acetaminophen-levels-in-overdoses/
Opiate Overdose in the ED	Simon Carley	Feb 27, 2015	AIR-PRO	http://stemlynsblog.org/opiate-overdose-in-the-ed-st-emlyns/
Treat and Release vs. Observation After Naloxone for Opioid Overdose	EMJ Club	Nov 24, 2014	AIR-PRO	http://www.foamem.com/2014/11/24/treat-and-release-vs-observation-after-naloxone-for-opioid-overdose/
Liver Transplantation for Paracetamol Toxicity	Chris Nickson	April 30, 2016	AIR-PRO	http://lifeinthefastlane.com/ccc/liver-transplantation-for-paracetamol-toxicity/
5 Tips in Managing Acute Salicylate Poisoning	Kristin Fontes	Nov 4, 2013	AIR-PRO	https://www.aliem.com/2013/5-tips-in-managing-acute-salicylate-poisoning/
Paracetamol/Acetaminophen Overdose	Chris Nickson	Sept 3, 2010	Honorable Mention	http://lifeinthefastlane.com/paracetamol-overdose/
Tricks of the Trade: Naloxone Dilution for Opioid Overdose	Bryan Hayes	Nov 17, 2014	Honorable Mention	https://www.aliem.com/2014/trick-trade-naloxone-dilution/
Paracetamol	Chris Nickson	2015	Honorable Mention	http://lifeinthefastlane.com/tox-library/toxicant/analgesia-and-anti-inflammatories/paracetamol/
Pearls and Pitfalls of Salicylate Toxicity in the Emergency Department	Justin Bright	Oct 13, 2015	Honorable Mention	http://www.emdocs.net/pearls-and-pitfalls-of-salicylate-toxicity-in-the-emergency-department/

withdrawal, unless the patient is in cardiac arrest. Naloxone has a shorter half-life than most long-acting opioids and will often need to be re-dosed. This is especially relevant in the patient who received one dose with significant response who is threatening to leave the department. Prior to discharge or admission it is also important to evaluate a patient for a possible intentional overdose requiring psychiatric evaluation, rhabdomyolysis or compartment syndrome due to prolonged unconsciousness, as well as for substance-abuse referral.

4. Cohn B, Schwarz E. Treat and Release vs. Observation After Naloxone for Opioid Overdose. *EMJ Club Podcast 17*. (November 24, 2014) http://emjclub.com/podcast/observation-after-naloxone

This 18-minute podcast uses a clinical case scenario to highlight the disposition considerations in the case of patients who overdose on opioids and received naloxone. Through a PubMed search, the podcast uses a journal club approach to analyze four articles on the topic.

Take home points

The literature supports a "treat and release" strategy for a specific set of patients who have overdosed on opioids. These patients must return to their pre-overdose baseline, be hemodynamically stable and alert, and understand the risks versus benefits of their medical condition prior to discharge. This strategy has not been tested in an overdose of long-acting opioids such as methadone. Thus, caution should be applied in its use in this scenario since rebound symptoms are common with long-acting opioids.

5. Nickson C. Liver Transplantation for Paracetamol Toxicity. *Life in the FastLane*. (April 30, 2016) http://lifeinthefastlane.com/ccc/liver-transplantation-for-paracetamol-toxicity

This post is an overview of liver failure in the setting of acetaminophen (paracetamol) toxicity. Nickson outlines the details for identification of possible transplant candidates, utility of the King's College Criteria and research thus far on long-term outcomes of acute liver failure from toxicity.

Take-home points

Keep a low threshold for transferring patients to a hepatobiliary transplant center for possible transplant if there are any signs to suggest severe end-organ damage. The King's College Criteria is the most commonly used tool for identifying transplant candidates. More recent studies suggest that survival rates without a liver transplant is improving and questions the utility of liver transplant in most cases.

King's College Criteria:

- pH < 7.3, or
- All below (within 24-hr period):
- INR > 6 (PT > 100s)
- Cr > 300 mmol/L
- grade III or IV encephalopathy

6. Fontes K. 5 Tips in Managing Acute Salicylate Poisoning. *ALiEM.* (November 4, 2013) https://www.aliem.com/2013/5-tips-in-managing-acute-salicylate-poisoning/

This blog post highlights several key clinical pearls in managing acute salicylate poisoning. Main discussion points include serum levels and concentrations, treatment with alkalinization, and indications for hemodialysis.

Take home points

Trending a patient's serum salicylate levels is more important than a single value level. Furthermore, acidosis correlates with severity of illness. The goal of treatment is to maintain a serum pH of 7.50-7.55 by adding three ampules (50 mL each) of 8.4% sodium bicarbonate to one liter of 5% dextrose in water. Avoid intubation if possible, but if necessary give sodium bicarbonate prior and hyperventilate the patient after to maintain compensatory respiratory alkalosis. Emergent hemodialysis should be seriously considered for patients with serum salicylate levels >100 mg/dL, as well as for patients with any salicylate level plus severe symptoms such as central nervous system dysfunction, renal failure, cerebral/pulmonary edema, or unexplained acid-based disturbance.

7. Nickson C. Paracetamol/Acetaminophen Overdose. *Life in the FastLane.* (Sept 3, 2010) http://lifeinthefastlane.com/paracetamol-overdose/

This blog post summarizes the key pearls in the epidemiology, identification and management of acetaminophen overdose.

Take home points

Paracetamol/acetaminophen (APAP) is the most common medication taken in overdose and the number one cause of acute liver failure in the U.S. APAP toxicity is typically thought to occur in four stages although these symptoms and timeline are not always consistent.

- Stage 1 (0-24 hr): Preclinical stage — Nonspecific symptoms
- Stage 2 (24-72 hr): Onset of liver injury — Nausea and vomiting, right upper quadrant pain, abnormal liver function tests, elevated lactate and creatinine
- Stage 3 (72-96 hr): Maximal hepatotoxicity — Liver failure, renal failure, coagulopathy, hypoglycemia, encephalopathy
- Stage 4 (>5 days): Recovery phase if the patient survives — Resolution of hepatotoxicity

Activated charcoal was previously used in the setting of acute ingestion, but is much less effective after 1-2 hours after ingestion. N-acetylcysteine (NAC) is now the standard treatment. NAC promotes the non-toxic metabolism of acetaminophen and should be started within eight hours of ingestion for maximum efficacy. If the patient presents after eight hours from ingestion with a significant risk for toxicity, it is reasonable to start IV NAC without an acetaminophen level as the risks of waiting outweigh the mild side effects of the drug such as flushing or a rash.

8. Hayes B. Tricks of the Trade: Naloxone Dilution for Opioid Overdose. *ALiEM.* (Nov 17, 2014) https://www.aliem.com/2014/trick-trade-naloxone-dilution/

This blog post discusses how to dilute naloxone to provide better titration in reversing the signs and symptoms from an opioid overdose, without inducing symptoms of opioid withdrawal.

Take Home Points

In a 10-mL syringe, combine 9 mL of sterile normal saline and 1 mL of 0.4 mg/mL naloxone. This results in a 10 mL solution of 0.04 mg/mL naloxone. Label the syringe and administer 1-2 mL (equal to 0.04-0.08 mg) of naloxone every 60 seconds to achieve the desired clinical state.

9. Nickson C. Paracetamol. *Life in the FastLane.* (2015) http://lifeinthefastlane.com/tox-library/toxicant/analgesia-and-anti-inflammatories/paracetamol/

This blog post is a review of the approach to acetaminophen (paracetamol) ingestion given different and complex ingestion scenarios.

Take Home Points

The toxic dose of acetaminophen in adults is >10 g or >200 mg/kg in 24 hours. The Rumack-Matthew nomogram is only validated for a single ingestion of acetaminophen; it is unreliable for multiple ingestions, delayed presentation, or modified release preparations. If a patient presents in the 8-24 hour period after the ingestion, obtain acetaminophen levels and liver enzymes to guide management, even if the patient is asymptomatic. For massive ingestions >30 g, higher doses of NAC may be necessary and will require expert consultation.

10. Bright J. Pearls and Pitfalls of Salicylate Toxicity in the Emergency Department. *emDocs*. (October 15, 2015) http://www.emdocs.net/pearls-and-pitfalls-of-salicylate-toxicity-in-the-emergency-department/

This blog post discusses the acute salicylate toxicity, specifically focusing on the optimization of fluid,

electrolytes, and acid-base management.

Take Home Points

A diagnostic pitfall is to rely solely on down trending salicylate levels alone. Down trending levels alone are not always reassuring for the patient's clinical course; be sure to monitor for signs of central nervous system (CNS) toxicity. Regarding management, patients are often hypovolemic, hypokalemic, and acidotic. Thus, ensure adequate fluid resuscitation, replace potassium levels to a goal of >4 mEq/L, and correct acidemia with sodium bicarbonate in dextrose 5% water (D5W) to a goal serum pH 7.45-7.55 to enhance elimination. Serum glucose levels should be maintained >150 mg/dL to prevent CNS-related hypoglycemia. If intubation is necessary, maintain pre-intubation minute ventilation to avoid worsening acidemia. Do not delay hemodialysis for those with serum levels >100 mg/dL or signs of significant toxicity.

CONCLUSION

The *WestJEM* 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. 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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Characteristics of Emergency Medicine Residency Programs in Colombia

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Introduction: Emergency medicine (EM) is in different stages of development around the world. Colombia has made significant strides in EM development in the last two decades and recognized it as a medical specialty in 2005. The country now has seven EM residency programs: three in the capital city of Bogotá, two in Medellin, one in Manizales, and one in Cali. The seven residency programs are in different stages of maturity, with the oldest founded 20 years ago and two founded in the last two years. The objective of this study was to characterize these seven residency programs.

Methods: We conducted semi-structured interviews with faculty and residents from all the existing programs in 2013-2016. Topics included program characteristics and curricula.

Results: Colombian EM residencies are three-year programs, with the exception of one four-year program. Programs accept 3-10 applicants yearly. Only one program has free tuition and the rest charge tuition. The number of EM faculty ranges from 2-15. EM rotation requirements range from 11-33% of total clinical time. One program does not have a pediatric rotation. The other programs require 1-2 months of pediatrics or pediatric EM. Critical care requirements range from 4-7 months. Other common rotations include anesthesia, general surgery, internal medicine, obstetrics, gynecology, orthopedics, ophthalmology, radiology, toxicology, psychiatry, neurology, cardiology, pulmonology, and trauma. All programs offer 4-6 hours of protected didactic time each week. Some programs require Advanced Cardiac Life Support, Pediatric Advanced Life Support and Advanced Trauma Life Support, with some programs providing these trainings in-house or subsidizing the cost. Most programs require one research project for graduation. Resident evaluations consist of written tests and oral exams several times per year. Point-of-care ultrasound training is provided in four of the seven programs.

Conclusion: As emergency medicine continues to develop in Colombia, more residency programs are expected to emerge. Faculty development and sustainability of academic pursuits will be critically important. In the long term, the specialty will need to move toward certifying board exams and professional development through a national EM organization to promote standardization across programs. [West J Emerg Med. 2017;18(6)1120-1127.]

INTRODUCTION

Colombia is a country of 47 million people located in the northwest corner of South America. The largest cities are Bogotá (pop 8.7 million), Medellin (pop 3.5 million), and Cali (pop 2.4 million) (Figure).[1] Despite a history of continuous internal armed conflict, Colombia has well-established democratic institutions and has made significant economic progress. In the last decade poverty has been reduced from 50% to 32.7%, extreme poverty has fallen from 17.7% to 10.4%, the capacity for basic education has been increased by almost 1.5 million, and unemployment has fallen from 15.6% to 9.6%.[2]

A new constitution in 1991 established healthcare as a fundamental right, and *Ley 100* [Law 100] of 1993 aimed to provide universal health insurance coverage. Although the level of health insurance coverage is high, access to healthcare varies greatly across geography, from small clinics with limited supplies and often staffed only by recent medical school graduates to tertiary hospitals in large cities, some with technology and resources like those of hospitals in developed nations.

In Colombia students apply to medical school immediately after high school.[3] There are currently 58 medical schools, of which 69% are private and 31% are public.[4] Medical school lasts 6-7 years, of which the last year, or *internado,* is similar in structure and responsibility to that of the first year of residency in the United States. After completing a year of service in an underserved area, graduates may apply to a residency, work independently as general practitioners in primary care, or work under the supervision of a specialist.[2] Colombia has residencies in all specialties but spots are limited, admissions are very competitive, the positions are often unsalaried, and almost all charge tuition.

Population Health Research Capsule

What do we already know about this issue?
Few countries have described their residency programs in the literature, and there is no universal standard curriculum for emergency medicine residencies.

What was the research question?
What is the current state of emergency medicine residency programs in Colombia and what are their characteristics?

What was the major finding of the study?
The seven emergency medicine residency programs in Colombia have different training approaches.

How does this improve population health?
In comparing EM residency programs, this study promotes the standardization of residency curricula with the potential to impact emergency care in Colombia and other countries.

Figure. Map of Colombia. Emergency medicine residencies in Colombia are found in the three largest cities, Bogotá, Medellin and Cali as well as in the mid-size city of Manizales.

There is increasing demand for emergency medicine (EM)-trained providers in Colombia.[3] Colombia has only about 200 trained EM specialists. In major urban areas most large hospitals have emergency physicians staffing higher acuity areas of the emergency department during part of the day. However, the great majority of emergency care is still provided by non residency-trained general practitioners and physicians from other specialties.[3] The first EM residency in Colombia was founded in 1996. There are currently seven EM residency programs in the country (Table 1). The goal of this study was to characterize the current state of the seven EM residencies in Colombia.

METHODS

Christian Arbelaez conducted site visits and semi-structured interviews with representatives from each of the seven EM residencies in Colombia between July 2013 and July 2016. Respondents included program directors, faculty, and residents. Phone calls and email communications were also used for follow-up questions. Topics covered in the interviews included the history of each program, number of residents, curricula, clinical

Table 1. General program characteristics of the seven emergency medicine residency programs in Colombia, which differ in tuition, length, number of faculty, number of residents and fellowships offered.

Program	CES	Rosario	Antioquia	Javeriana	FUCS	Caldas	ICESI
Year founded	1996	2001	2004	2008	2008	2013	2016
City	Medellin	Bogotá	Medellin	Bogotá	Bogotá	Manizales	Cali
Length	3 years	4 years	3 years	3 years	3 years	3 years	3 years
Tuition [A]	10,661,000	13,000,000	No tuition	13,228,000	13,050,000	10,300,000	11,840,000
Class size [B]	6	10	4	8	6	3	4
Residents total [C]	17	40	9	17	21	8	2
Emergency medicine faculty	15	10	1 plus 2 part-time	9	2	3	5
Application requirements [D]	Interviews	Interviews	English test	Simulation, oral exam, interviews	Interviews	Interviews	Interviews
Fellowships	Critical care	None	Critical care	None	None	None	Critical care
Special features	Oldest EM program in the country All EM rotations done with EM faculty	Only four-year program in the country	Only program with free tuition	Program has its own academic journal	Hospital San José was first hospital to train medical specialists in Colombia, starting 120 years ago	First residency program in a mid-size city	Newest program in the country

FUCS, Fundacion Universitaria de Ciencias de la Salud.
[A]Tuition in Colombian pesos (2,900 Colombian pesos ~ 1 USD).
[B]Number of residents accepted per year.
[C]Total number of residents in the program.
[D]Application requirements listed are in addition to a written test, which all programs require.

sites, faculty, and challenges faced. Interviews were performed in Spanish, recorded, transcribed, and translated to English. We analyzed responses to create descriptions of each program and identify common themes. We also reviewed program websites and documents detailing curricula provided by the programs. This survey was granted exemption through the Partners Healthcare Institutional Review Board.

RESULTS

History of Emergency Medicine Residencies

Of the seven EM residency programs, three are in Bogotá, two in Medellin, one in Manizales, and one in Cali.[3] The first EM residency program in Colombia was created in 1996 in Medellin by Universidad CES. In 2001 Universidad del Rosario in Bogotá, opened the second and only four-year program.[3] In 2004 Universidad de Antioquia in Medellin started the only public, tuition-free program to date.[3] In 2008, two programs opened in Bogotá: Pontificia Universidad Javeriana and Fundacion Universitaria de Ciencias de la Salud (FUCS). The Universidad de Caldas program started in Manizales in 2013. Universidad ICESI Fundación Valle del Lili in Cali was previously a site for the CES program and started its own residency program in 2016 (Table 1). In 2005, the Ministry of Social Protection (Ministry of Health) recognized EM as a medical specialty.[3] There are currently two Colombian EM peer-reviewed journals. They include *Perspectiva en Urgencias*, from the Asociación Colombiana de Especialistas de Emergencias, and *Urgentia* from Javeriana. The Asociación Colombiana de Especialistas de Emergencias (ACEM) is the largest EM organization in the country, representing over 200 emergency physicians and EM residents.

Applicant Selection

Applicants come mostly from the cities where the programs are located, but also from many other regions of the country. Similar to the application process for residencies in other specialties, EM residency applications are not centralized. The first step for all physicians applying to an EM residency consists of a general medicine written exam created by each residency program. Then each program has different processes to select candidates. CES conducts interviews with emphasis on clinical knowledge and leadership skills. Rosario has applicants shadow in the ED for half a day and discuss patient management with preceptors and also interview with psychiatry, EM faculty, the chief EM resident, the chief of EM, and an invited professor. Antioquia requires an English-language test and does not require interviews. Javeriana invites applicants with the best scores for a clinical simulation test, an oral exam and interviews with faculty

and the program director. FUCS invites the applicants with the top five test scores for interviews with the program director, the assistant coordinator, a psychologist and human resources staff. Caldas and ICESI require interviews. Programs receive between 30 and 60 applications every year. Some programs accept new residents on a yearly basis: CES accepts six, Antioquia four, Caldas three, and ICESI four. The remaining programs accept new residents every six months: Rosario accepts five, Javeriana four, and FUCS three (Table 1). The graduation rate is 90-100% across programs.

Tuition

Most residency programs in Colombia charge tuition. Antioquia is affiliated with a public university that does not charge tuition. Further, it provides a stipend of approximately $650 USD (CO$1,300,000) per semester. The rest of the programs do not provide a stipend and charge approximately $3,400 - $4,500 USD (CO$ 10,300,000 to 13,200,000) per semester (Table 1). *Crédito Ley 100* is a "forgivable" loan awarded to a limited number of residents through ICETEX, a government financial institution that provides financial aid for post-secondary education.[5]

Residency Program Characteristics

The curricula of the different programs are loosely based on those of U.S. EM residencies but with significant variations (Table 2 and Table 3).[6-13]

Emergency Medicine Faculty

At the time of this survey, the older programs, CES and Rosario, had the most EM faculty. CES had 15, and all EM rotations were done with EM faculty supervision. Rosario had 25 EM faculty, Javeriana nine EM faculty, FUCS two EM-trained faculty, and Antioquia had one full time and two part-time EM-trained faculty (Table 1). All program directors were EM-trained except for one who was surgery trained. EM is its own department at Rosario. At Javeriana and Antioquia EM is under the department of internal medicine.

Point-of-Care Ultrasound Training

All Colombian programs cited point-of-care ultrasound (POCUS) as one of the weaknesses in their curricula in a 2014 study.[14] The most commonly cited barriers to POCUS use were lack of instructors, lack of machines, and lack of time.[14] Other barriers included turf battles with other specialties, billing issues and equipment cost. However, since 2014 POCUS has become more available and now Rosario, Javeriana, Caldas and ICESI offer ultrasound training.

Residency Program Assessment and National Quality Assurance

The Ministry of Education plays an active role in ensuring the quality of postgraduate programs, including EM residencies, through the *Consejo Nacional de Acreditación de Colombia* (CNA), or National Accreditation Council. The accreditation system begins with a self-assessment, with the purpose of formulating actions to improve the quality of the program. This self-assessment is followed by an external evaluation by peer review, referred to as *Evaluación por Pares,* which evaluates the accuracy of the self-assessment and results in a submitted report to the CNA. Accreditation is granted after a final review based on the self-evaluation and peer review. This is valid for a period of 4-10 years depending on the quality of the program.[15]

Post-Residency

Most EM-residency graduates are finding jobs in community hospitals or in academic centers, usually in critical care areas within the ED. Since the specialty of EM is relatively young, these graduates are often the first EM-trained physicians and are often in charge of establishing the specialty in those institutions. Fellowship training in critical care is available in some programs. Fellowships such as ultrasound, EMS, pediatric EM or disaster medicine are not currently available. Many EM residency graduates go on to work in intensive care units rather than EDs, given better financial incentives.

Strengths and Challenges

CES

As the oldest program in the country with more than 20 years of experience, all EM rotations at CES are done with EM-trained faculty. The EM specialty and residency program are well established. Nonetheless, the program feels it needs to continue promoting itself within the university and hospitals to achieve the same level of recognition as older specialties.

Rosario

Rosario is the only four-year residency in the country and has 40 residents, the largest number in the country. Its seven clinical sites add expertise in trauma, toxicology, prehospital care, disaster preparedness, and cardiology. The program is working towards establishing a stronger academic connection with the university, since residents and faculty have felt disconnected from the larger university community.

Universidad de Antioquia

Antioquia is the only program in the country that offers free tuition. It has a strong emphasis on local epidemiology. Being part of the university faculty has significant financial benefits. Over the years the program has had to overcome political and administrative barriers within the hospitals and in relation to other specialties.

Javeriana

Javeriana has a strong emphasis on academic production and has its own academic journal. A weakness initially identified by trainees was the lack of ultrasound training. However, ultrasound training is now provided. Another weakness is relatively low exposure to trauma patients locally. However, at the time of this

Table 2. Clinical rotation curricula In Colombia. Colombian emergency medicine (EM) residency curricula are loosely based on U.S. EM residency curricula with important differences in percent of time spent in EM and other rotations. Residencies in the U.S. are accredited by the Accreditation Council for Graduate Medical Education (ACGME). ACGME requirements for EM residencies are included in the table for comparison.

Program	CES	Rosario	Antioquia	Javeriana	FUCS	Caldas	ICESI	U.S. ACGME[13]
EM time in months	11 (31%)	11 (23%)	4 (11%)	7 (19%)	12 (33%)	10 (28%)	7(19%)	60% of all clinical time
Pediatric time in months	2	2	2	4	1	2	None	5 months (or 20% of all EM time)
Critical care time in months	4	7	4	2	6.5	6	6	4 (2 during PGY2 or higher)
Obstetrics time in months	1	2	2	2	1	1	1	0.5 months or 10 low risk vaginal deliveries
Other Rotations	Anesthesia Cardiology Surgery IM Neurology Orthopedics Psychiatry Radiology Toxicology Elective	Anesthesia Cardiology Surgery IM Neurology Orthopedics Pain Psychiatry Radiology Toxicology Trauma Ultrasound Elective	Anesthesia Cardiology ENT/ophtho Surgery ID IM Neurology Orientation Orthopedics Plastic Surgery Radiology Toxicology	Anesthesia Cardiology ENT/ophtho Surgery IM Orthopedics Ophthalmology Psychiatry Radiology Trauma Ultrasound Urology Health Administration Electives	Anesthesia Surgery Neurology Neurosurgery Orthopedics Pulmonology Radiology Toxicology ENT Ophthalmology Research Electives	Anesthesia Endocrinology Cardio/ Pulm ENT Gastroenterology ID IM Nephrology Neuro-trauma Ophthalmology Plastic surgery Psychiatry Radiology Surgery Toxicology Trauma Ultrasound Urology Electives	Anesthesia Cardiology Epidemiology ID Nephrology Neurology Neurosurgery Pulmonology Radiology Research Toxicology Trauma Ultrasound Elective	Varies by program. Anesthesia, orthopedics, toxicology, ophthalmology, ENT common. Ultrasound required

ACGME,Accreditation Council for Graduate Medical Education; *EM*, emergency medicine; *ENT*, otorhinolaryngology; *ID*, infectious diseases; *IM*, internal medicine; *Ophtho*, ophthalmology.

Table 3. Didactics, research, and resident evaluation. The seven EM residency programs in Colombia differ in didactics, research and resident evaluation requirements. The U.S. ACGME* requirements are included for comparison.

	CES	Rosario	Antioquia	Javeriana	FUCS	Caldas	ICESI	U.S. ACGME
Didactics (hours per week)	4 plus rotation-specific didactics	5 plus 4 hours of research	5	5	6	Varies	6	5
Prehospital rotations	Educational sessions	None	4-week rotation	1-month rotation	No information available	Educational sessions	None	Ambulance rides Direct medical command experience Multi-casualty drills
Certifications (ACLS, ATLS, PALS)	Done in-house	Program covers 60% of cost	Not required but encouraged	ACLS and ATLS required	Required	ACLS required	Not required	Not required by ACGME but required by most hospitals
Research Requirement	1 project	1 project / semester 1 final thesis	1 project	1 project	1 project / year	1 project	None	1 project
Evaluation	Written test at random times Individual evaluation for each rotation according to competencies	Written tests every 3 months Evaluations after each rotation Evaluation for promotion to following year (meeting with PD)	Evaluation at the end of each rotation Semester evaluation "German seminar" i.e. seeing patients with faculty and getting feedback	Written exams every 3 months by subject Written and oral exam at the end of each rotation Test for promotion to the following year	Written and oral exams every 3 months administered by internists and surgeons	Clinical supervisors evaluate residents after every rotation block on their knowledge, clinical skills, teaching skills, and bedside manner.	Evaluation at the end of each rotation	Continuous clinical evaluation Twice-yearly written feedback on clinical perforance Yearly evaluation with program director

ACLS, Advanced Cardiac Life Support; *ATLS* Advanced Trauma Life Support; *PALS*, Pediatric Advanced Life Support, *ACGME*, Accreditation Council for Graduate Medical Education; *PD*, program Director.

study, there was a plan to have residents do a trauma rotation at Hospital Universitario del Valle in Cali, which has large numbers of trauma.

FUCS

FUCS has a strong emphasis on critical care and the larger university has a strong tradition of academic training with one of its hospitals having had the first residencies in any specialty in the country more than 120 years ago. Two weakness identified by the program are its lack of ultrasound training and absence of a formal university affiliation for program faculty.

Caldas and ICESI

These two programs are new with a small faculty but have dynamic leaders as program directors. They are both located in urban settings and are affiliated with strong medical schools that offer excellent clinical training.

DISCUSSION

Colombia is a land of contrasts. Its large cities have hospitals that rival those in the developed world, while healthcare in rural areas is more akin to that of a developing country with minimal infrastructure. EM professionals not only can improve the care Colombians receive in the ED but also bring expertise to strengthen prehospital and disaster care, both in urban and rural underserved areas. While Colombia's Constitution of 1991 established healthcare as a right and Law 100 expanded health insurance coverage to cover greater than 90% of the population, access, quality and funding continue to be a challenge. Deficiencies in the system have led to ED crowding around

the country. Most emergency care in Colombia is still being provided by non-residency trained providers. Emergency care requires expertise in the recognition and timely treatment of life-threatening conditions as well as the prioritization of resources for the flow of the ED. Now more than ever EM-trained physicians can help maximize ED resources to optimize throughput and clinical outcomes.

Colombia has made important strides in the development of EM with its seven residency programs and official recognition of EM as a specialty. Curricula are similar to those of residencies in the U.S., though with important variation. For example, ACGME requires 60% of clinical time to be spent in the ED under the supervision of EM-trained faculty.[13] In contrast, EM residents in Colombia spend 11-39% of their time in the ED. This low ratio of EM clinical time is likely related to the youth of EM as specialty in Colombia and the relatively few EM faculty. Colombian EM residents receive strong training in critical care with programs requiring 4-7 months, compared to the 4-month ACGME requirement. All programs offer about 4-6 hours of protected didactic time each week and all programs require or encourage residents to obtain Avanced Cardiac Life Support (ACLS), Pediatric Advanced Life Support (PALS), and Advanced Trauma Life Support (ATLS) certifications. Ultrasound training has been expanding, with four of the seven residencies providing ultrasound training at this time. Ultrasound is Colombia is not only an important tool for every emergency physician, but it can also be crucial as EM-trained providers start working in hospitals in more rural areas with no other imaging resources.

Most EM residency graduates go on to work in community hospitals with most becoming the first EM specialist at their workplaces. Many go on to work in intensive care units given their extensive training in critical care and better compensation. As EM matures, the specialty must advocate for better compensation and working conditions in order to attract emergency physicians to EDs. As EM continues to develop in Colombia, more residency programs are expected to emerge along with a growing number of EM faculty. Standardization of training across programs, certifying board exams, strengthening of professional societies, and academic development will be important steps to further advance the specialty.

LIMITATIONS

A limitation for this study is its data collection over a three-year span, which with the rapid evolution of the residency programs may have resulted in some of the results not being up to date at the time of publication. Co-authors of the study are part of the different residency programs, which could have introduced bias. However, this is balanced by the fact that each residency is represented by a co-author in the study.

CONCLUSION

Colombia has made great strides in the development of EM. EM continues to gain traction as a specialty and the number of residencies will likely continue to grow. There are seven EM residencies at this time with different curricula that will serve as models for future programs.

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ALiEM Blog and Podcast Watch: Procedures in Emergency Medicine

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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 Academic Life in EM (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 procedure 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 85 blog posts and podcasts were evaluated in June 2016. This report summarizes key educational pearls from the three AIR posts and the 10 Honorable Mentions.

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 procedure emergencies within the AIR series. [West J Emerg Med. 2017;18(6)1128-1134.]

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.[2-6] 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 (III).[7]

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.[8,9] 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.[10,11]

This installment from the AIR Series summarizes the highest scoring social media educational resources on EM procedures.

METHODS

Topic Identification

The AIR Series is a continuously building curriculum with topics based on the CORD testing schedule (http://www.cordtests.org/) and its monthly topics.

Inclusion and Exclusion Criteria

A search of the 50 most frequently visited sites per the Social Media Index (SMI)[12] was conducted for resources relevant to procedure emergencies, published within the previous 12 months. The search, conducted in June 2016, 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. Two of the AIR Editorial Board members, AG and TT, are reviewers for the *Western Journal of Emergency Medicine*. None of the AIR Editorial Board members have conflicts of interest with this publication series. The scoring process allows quality and educational-utility assessment for each blog post and podcast identified. 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 1).[13] More detailed methods are described in the original description of the AIR Series.[8,9] 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. More in-depth analysis of the methodology of the AIR series can be viewed in the initial article by Lin et al.[9]

RESULTS

The SMI-50 search yielded 85 blog posts and podcasts relevant to procedures, all of which were filtered and scored. Three AIR and 10 "Honorable mention" posts met our predetermined cut-offs. These 13 posts and podcasts are described below.

AIR Content

1. Nickson C. Apnoeic Oxygenation. Life in the Fast Lane. (January 10, 2016) AIR
http://lifeinthefastlane.com/ccc/apnoeic-oxygenation/

This blog post provides an overview of apneic oxygenation: defining the concept of safe apnea time, describing the relevant physiology, instructing on patient application, and analyzing the published literature.

Take-home points

Apneic oxygenation is an adjunct to pre-oxygenation prior to endotracheal intubation that can significantly increase the time before critical arterial desaturation, defined as a SaO2 below 88-90%. Apneic oxygenation can be particularly useful in critically ill patients who are prone to rapid hypoxia with intubation. The ideal method of apneic oxygenation is to provide oxygen via a nasal cannula set at oxygen flow rate of 15L/min oxygen. While it can be initiated at any time during the intubation process, it is ideally started before the administration of an induction agent. If the pre-induction SaO2 is below 95%, positive- pressure ventilation can be used in conjunction with nasal cannula prior to the intubation attempt. Although the literature on apneic oxygenation is both flawed and inconclusive, no studies show harm or desaturation as compared with standard treatment.

2. Weingart S. The Central Line Show Part 1: Avoiding Complications. (August 29, 2015) AIR
http://emcrit.org/podcasts/central-line-show/

This blog post focuses on preventing complications from central line placement.

Take-home points

The podcast first discusses unrecognized arterial line placement. To avoid this complication, Dr. Weingart advocates for confirmation of venous puncture prior to dilation. This is especially important in non-crash cases as well as with large-bore hemodialysis catheter placement. He outlines in detail a few confirmation methods including pressure transduction with the wire sheath, and the bubble test (also known as the flush test or rapid atrial swirl sign). He includes videos that demonstrate these methods in full detail. If a central line is inadvertently placed in an artery, he recommends to consult vascular surgery and not to remove the catheter in the subclavian position. He lastly discusses methods to prevent a lost guidewire: deliberate practice, improved training and supervision, and the avoidance of interruptions.

Table. Approved Instructional Resources 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; *EP*, emergency physician; *EBM*, evidence-based medicine.

3. Rezaie S. All Vascular Access Episode. REBEL EM. (November 12, 2015) AIR
http://rebelem.com/november-2015-rebelcast-all-vascular-access-episode/

This podcast covers two recent publications in vascular access. The first covers intravascular complications of central venous catheter (CVC) access and the second covers ultrasound- (US) vs. landmark-guided peripheral intravenous (IV) access.[14,15]

Take-home points

Among the three standard sites for CVC placement, the subclavian vein has the lowest risk of infectious complications when compared to internal jugular and femoral vein. In contrast, the femoral vein has the lowest rate of mechanical complications. Patient factors and the clinical scenario should determine which site is most appropriate. Regarding peripheral IV placement in patients with no palpable visible veins, the reviewed paper supports the use of US guidance over traditional landmark techniques. In patients with visible or palpable peripheral veins, the traditional landmark technique is quicker with better success rates.

4. Nickson C. Preoxygenation. Life in the Fast Lane. (March 15, 2016) Honorable Mention
http://lifeinthefastlane.com/ccc/preoxygenation/

This blog post reviews the methods, techniques, troubleshooting, and complications of pre-oxygenation prior to attempting endotracheal intubation.

Take-home points

The primary mechanism of pre-oxygenation is a process called denitrogenation, in which the nitrogen in the lungs is replaced with oxygen. In a healthy, fully pre-oxygenated patient, the safe apneic time is approximately eight minutes. In comparison the safe apneic time is as short as one minute in the patient who is not pre-oxygenated. For patients with SpO2 > 95% and adequate respiratory drive, a non-rebreather at 15L/min is usually effective for pre-oxygenation. High-flow nasal cannula for a minimum of three minutes may be an acceptable, and perhaps superior, alternative. For hypoxic patients, a bag-valve mask (BVM) with PEEP valve at 15L/min should be used. Positive pressure ventilation can improve pre-oxygenation in patients with inadequate respiratory drive. Reasons for inadequate pre-oxygenation include decreased preparatory time, poor mask seal, uncooperative patient, airway obstruction, poor respiratory reserve, and shunt physiology. Pre-oxygenation can be combined with apneic oxygenation.

5. Rezaie S. REBEL Cast: The All Thoracotomy Episode (October 8, 2015) Honorable Mention
http://rebelem.com/october-2015-rebelcast-the-all-thoracotomy-episode/

This blog and podcast reviews two articles discussing the factors that influence successful outcomes after resuscitative thoracotomy (RT).[16,17]

Take-home points

The first paper is a single center, observational study of survival after RT. In this study, every patient who survived or became an organ donor after RT had cardiac motion on Focused Assessment with Sonography in Trauma (FAST) exam. There were no survivors after RT in patients with no cardiac motion or pericardial effusion on FAST. Importantly, this data came from an institution that regularly performs RT. Thus, it likely represents a best-case scenario. The second article is a systematic review and meta-analysis that investigated factors that influence successful RT after blunt traumatic arrest. The article concludes that RT is not recommended for blunt trauma patients who have neither vital signs at any time after injury nor non-survivable head injuries. However, RT should be considered in patients who arrest upon arrival to the ED or have less than 15 minutes of CPR.

6. Morgenstern J. Neonatal (Newborn) Resuscitation 2015 Update. First10EM. (November 2, 2015) Honorable Mention
https://first10em.com/2015/11/02/neonatal-resuscitation-2015/

This is a blog post that reviews neonatal resuscitation and new recommendations from the 2015 International Liaison Committee on Resuscitation, American Heart Association, and European Resuscitation Council (ILCOR, AHA, and ERC) guidelines.[18,19]

Take-home points

The most important guideline updates are as follows: routine intubation and suctioning is no longer required for meconium; heart rate is measured using electrocardiogram leads and not umbilical cord palpation; and positive pressure ventilation can be used for respiratory distress or persistent cyanosis. The author also describes his protocol for neonatal resuscitation. Prior to neonate arrival, call for more physician help, assemble sufficient staff, and ready the necessary equipment including the warmer, medications, and appropriately-sized lines and endotracheal intubation supplies. Once present, the neonate requires appropriate positioning and warming. In premature infants < 28 weeks, use plastic materials to wrap the child to maintain warmth as towel drying can damage the fragile skin. If the neonate is > 28 weeks, proceed to rigorous stimulation. The initial assessment includes term, tone, and breathing and crying. After the initial interventions, reevaluate the heart rate every 30 seconds and intervene if there is no improvement by escalating to BVM and then to chest compressions. Consider ventilation problems from obstruction or underlying lung disease, cardiac pathology, shock, or sepsis.

7. Horeczko T. PEM Playbook – Adventures in RSI. EM Docs. (November 1, 2016) Honorable Mention
http://pemplaybook.org/podcast/adventures-in-rsi/

This blog and podcast uses various clinical scenarios to discuss pediatric airway management with a focus on advanced decision-making.

Take-home points

The blog presents an in-depth discussion about choice and dosing of induction and paralytic agents for four cases: sepsis, trauma, congenital cardiac disease, and status epilepticus. The author emphasizes that in managing critically ill patients the provider should resuscitate prior to intubation, increase the paralytic dose, and decrease the sedative dose. Providers should also prepare for post-intubation care prior to intubation. Lastly, the relative advantages and disadvantages of ketamine, etomidate, rocuronium, succinylcholine, and propofol are reviewed in each of these clinical scenarios. For sepsis, this post recommends ketamine with etomidate as second line. For trauma, the induction agent depends on the clinical scenario. For cardiogenic shock in a "blue baby," ketamine is recommended, but for a "pink baby" etomidate is preferred. Lastly, for status epilepticus, propofol or ketamine can be used.

8. Rezaie S. Complications of Procedural Sedation. REBEL EM. (February 22, 2016) Honorable Mention
http://rebelem.com/complications-of-procedural-sedation/

This blog post reviews a systematic review and meta-analysis of the incidence of adverse events during procedural sedation.[20]

Take-home points

In the 55 articles (25 randomized control trials and 30 observational studies) included in the review, the most common adverse events from procedural sedation were hypoxia, vomiting, hypotension, and apnea. Severe adverse events including aspiration, laryngospasm, and intubation were extremely rare. The post praised the methodology of the reviewed study, citing the vigorous search strategy, which included eight electronic databases, adherence to PRISMA (Preferred Reporting Items for Systematic Reviews) guidelines, and a high level of inter-observer agreement among the reviewers. These results can be used for enhanced shared decision-making with patients, which is further facilitated by a pocket card published with the meta-analysis.

9. Downham J. 6 Ways to Be Better with the Bag-Valve Mask. Critical Care Practitioner. (June 6, 2016) Honorable Mention
http://www.jonathandownham.com/6-ways-to-be-better-with-the-bag-valve-mask/

This blog post reviews BVM ventilation, common pitfalls, and strategies to maximize its success.

Take-home points

BVM ventilation is both a life-saving technique and a learned skill. As a skill, like intubation it requires practice and refinement to optimize. The three major errors in BVM ventilation are poor positioning, poor mask seal, and poor ventilation. Proper ventilation can be maximized by placing the head in the sniffing position, raising the head to align the ear to sternal notch, and placing both an oropharyngeal airway and a nasopharyngeal airway. Poor mask seal is best resolved with the two-handed thenar technique instead of the EC-clamp method. Apneic oxygenation, with a nasal cannula at 15 L/min, can be used in addition to BVM in patients who are difficult to bag.-

10. Kilian M and Helman A. Episode 76 – Pediatric Procedural Sedation. EM Cases. (January 2016) Honorable Mention
https://emergencymedicinecases.com/pediatric-procedural-sedation/

This blog post reviews the management of pediatric procedural sedation including pre-procedural planning, medication review, and post-procedural assessments.

Take-home points

The clinician should consider all procedural sedation options prior to starting the sedation. Possible options are upfront pain management with intranasal (IN) fentanyl and/or an oral analgesic early in the patient's ED course; ample use of distracting techniques; keeping familiar faces around the child; and encouraging family presence during the sedation. Based on current evidence, there is no clear indication to delay an urgent procedure because of time since the last meal.

The blog additionally reviews the relative risks and benefits of ketamine, etomidate, propofol, and nitrous oxide. The authors recommend the use of IV and intramuscular ketamine whenever possible and strongly urge against fentanyl with midazolam. In addition to these drugs, which are commonly used for painful procedures, the authors recommend IN or oral midazolam for non-painful procedures such as diagnostic imaging. The authors additionally recommend the use of sucrose for infants undergoing lumbar puncture. With regard to post-sedation management, the authors emphasize the importance of clinical parameters over strict time guidelines. The patient should be monitored until he is able to tolerate oral intake and at baseline functional status.

11. Turchiano M. Procedural Sedation and Analgesia Resources. (July 15, 2016) Honorable Mention
http://coreem.net/core/procedural-sedation-and-analgesia-resources/

This blog posts includes an extensive three-part video series that covers procedural sedation preparation, mitigation of harm, and sedative agents.

Take-home points

The author emphasizes the need for an organized and systematic approach to the preparation and management of procedural sedation and analgesia (PSA). In preparing for PSA, the authors recommend clinicians use the included checklist to systematically review the appropriateness of the sedation method, medication, monitoring, and material preparation. Although hypoxia, hypotension, and vomiting can occur during PSA, the authors emphasize the importance of awareness and evaluation of obstruction and hypoventilation as these are by far the most common complications. To monitor for obstruction and hypoventilation, the author recommends the routine use of real-time waveform capnography, with an emphasis on monitoring the capnograph and not the absolute ETCO2 level. Additionally, the author stresses the need for a systematic approach to the management of hypoventilation, which emphasizes airway maneuvers over immediate BVM ventilation.

Additionally, the videos contain an extensive discussion of the pros and cons of common sedative agents. Overall, the author recommends the use of propofol for procedures that are brief and/or require profound muscle relaxation, and ketamine for procedures that are longer and/or in children.

12. Vetter N and Sturm J. Procedural Sedation Errors in the Emergency Department. (May 11, 2016) Honorable Mention
http://www.emdocs.net/top-10-errors-of-procedural-sedation-in-the-emergency-department/

This post highlights 10 common errors during emergency department PSA and provides strategies for mitigating them.

Take-home points

Based on both the best available evidence and the American College of Emergency Physicians' 2013 clinical policy, clinicians should not delay sedation for an urgent procedure because of a recent meal. While severe complications from PSA are rare, providers should nonetheless prepare the necessary airway equipment in advance, including suction, airway adjuncts, and intubation equipment. For the management of hypoventilation, clinicians should use a stepwise approach starting with the cessation of further sedatives and incorporation of airway positioning maneuvers before the use of a BVM. The authors emphasize the importance of maintaining proper ventilation via capnography, as this will identify hypoventilation earlier than hypoxemia via pulse oximeter. The authors recommend ketamine for PSA, but caution clinicians to be prepared to prevent and treat emergent reactions. In addition, as propofol requires a more frequent dosing due to lack of tissue accumulation, clinicians can provide more generous upfront dosing (1 mg/kg), and then revert to maintenance doses (0.5mg/kg) every 5-10 minutes. Lastly, PSA medications dosing should start low and re-dosing should occur less frequently in elderly patients because of their increased sensitivity to PSA medications.

13. Kurkowski E. Ultrasound-Guided Pericardiocentesis. Core EM. (July 22, 2015) Honorable Mention
http://coreem.net/core/ultrasound-guided-pericardiocentesis/

This post reviews the clinical presentation, diagnosis, and management of pericardial tamponade as well as reviewing both ultrasound-guided and landmark-based pericardiocentesis.

Take Home Points

Pericardial tamponade commonly presents with dyspnea or decreased exercise tolerance, tachycardia, and hypotension. The treatment for atraumatic pericardial tamponade is pericardiocentesis, which can be performed either with ultrasound guidance or through a landmark-based approach. This post recommends an ultrasound-guided approach because it allows for real-time visualization of both the effusion and the needle insertion into the pericardium. The parasternal approach may be preferred due to the shorter distance from skin and decreased chance of damaging interposed organs. The authors cite a case series of nine patients to provide a recommendation that use of ultrasound is preferred because of the decreased risk of injury and reduction for the need for more invasive surgical drainage.

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 that the search only includes content produced within the previous 12 months from the top 50 SMI 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. The other limitation is that the SMI score, which is the initial search criteria, is based upon an impact score and is not a quality indicator itself. Based upon this, it is possible that blog posts and podcasts that would meet the quality and educational marker could be missed. In addition, our scoring cut-offs of 30 and 27 were based on a consensus from the AIR series executive board and includes the highest scoring 20% of blog posts reviewed.

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Emergency Department Attending Physician Variation in Opioid Prescribing in Low Acuity Back Pain

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Introduction: Despite treatment guidelines suggesting alternatives, as well as evidence of a lack of benefit and evidence of poor long-term outcomes, opioid analgesics are commonly prescribed for back pain from the emergency department (ED). Variability in opioid prescribing suggests a lack of consensus and an opportunity to standardize and improve care. We evaluated the variation in attending emergency physician (EP) opioid prescribing for patients with uncomplicated, low acuity back pain (LABP).

Methods: This retrospective study evaluated the provider-specific proportion of LABP patients discharged from an urban academic ED over a seven-month period with a prescription for opioids. LABP was strictly defined as (1) back pain chief complaint, (2) discharged from ED with no interventions, and (3) predefined discharge diagnosis of back pain. We excluded providers if they had less than 25 LABP patients in the study period. The primary outcome was the physician-specific proportion of LABP patients discharged with an opioid analgesic prescription. We performed a descriptive analysis and then risk standardized prescribing proportion by adjusting for patient and clinical characteristics using hierarchical logistic regression.

Results: During the seven-month study period, 23 EPs treated and discharged at least 25 LABP patients and were included. Eight (34.8%) were female, and six (26.1%) were junior attendings (≤ 5 years after residency graduation). There were 943 LABP patients included in the analysis. Provider-specific proportions ranged from 3.7% to 88.1% (mean 58.4% [SD +/- 22.2]), and we found a 22-fold variation in prescribing proportions. There was a six-fold variation in the adjusted, risk-standardized prescribing proportion with a range from 12.0% to 78.2% [mean 50.4% (SD +/-16.4)].

Conclusion: We found large variability in opioid prescribing practices for LABP that persisted after adjustment for patient and clinical characteristics. Our findings support the need to further standardize and improve adherence to treatment guidelines and evidence suggesting alternatives to opioids. [West J Emerg Med. 2017;18(6)1135-1142.]

INTRODUCTION

Effective pain management is a responsibility of emergency physicians (EP) and an integral part of providing quality healthcare. Recent increased attention to the treatment of pain has contributed to a substantial increase in the prescribing of opioid analgesics in the United States. The U.S. Food and Drug Administration commissioner recently highlighted the critical role medical providers play in the prescription opioid epidemic as deaths continue to rise, contributing to the first decline in American life expectancy since 1993.[1-2]

Despite the heightened awareness of harm from opioids and recent interventions, EP opioid-prescribing practices are hypothesized to be highly variable.[3-5] Tamayo-Sarver and colleagues found variation in provider opioid-prescribing choices even when providers were given identical patient scenarios.[6] High variation suggests lack of provider consensus about how to manage pain and signals opportunities to standardize and improve care. Specifically, reduction of opioid prescribing may reduce the risk of drug diversion and overdose. While some variation is expected because of case-specific issues (e.g., drug allergies, comorbidities), extensive variation is concerning, and identifies the need for system-level interventions to address practice variation in order to increase benefits to ED patients.[7]

Back pain is a model presenting complaint for assessing variations in opioid prescribing. It is one of the most common painful conditions leading to emergency department (ED) visits.[8] Opioids are commonly used to treat back pain despite the lack of evidence that they are superior to other treatments, with up to 61% of ED patients receive an opioid in the ED or an opioid prescription to treat their pain.[9-11] Further, there is evidence of significant consequences with opioid use for back pain including future opioid use, higher medical costs, and increased disability.[12-14] Furthermore, the American College of Emergency Physicians (ACEP) clinical policy statement on the use of opioids in the ED to treat pain suggests using opioids only when pain is severe, debilitating, or refractory to other treatments.[15] Similarly the American Academy of Emergency Medicine (AAEM) considers opioids second-line treatment in their clinical practice statement.[16]

To our knowledge, little is known about emergency provider opioid analgesic-prescribing variation and clinical factors associated with this variation in the context of treatment guidelines that suggest non-opioid alternatives. To address this knowledge gap, we examined variation in attending EP prescribing of opioid analgesics to patients with uncomplicated back pain that did not require diagnostic testing or medication treatment in the ED.

Population Health Research Capsule

What do we already know about this issue?
Opioids are commonly used to treat back pain in the ED, despite a lack of evidence of superiority to other agents and guidelines recommending against their use.

What was the research question?
How variable are ED attending opioid-prescribing rates within a cohort of patients with comparable acuity?

What was the major finding of the study?
We found a six-fold variation in risk-standardized ED attending opioid-prescribing rates for low acuity back pain.

How does this improve population health?
Extensive variability in opioid prescribing for low back pain suggests the need for interventions to improve guideline adherence and address practice variation.

METHODS

Design

This is a retrospective study evaluating the proportion of adult patients with low acuity back pain (LABP) for whom attending EPs prescribed opioids. The study period was from May 01, 2013, to November 30, 2014. The local institutional review board (IRB) approved this project.

We used strict criteria to identify an ED patient population of similar acuity in order to focus on EP variation rather than patient variation. We limited our study cohort to adult patients (≥ 18 years) with the following characteristics: 1) chief complaint related to back pain symptoms including back injury, back pain, and back/neck/shoulder pain (obtained from a pre-populated pull-down list); 2) discharged home from Intake (see below for description of Intake); and 3) a primary discharge diagnosis of uncomplicated back pain, defined as the Health Care Utilization Project (HCUP) Clinical Classification Software (CCS) number 205 (spondylosis; intervertebral disc disorders; other back problems). HCUP is a federal-state-industry partnership sponsored by the Agency for Healthcare Research and Quality. CCS for *ICD-9-CM* is a diagnosis and procedure categorization scheme based on the *International Classification of Diseases, 9th Revision, Clinical Modification*, and provides a uniform and standardized coding system. CCS collapses *ICD-9* codes into a smaller number of clinically meaningful categories.[17]

Setting

We conducted this study in a single, large academic ED with approximately 100,000 annual ED visits and an admission proportion of 24.9% (12.5% inpatient and 12.4% ED clinical decision unit).

This study focused on patients evaluated in ED Intake. Intake is a front-end physician evaluation model used by our ED. The Intake zone is located by the ED walk-in entrance and is responsible for evaluating all stable patients who arrive by any means other than ambulance. An attending EM

board-certified/ eligible physician staffs the area from 9am to 1am daily with two consecutive eight-hour shifts. The average daily Intake census is 75 patients per eight-hour shift (average daily ED census is approximately 277). All patients are evaluated by the EP with three possible destinations: (1) discharge to home (low acuity); (2) Super Track (to be further evaluated and treated by a physician assistant/nurse practitioner for minor imaging, limited studies, minor procedures, or re-evaluation after medications); or (3) to the main ED for additional work-up. Patients discharged from Intake do not have imaging studies, parenteral medications or procedures performed.

Briefly, the Intake process consists of a trained ED tech (EMT-B or paramedic) who greets the patient, obtains vital signs and enters the chief complaint (chosen from a pull-down list). The patient is then placed into one of four Intake rooms, where the attending EP assesses every patient to determine whether or not he/she can be fully evaluated, treated and safely discharged or if they need further work-up and/or treatment in Super Track or the main ED. This approach allows the EP to discharge patients with low acuity conditions (not requiring diagnostic testing or emergent medications) to home after an evaluation. The authors concluded that all patients with back pain discharged directly from Intake without requiring any further work-up were low acuity. We expect this to be a similar population of patients; therefore, we can evaluate the variation of EP treatment decisions independently of patient variation.

Prior to study initiation, an Internet-based statewide prescription drug monitoring program (PDMP) and an institution-specific controlled medication prescription policy existed. The institution-specific policy, implemented in 2012, was not changed during the study. The PDMP in our state was established in 2008 and mandates pharmacist entry for all controlled substance prescriptions at the time the prescription is filled. The PDMP was accessible to all EPs and it remained unchanged with regard to entry of patients and prescriber access during the data collection period. There was no formal policy in the physician practice group or at a state level that structured or directed use of this program. Therefore, physicians used this database at their own discretion with influences on their prescribing patterns unique to each physician.

Subjects

The physician group includes attending EM board certified/eligible physicians working in the ED. Advanced practice providers (APP) and residents do not work in Intake and therefore were not included. Similar to previous studies, in order to assess the EP opioid prescription variation and increase the confidence in our results, we excluded all providers who evaluated less than 25 patients that met our LABP inclusion criteria.[18]

Primary outcome

The main outcome of the study was the provider-specific proportion of LABP patients prescribed an opioid analgesic. To determine if there was opioid prescribing variation, for each EP we calculated the percentage of LABP patients prescribed one or more opioid analgesics at ED discharge. We chose receiving a prescription as a binary outcome rather than assessing morphine equivalents because prior work at our institution found that the vast majority of our ED prescriptions are for a small number of pills and similar strength preparations (15 pills, IQR 12-20). Since these are similar to national trends for ED opioid prescribing, small differences between ED opioid prescriptions are unlikely to be clinically relevant.[19]

Measurements

We extracted LABP ED visits and discharge opioid analgesic prescriptions from Intake from the electronic health record (EHR: Epic 2010 Verona, WI) via computer algorithm. Data collected included EP provider, chief complaint, age, gender, race/ethnicity, insurance status, and opioid prescriptions. No patient identifiers (medical record number or patient identity) were recorded in the database. Race was coded as Black, White, Hispanic or Other. Insurance status was coded as federal (Medicare or Medicaid), commercial, self-pay, medically indigent and other (Worker's Comp, Veteran's Affairs, Child Health Plus). We abstracted all medical record data through electronic reports, eliminating potential bias and data entry errors associated with manual abstraction.

We defined an opioid analgesic prescription as any schedule II, III, and IV medications that contained an opioid, including tramadol. We did not include sedatives or stimulants. All prescriptions were ordered electronically via the EHR. We did not evaluate if the patient filled the discharge opioid prescription.

Analysis

We used descriptive statistics to describe our study population. We compared groups using chi-square analysis for categorical variables and ANOVA for continuous variables. A two-tail p value <0.05 was considered statistically significant. We assessed the association between patient characteristics and receipt of opioid prescription using logistic regression analysis. We reported the odds ratio (OR) and 95% confidence intervals (CI).

We calculated each provider's percent of LABP patients prescribed an opioid analgesic. Our strict inclusion criteria produced a similar cohort, but we wanted to adjust for patient-related factors that may influence EP opioid prescribing such as age, gender, race, and primary care provider status. It is possible that evaluating and discharging more LABP patients may have an effect on a provider's proportion of opioid prescribing; to address this we also adjusted for each EP's back-pain patient volume in Intake. The patient LABP volume consisted of all patients who fit

our study inclusion criteria: chief complaint of back pain, final diagnosis of back pain, and were discharged from Intake, with or without an opioid analgesic prescription.

To adjust for patient-related factors, we calculated the risk-standardized opioid prescription proportion at the provider level. The EP risk-standardized opioid prescription proportion was defined as the ratio of observed to predicted number of opioid prescriptions per provider, which was then multiplied by the group's mean opioid prescription proportion. We used logistic hierarchical regression analysis, where the physicians were considered random effects in the analysis.[20-25] All analyses were conducted in SAS 9.3 (Cary, NC).

RESULTS

Twenty-three EPs treated and discharged at least 25 LABP patients and were eligible for inclusion in the final analysis; eight (34.8%) were females and six (26.1%) were junior attendings (≤ 5 years after graduation from residency) (Table 1). They treated 943 LABP patients. During the seven-month study period 1,857 patients presented to the ED with a chief complaint related to back symptoms and were discharged from Intake; of these, 1,166 (63%) patients also had a final diagnosis of back pain. We excluded patients seen by providers who had seen less than 25 patients with LABP in Intake, resulting in the final cohort of 943 patients.

Table 2 describes the LABP patients' characteristics and whether or not they received an opioid prescription. The mean age was 37.8 (SD +/- 12.1); 568 (60.2%) were females, and most patients were minorities, including 289 Blacks (30.7%) and 197 Hispanics (20.9%). The most common insurance coverage was Medicaid (38.0%). When compared with Whites, Blacks were less likely to receive an opioid prescription for LABP (OR 0.65; 95% CI [0.48-0.89]). When compared with patients who were not seen in the ED for back pain in the last 30 days, those who were visiting the ED with a chief complaint of back pain for a second time within 30 days were more likely to receive an opioid prescription on the second visit (OR 1.68; 95% CI [1.03-2.73]). Oxycodone (65%) was the most commonly prescribed opioid in this cohort, followed by hydrocodone (27%) and tramadol (8%).

Table 1. Characteristics of ED attending physicians in a study examining variation in opioid prescribing for low acuity back pain.

Provider characteristics	n=32
Gender	
Male	15 (65%)
Female	8 (35%)
Experience (after residency)	
0-5 years	6 (26%)
>5 years	17 (74%)

Figures 1a and 1b show the raw EP opioid prescription variation and the adjusted EP risk-standardized opioid prescription variation, respectively. The unadjusted variation in EP opioid analgesic-prescribing proportion for patients with LABP ranged from 3.7% to 88.1%, a 22-fold variation. The mean unadjusted EP opioid-prescribing proportion was 58.4% (SD +/- 22.2). The adjusted variation in EP opioid-prescribing rates for ED patients with LABP ranged from 12.0% to 78.2%, a 6-fold variation. The adjusted mean EP opioid- prescribing proportion was 50.4% (SD +/-16.4).

DISCUSSION

In this study, we found a six-fold variation in the provider-specific adjusted proportion of LABP patients prescribed an opioid analgesic. Physician opioid-prescribing practices play an important role in the current opioid epidemic. Wide variability in prescribing decisions for ED discharges has been previously described and, importantly, higher prescribing rates were associated with increased risk of future opioid use.[26] This study is novel in that we assessed opioid prescribing variability for EP attendings within a homogeneous cohort of patients with a low acuity condition. While there is no accepted "correct" proportion of back pain patients who may benefit from an opioid on discharge, it is reasonable to expect low variability in the setting of national guidelines supporting non-opioid alternatives, lack of evidence of superiority, and evidence of poor long-term outcomes associated with opioids.[8-14] This widespread variation in proportions of opioid prescriptions suggests that ED patients are at risk for both the under-treatment and over-treatment of pain with opioids when presenting to the ED with back pain. This is a major patient safety issue.

Deciding whether or not opioids are the safe and appropriate choice for a given patient is fraught with physician preferences and perceptions. One approach to decreasing overall provider treatment variation is to implement clinical pathways into the ED workflow.[27-28] Clinical pathways help decrease provider practice variation when developed in conjunction with practicing providers and by using evidence-based medicine.[29-30] ED providers are able to access prior controlled medication prescriptions for patients through the use of a PDMP, but many systems are time consuming and there is variability in the interpretation of the information. While the use of the PDMP appears to be the most objective way to identify patients at risk for becoming dependent or even dying from opioid, very little is known about how to best use this critical information in clinical practice.[31]

Another contributing factor to opioid prescription variation relates to the EP's perception that opioid prescription may be associated with patient satisfaction and the path of least resistance for a rapid discharge. This perception has been contradicted by a recent study suggesting that patient satisfaction scores are not associated with opioid prescription.[32] Nonetheless, ED providers

Table 2. Low acuity back pain patient characteristics.

Patient characteristics	Did not receive opioid N=375 (39.8%)	Received opioid N=568 (60.2%)	Total N=943	Odds of receiving an opioid
Female	292 (51.4%)	276 (57.6%)	568 (60.2%)	1.25 (95%CI 0.96-1.62)
Age (mean)	36.3 (SD 12.2)	38.8 (SD 12)	37.8 (SD 12.1)	1.02 (95%CI 1.01-1.03)
Race				
White	142 (38%)	254 (44.8%)	396 (42.1%)	Reference
Black	133 (35.6%)	156 (27.5%)	289 (30.7%)	0.65 (95%CI 0.48-0.89)
Hispanic	77 (20.6%)	120 (21.2%)	197 (20.9%)	0.87 (95%CI 0.62-1.23)
Other	22 (5.9%)	37 (6.5%)	59 (6.3%)	0.94 (95%CI 0.53-1.66)
Insurance				
Medicaid	144 (38.4%)	214 (37.7%)	358 (38%)	1.09 (95%CI 0.72-1.65)
Medicare	25 (6.7%)	56 (9.9%)	81 (8.6%)	1.65 (95%CI 0.91-2.97)
Private	53 (14.1%)	72 (12.7%)	125 (13.3%)	Reference
Indigent	49 (13.1%)	101 (17.8%)	150 (16%)	1.52 (95%CI 0.93-2.48)
Other	11 (2.9%)	25 (4.4%)	36 (3.8%)	1.67 (95%CI 0.76-3.70)
Self-pay	93 (24.8%)	100 (17.6%)	193 (20.5%)	0.8 (95%CI 0.50-1.25)
Has a PCP				
Yes	161 (42.9%)	274 (48.2%)	435 (46.1%)	1.24 (95%CI 0.95-1.61)
No	214 (57.1%)	294 (51.8%)	508 (53.8%)	Reference
Emergency department visit within last 30 days for back pain	25 (6.7%)	61 (10.7%)	86 (9.1%)	1.68 (95%CI 1.03-2.73)

PCP, primary care physician.

are asked to rapidly and safely treat pain without the benefit of an established doctor-patient relationship in an environment with limited time and resources. Competing priorities make it difficult to adequately address all of our patients' needs and questions. Recent shifts in clinical expectations (both administrative and patient specific) without the necessary increased time spent on provider education can put EPs in a difficult position.[33]

This study is the first to describe the EP opioid-prescribing variation in clinical practice within a cohort of patients with comparable acuity. The prescribing information was easily obtained from administrative data and can be easily reproduced in clinical settings where prescribing is done via computer order entry. Using this information to evaluate both random and specific variation in physician practice is an important part of the current healthcare quality environment.[7] Given the escalation of poor outcomes associated with increased opioid availability,[2] variation in opioid analgesic prescribing to ED patients requires further study.

Any intervention aimed at decreasing opioid availability and increasing quality care by increasing guideline adherence should include an assessment of doctors' practice variation, risk tolerance and perceptions. Clinical interventions and policy changes can address opioid-prescribing variation via the use of clinical pathways, embedded decision support, and provider opioid-prescribing metrics. Ultimately, EPs will need to assess the impact of provider variation on patient outcomes with sufficient follow-up and end points. Understanding and evaluating departmental and local hospital variation of prescribing may serve as valuable internal and external benchmarks in the assessment of emergency medicine prescribing safety and quality.

LIMITATIONS

Our study should be evaluated in the context of a few limitations. First the external validity of our findings is limited because this is a single-center, retrospective study and the use of a process (Intake) that is not universally available in all EDs. While our specific intake process may be somewhat unique, the process of having a provider assessing patients as they present to the ED is not.[32] Our overall ED patient population and local opioid-prescribing practices may differ from those at other centers; however, the fundamental concept of addressing prescribing variation in the practice of EM remains valid.[35] To limit our sample we used the combination of chief complaints and final diagnosis, which may have excluded patients with LABP, therefore leading to classification bias. Further, we were unable to track or account for use of our state PDMP in these decisions because of statutory limitations accessing this data. Finally, we did not assess whether patients filled their prescriptions, as we were interested solely in understanding the physician practice habits.

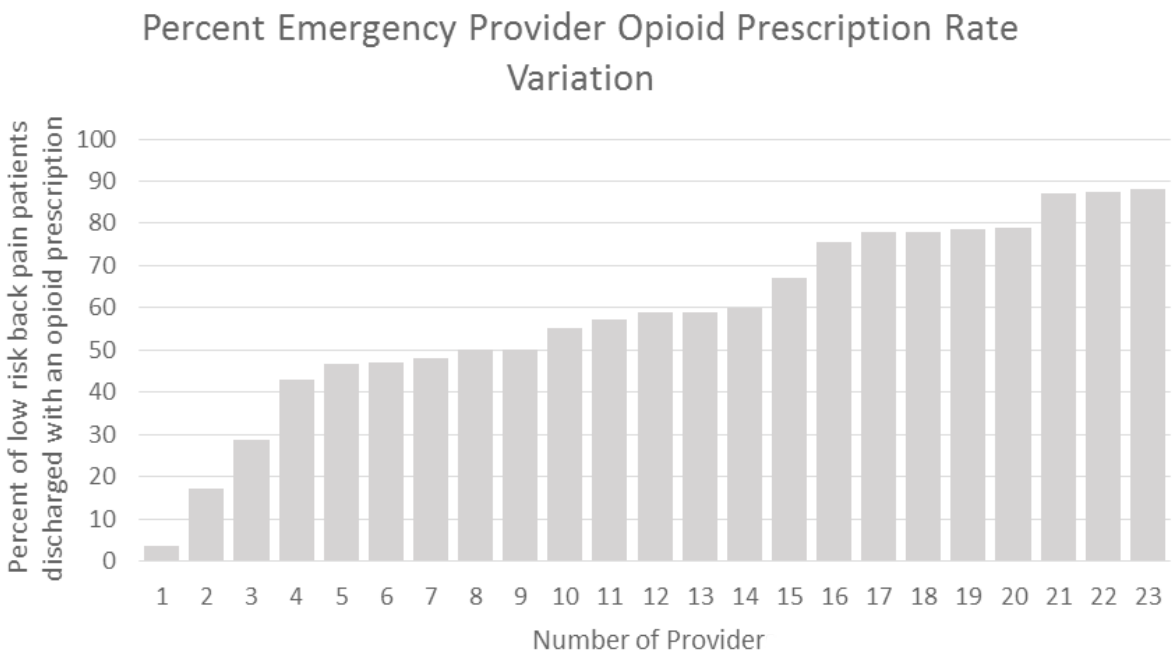

Figure 1A. Emergency department attending physician opioid prescribing rates for patients with low acuity back pain.

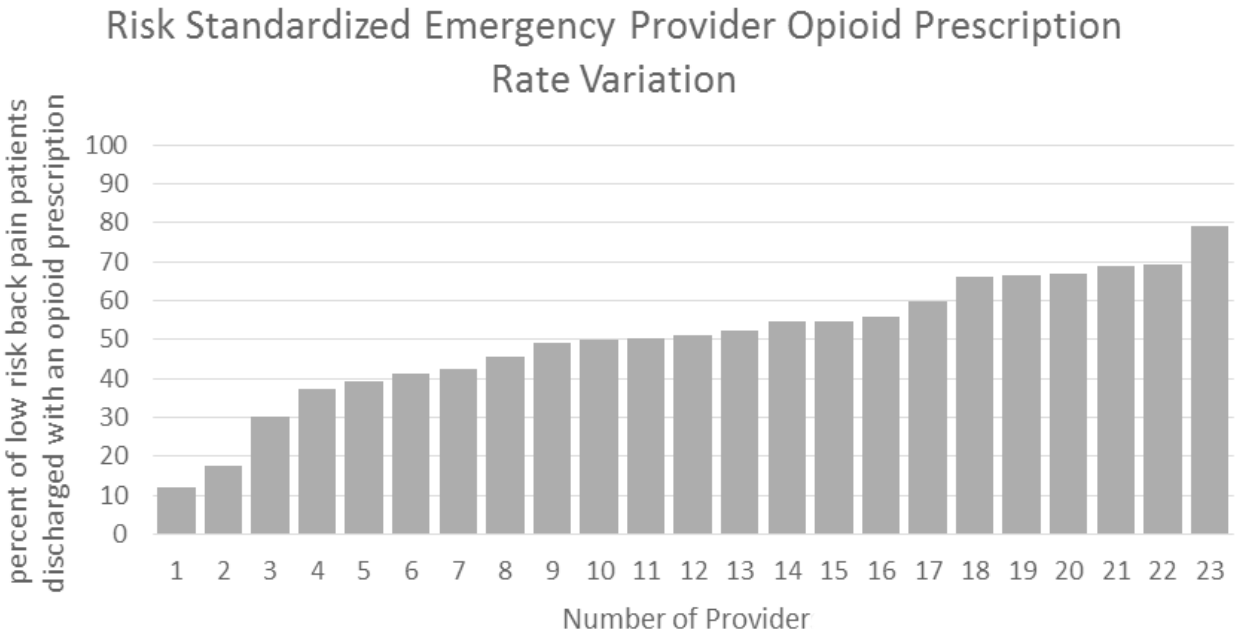

Figure 1B. Risk-standardized opioid-prescribing rates of emergency department physicians for patients with low acuity back pain.

CONCLUSION

We found significant variation among attending emergency physicians in the decision to prescribe opioids analgesics within a cohort of low acuity back pain patients. This implies a critical need for further assessments of this decision and interventions to promote the safe and effective prescribing of opioid pain medications consistent with national treatment guidelines.

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Effectiveness of SBIRT for Alcohol Use Disorders in the Emergency Department: A Systematic Review

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Introduction: Alcohol use disorders (AUD) place a significant burden on individuals and society. The emergency department (ED) offers a unique opportunity to address AUD with brief screening tools and early intervention. We undertook a systematic review of the effectiveness of ED brief interventions for patients identified through screening who are at risk for AUD, and the effectiveness of these interventions at reducing alcohol intake and preventing alcohol-related injuries.

Methods: We conducted systematic electronic database searches to include randomized controlled trials of AUD screening, brief intervention, referral, and treatment (SBIRT), from January 1966 to April 2016. Two authors graded and abstracted data from each included paper.

Results: We found 35 articles that had direct relevance to the ED with enrolled patients ranging from 12 to 70 years of age. Multiple alcohol screening tools were used to identify patients at risk for AUD. Brief intervention (BI) and brief motivational intervention (BMI) strategies were compared to a control intervention or usual care. Thirteen studies enrolling a total of 5,261 participants reported significant differences between control and intervention groups in their main alcohol-outcome criteria of number of drink days and number of units per drink day. Sixteen studies showed a reduction of alcohol consumption in both the control and intervention groups; of those, seven studies did not identify a significant intervention effect for the main outcome criteria, but nine observed some significant differences between BI and control conditions for specific subgroups (i.e., adolescents and adolescents with prior history of drinking and driving; women 22 years old or younger; low or moderate drinkers); or secondary outcome criteria (e.g. reduction in driving while intoxicated).

Conclusion: Moderate-quality evidence of targeted use of BI/BMI in the ED showed a small reduction in alcohol use in low or moderate drinkers, a reduction in the negative consequences of use (such as injury), and a decline in ED repeat visits for adults and children 12 years of age and older. BI delivered in the ED appears to have a short-term effect in reducing at-risk drinking. [West J Emerg Med. 2017;18(6)1143-1152.]

INTRODUCTION

The literature refers to harmful, hazardous, and risky drinking interchangeably as a pattern of drinking that increases risk of harm for the person consuming alcohol and/or others.[1] Alcohol dependence is a result of repeated use leading to a person having impaired control over the use of alcohol despite physical, psychological, and social harms.[2] The fifth edition of the *Diagnostic and Statistical Manual* (DSM–5) integrates alcohol abuse and alcohol dependence into a single disorder called alcohol use disorder (AUD), with mild, moderate, and severe sub-classifications.[3]

Excess alcohol consumption places a significant burden on individuals and society. The majority of adult patients in the United States consume alcohol with a 71% one-year and 57% one-month prevalence reported by those over age 18.[4] Another 24.7% report binge drinking and 6.7% report heavy drinking.[5] Moreover, 16.3 million adults, 6.8% of the U.S. population meet criteria for an AUD.[6] Only 8.9% of the 16.3 million with AUD (i.e., about 1.5 million) received treatment for an AUD at a specialized facility.[7] The 2012-2013 National Epidemiologic Survey on Alcohol and Related Conditions III (NESARC-III) found that the lifetime prevalence of AUD was 29.1%, with only 19.8% of respondents with lifetime AUD having ever been treated.[8] In 2014, an estimated 679,000 adolescents aged 12 to 17 years [9] (2.7% of this age group) [10] had an AUD, with only 8.1% (18,000 males and 37,000 females) receiving treatment for an alcohol problem in a specialized facility.[11]

Excessive alcohol consumption accounts for nearly 88,000 deaths annually[4] and is the fourth leading preventable cause of death in the U.S. [5]Alcohol-impaired driving fatalities account for 31% of overall driving fatalities.[12] In addition, alcohol consumption contributes to non-fatal injuries resulting from traffic accidents, falls, and impaired judgment. Heavy alcohol drinkers suffer greater risk of alcohol dependence and withdrawal, liver cirrhosis and failure, and cancers of the mouth, esophagus, pharynx, larynx, liver, and breast.[13-15] This high burden of alcohol-related injury and disease indicates a need to increase awareness of AUD and its effective treatment options.[8]

Given the rate of complications from AUD, the emergency department (ED) is a commonly used portal of entry into the healthcare system for many patients, and offers a unique opportunity for screening, brief intervention and referral to treatment (SBIRT).[16, 18] Several professional and government organizations have already provided recommendations on implementation of SBIRT for certain patients, including those presenting with trauma.[19, 20] However, little guidance exists on broader use of ED-based AUD interventions. This article provides a critical appraisal of the effectiveness of brief ED-based interventions as an injury-prevention strategy aimed at reducing alcohol intake and alcohol-related injuries among patients screened for AUD in the ED setting.

Population Health Research Capsule

What do we already know about this issue?
Screening, brief intervention, and referral to treatment (SBIRT) is an evidence-based practice used to identify substance abuse disorders, early intervention and treatment.

What was the research question?
What was the effectiveness of SBIRT at reducing alcohol intake for ED patients at risk for alcohol use disorder?

What was the major finding of the study?
Brief interventions in the ED showed a small reduction in alcohol use (low/moderate drinkers) and negative consequences.

How does this improve population health?
Alcohol use disorders and their negative consequences are a reason for ED visits, and any type of basic intervention may have an effect on subsequent outcomes of reducing harm in this population.

METHODS

We conducted a systematic review of the literature regarding the effectiveness of SBIRT in the ED setting using the following key terms: alcohol consumption (related terms), alcohol reduction, alcohol dependence, alcohol screening, brief intervention, brief negotiated interview, computerized intervention, motivational interviewing, tailored feedback, injury, and emergency department. Electronic database searches of Medline (OVID), EMBASE (OVID), PsycInfo (OVID), The Cochrane Library (Wiley), CINAHL (EBSCO) and Web of Science (Databases: SCI-EXPANDED, SSCI, A&HCI) were conducted for English-language articles published between January 1966 and April 2016. We also considered websites of relevant organizations/networks and reference lists of included articles.

Article selection and review

We selected articles for review based on information derived from the title, abstract, and keywords. If the title, abstract, and keywords did not yield enough information we then reviewed the full paper, We evaluated for inclusion all randomized studies of patients with known, suspected AUD, or

alcohol- related injuries, assessing the effectiveness of brief ED-based interventions for the reduction of alcohol consumption, as well as the secondary goals of reducing alcohol-related negative consequences for both physical and social consequences of AUD,

Next, the articles that met inclusion criteria were appraised and assessed by two authors for their methodological quality, such as the method of randomization, blinding, allocation, description of withdrawals and dropouts, as well as loss to follow-up (Table).[18] A third author reviewed the articles if there were any discrepancies in the grading. The reviewers were not blinded to the study hypothesis.

Analysis

Given the lack of standardization across studies, including variations in patient populations, settings, screening techniques, and outcomes, data were analyzed descriptively. We focused on presenting trends and themes that emerged with regard to alcohol consumption and complications from continued alcohol use, such as injury. We also present the quality of studies that met our inclusion criteria.

RESULTS

Thirty-five randomized control trials[21-55] of patients of all ages seen in the ED with AUD were included (see Figure) in the final evidentiary table (Appendix A). The evidentiary table describes the target group, study design, primary and secondary outcomes, the main results, and the quality grading for each study.

Studies were generally limited to individuals older than 18 years with the exception of six studies that surveyed adolescents and young adults between the ages of 13 and 21 years old.[30, 35, 38, 41, 48, 49]

Screening for Alcohol Use Disorder

The alcohol screening tools differed among the studies and included both self-reported questionnaires and biomarkers. Several structured questionnaires (Appendix B) were used to determine current and/or past alcohol use, and increased the sensitivity of self-report.[56-76] Of the controlled randomized studies included in Appendix B, the self-reported screening instruments were as follows: one study used AUDIT (Alcohol Use Disorder Identification Test)-C[42] and 12 studies used the full AUDIT.[23, 24, 28, 31-33, 38, 39, 42, 50, 53, 54] Of these, 10 studies included all patients with a score of 8 or higher,[28, 31-33, 38, 39, 42, 50, 53, 54] and two studies stratified the patients into three categories: low risk (0 to 6), at risk/moderate risk (7 to 18), and high risk (19 to 40).[3, 24] Authors mainly chose a lower cut-off score of 4 or greater for inclusion of adolescents.

In some studies, AUDIT was used with other alcohol screening tools such as the National Institute on Alcohol Abuse and Alcoholism (NIAAA) Guide,[31] the CAGE questionnaire,[23, 39] positive test for alcohol, and self-report of ingesting alcohol within six hours prior to the injury.[50] Six studies[21-24, 35, 39] used the CAGE questionnaire to screen injured patients for alcohol consumption; however, in one study it was followed by AUDIT to evaluate the quantity and frequency of alcohol consumption,[24] while in another study the patients were initially screened using NIAAA followed by CAGE.[35] Two studies, one in the United Kingdom and one in Australia, employed the Paddington Alcohol Test. (PAT)[29, 34] *[PAT features a table of commonly encountered beverages coded in British units. Eight grams of alcohol are equivalent to one unit. The PAT allows for the different relative strengths of certain products, thus differentiating between a patient who may consume two pints (i.e., four "drinks") of

Table. Scoring system used in a survey looking at the effectiveness of brief interventions for suspected alcohol use disorder.

Type of study	Question	Score
Randomized control trials	Was the study described as randomized?	1 for "yes" 0 for "no"
	Was the study described as double blind?	1 for "yes" 0 for "no"
	Was there a description of withdrawals and dropouts?	1 for "yes" 0 for "no"
	a) Was the method to generate the sequence of randomization described and was it appropriate (random numbers, computer generated, etc.)?	1 for "yes" 0 for "no"
	b) Was it inappropriate (alternate allocation, by date of birth, chart number, etc.)?	-1 for "yes" 0 for "no"
	a) Was the method of double blinding described and appropriate (identical placebo, etc.)?	1 for "yes" 0 for "no"
	b) Was it inappropriate (comparison of tablet to injection without double dummy, etc.)?	-1 for "yes" 0 for "no"
	Was the loss to follow-up rate greater than 20%?	-1 for "yes" 0 for "no"

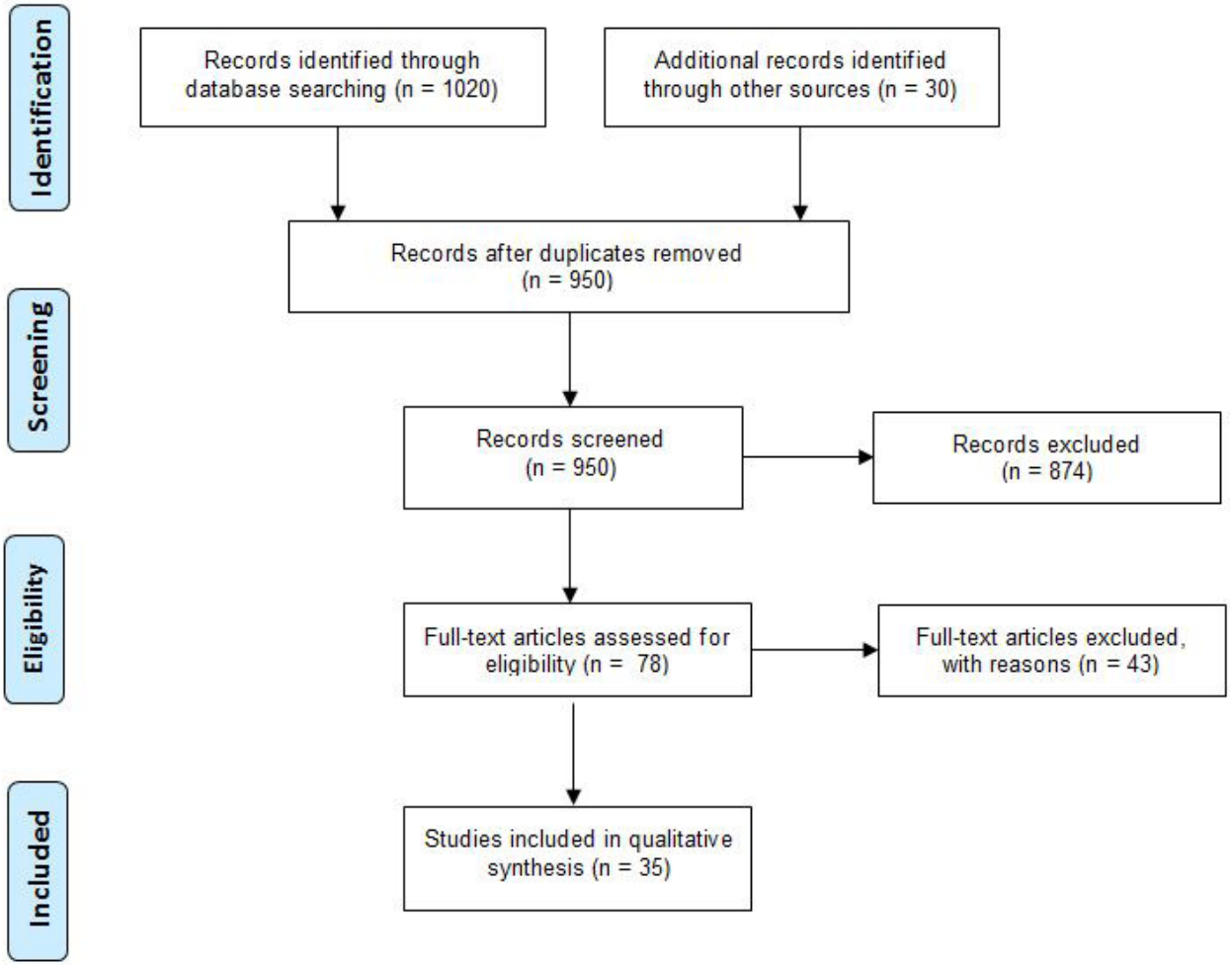

Figure. PRISM flow diagram[94] for a systematic survey of studies that looked at the effectiveness of brief interventions in emergency department patients with suspected alcohol use disorder.

normal strength beer (four units) and the same amount of "strong" lager (10 units)].

Five studies used the NIAAA guide to screen patients.[21, 22, 31, 35] In three of the five studies, NIAAA was used in conjunction with CAGE;[21, 22, 35,] in one additional study it was used with AUDIT, [31] and in another study it was used with Alcohol, Smoking and Substance Involvement Screening Test (ASSIST).[43]

Several instruments (Appendix C) were used to evaluate adolescent alcohol intake and consequences of drinking.[77-85] Three studies involving adolescents [44, 48, 49] used Adolescent Drinking Questionnaire (ADQ) and Adolescent Drinking Index (ADI) instruments to evaluate alcohol consumption, and at follow-up used Adolescent Health Behavior Questionnaire and Short Michigan Alcoholism Screening Test (SMAST) to evaluate alcohol-related injuries. Eleven of the 35 studies used biomarkers (blood, breath or saliva tests) [25, 33, 36, 37, 39, 44-47, 48-50] as part of the screening tools.

Instruments to Evaluate the Negative Consequences of Drinking Alcohol and Readiness to Change

Drinker's Inventory of Lifetime Consequences (DrInC), a 45-item, self-report questionnaire about the negative consequences experienced from drinking that was validated on an alcohol treatment-seeking population of 1,728 inpatients and outpatients [86] and on Project MATCH, [87] was used by six studies [25, 27, 40, 50, 53, 55] to measure not only the physical but also the intrapersonal, social, interpersonal, and impulse control (e.g., driving while intoxicated, physical fights) consequences from drinking.

One author [50] used the Readiness to Change Contemplation Ladder [88] adapted for an ED treatment-seeking population of injured drinkers [69] to measure the subject's attitude towards modifying alcohol-related behaviors with response categories ranging from 0 (no thought of changing) to 10 (taking action to change [e.g., cutting down]).

Brief intervention and brief motivational intervention

Brief interventions (BI) are designed to motivate reduction and cessation of substance use by exploring and highlighting individual risks and negative outcomes of problematic substance use. Though it is not intended to treat people with serious substance use disorders, it can be used to encourage those with more serious dependence to accept either more intensive treatment within the primary care setting or a referral to a specialized alcohol and drug treatment agency.

The most common behavioral therapies used in SBIRT programs are brief versions of cognitive behavioral therapy and motivational interviewing or some combination of the two. Brief interventions can be made more effective by using the technique of motivational interviewing. The principles of brief motivational interviewing (BMI) and asking for permission to discuss alcohol use; (2) providing feedback on current drinking and consequences; (3) assessing readiness to change; and (4) providing options to help with behavioral changes and assisting in obtaining appointments or placements if desired.[91]

ED-based brief interventions were performed by a variety of professionals and staff members including, physicians, medical students, mid-level providers,[21, 31] nurses,[35] social workers, psychologists,[23, 36,] community outreach workers and ''health promotion advocates.''[24] ED staff nurses trained to conduct SBIRT were less fully engaged with SBIRT implementation when the ED was extremely busy. [35] The training required to prepare staff for delivering BI included reading review of materials about the assessment of adverse consequences of alcohol abuse, [89] as well as structured sessions to teach and practice the principles and techniques of SBIRT. [20]

Main Outcomes

All studies used reduction of alcohol consumption as the primary outcome measure. Thirteen studies (37%) enrolling a total of 5,261 participants reported significant differences between control and intervention groups defined by the number of drink days and number of units per drink day.[21-23, 28, 29, 36, 37, 39, 40, 44, 45, 50, 51] Sixteen studies (46%) showed a reduction in alcohol consumption in both the control and intervention groups. [25, 26, 31- 37, 42, 43, 47, 49, 50, 52, 55] Nine[25, 26, 35-37, 42, 49, 50, 55] out of these 16 studies showed greater improvement in the BI group as compared to the control group as follows: a higher reduction in the overall consumption of alcohol;[25, 26, 35, 49] reduction in the concomitant use of marijuana and alcohol;[55] and fewer injuries.[35, 36, 50] However, the effectiveness of the interventions in reducing at-risk drinking was weakened at six- and 12-month follow-up points.[22, 29-33, 41, 46, 48, 49]

Seventeen out of 35 studies failed to demonstrate an intervention effect for the primary outcome of alcohol consumption reduction.[21, 24-27, 30-35, 38, 41-43, 46-49, 51-55] However, 11 of those 17 studies (65%) enrolling a total of 4,706 participants observed some significant differences between BI and control conditions, at least for specific subgroups or secondary outcome criteria.[21-26, 38, 41, 42, 47, 48, 53-55] For example, one author found[24] statistically significant changes in "trying to be careful while drinking" in the intervention group in patients 18-21 years old with low AUDIT scores, and another[26] reported decrease in drinking, drinking days per week, maximum drinks per occasion and negative consequences of drinking in injured patients older than 18 years old. Among adolescents, a subgroup with a history of previous drinking and driving, the intervention group showed a beneficial effect in the reduction of drinking and driving.[41] Additionally, Segatto[47] found in adolescent and young adult patients a decrease in the following outcomes: days of alcohol use; days with moderate and heavy use; and negative consequences. Spirito et al.[48] found that the subgroup of adolescents who screened positive for problematic alcohol use at baseline reported significantly more improvement with fewer drinking days as well as fewer high-volume drinking days. Focusing on women, for example, the subgroup age 22 years, a reduction was found on the Drinker Inventory of Consequences (DrInC) in the intervention group.[25] Havard et al.[38] also found that women in the intervention group engaged in heavy drinking at one third of the frequency as the control group.

In some studies BI was shown to have an effect only on low or moderate drinkers [23] and not on high-risk or dependent drinkers (defined as an AUDIT score >15 or >18, respectively). However, Mello et al.[42] found the subgroup of participants with AUDIT scores>15 in the BI group had a lower three-month impaired score. If the participants attributed their injury to alcohol, Walton et al.[53] demonstrated lower levels of average alcohol consumption and less-frequent heavy drinking in the BI group. In addition, Wang et al.[54] found a significant increase in readiness to change in the BI group (in excessive alcohol users, AUDIT 2+ for men and 1+ for women), but not in the control group. Woolard et al.[55] showed binge drinking and concomitant marijuana use decreased for the BI group.

Readiness to Change Combined with BMI

A study by Stein [50] looked at pretreatment readiness to reduce drinking as a mediator of BMI effectiveness on alcohol-related consequences and found positive effects only on those highly motivated to change prior to the intervention but not for those with low pre-intervention motivation.

ED Referral to Outpatient Alcohol Health Worker

In the United Kingdom study by Crawford, [29] the patients were screened in the ED and then referred for outpatient follow-up with an alcohol health worker (AHW) for about 30 minutes of assessment and discussion of current and previous drinking. Of those referred, 65.8% followed up with an AHW. Alcohol consumption in patients who followed up with an AHW decreased to a mean of 59.7 units* per week as compared with 83.1 units in patients in the control group (t –2.4, p=0.02). At 12 months, those who pursued follow-up were drinking 57.2 units per week compared with 70.8 in controls (t –1.7, p=0.09). This study also showed that the patients followed by the AHW had a

mean of 0.5 fewer visits to the ED over the following 12 months (1.2 compared with 1.7, t –2.0, p=0.046).

DISCUSSION

The studies reviewed employed several alcohol screening tools, including in order of frequency the AUDIT, CAGE, NIAAA, and PAT. Although longer than other tools, the AUDIT can be completed in one minute and 13 seconds and its test characteristics make it preferable in study settings.[58] However, AUDIT-C, CAGE and MAST are designed for a range of health settings and are particularly appropriate for use in the ED because of their brevity and their focus on harmful drinking.[90] Despite these validated and easily applied tools the minority of patients (less than one in five) ever reports being questioned by physicians about alcohol use. [93]

Most studies employed a face-to-face BI delivered by healthcare personnel (nurses, doctors, or social workers) who had received specialized training. A few studies used booster sessions delivered after the initial BI. There was no difference in short-term and long-term outcomes in the studies that used one session as compared to studies that had a follow-up BI session.

All studies used reduction of alcohol consumption as the primary outcome. Many studies showed an improvement in AUD in both the control and intervention group. Our interpretation of the data from these studies suggests that the simple intervention of a doctor showing concern while questioning a patient's excessive alcohol consumption reinforces the connection between drinking and the patient's health issues. This brief intervention alone, provided in most of the control groups, goes beyond what most providers do in current practice and is likely to be effective in decreasing patients' harmful drinking as reflected by the reduction in alcohol consumption seen in the control patients in our reviewed studies. More intensive and costly interventions had limited additional benefit beyond the control group efforts. In reality, the minimal effort provided for these control groups amount to a significant intervention over baseline practices and should be considered for inclusion during all patient encounters. Since AUD and alcohol-related problems are a frequent reason for ED visits, any type of basic intervention implemented in the ED itself may have an important effect on subsequent outcomes of potentially reducing harm in this population.

Future areas of focus will need to look more closely at subpopulations identified by their willingness/readiness to change. Targeted interventions are more likely to have benefit, and scale-up of such interventions requires judicious use of resources in busy EDs. In addition, future studies will need to more closely examine the duration of BI/BMI effect. This information would allow for a more evidence-based approach to determine the need and frequency for booster sessions as a tool for maintaining long-term outcomes and sustainability.

LIMITATIONS

This systematic review included a heterogeneous group of studies; most of the studies were conducted in the U.S., with one study from the UK and one from Australia. We only included trials published in English. The abstractors were not blinded to the study hypothesis. We did not conduct a formal meta-analysis of the trials identified.

CONCLUSIONS

Among adults and children 12 years of age and older, the effectiveness of BI/BMI during an ED visit for alcohol use-related problems has been inconclusive, with heterogeneity of conditions and outcomes researched across studies. Nevertheless, a small but important number of studies have demonstrated small reductions in alcohol consumption, in negative consequences of alcohol use (such as injury), and in ED repeat visits. In addition, BI/BMI delivered in the ED appears to have at least short-term effectiveness in reducing at-risk drinking, possibly highlighting the need for supplementing the ED-based BI/BMI with referrals to outpatient programs equipped to maintain long-term contact with risky drinkers to sustain its effect. Although there are challenges to universal implementation of BI/BMI in the ED, the positive effect of asking about alcohol consumption seen in control groups is heartening in that relatively low-intensity intervention strategies may help our patients reduce the harmful effects of alcohol consumption.

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Case-controlled Analysis of Patient-based Risk Factors for Assault in the Healthcare Workplace

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Introduction: Violence against healthcare workers in the medical setting is common and associated with both physical and psychological adversity. The objective of this study was to identify features associated with assailants to allow early identification of patients at risk for committing an assault in the healthcare setting.

Methods: We used the hospital database for reporting assaults to identify cases from July 2011 through June 2013. Medical records were reviewed for the assailant's (patient's) past medical and social history, primary medical complaints, ED diagnoses, medications prescribed, presence of an involuntary psychiatric hold, prior assaultive behavior, history of reported illicit drug use, and frequency of visits to same hospital requesting prescription for pain medications. We selected matched controls at random for comparison. The primary outcome measure(s) reported are features of patients committing an assault while undergoing medical or psychiatric treatment within the medical center.

Results: We identified 92 novel visits associated with an assault. History of an involuntary psychiatric hold was noted in 52%, history of psychosis in 49%, a history of violence in the ED on a prior visit in 45%, aggression at index visit noted in the ED chart in 64%, an involuntary hold (or consideration of) for danger to others in 61%, repeat visits for pain medication in 9%, and history of illicit drug use in 33%. Compared with matched controls, all these factors were significantly different.

Conclusion: Patients with obvious risk factors for assault, such as history of assault, psychosis, and involuntary psychiatric holds, have a substantially greater chance of committing an assault in the healthcare setting. These risk factors can easily be identified and greater security attention given to the patient. [West J Emerg Med. 2017;18(6)1153-1158.]

INTRODUCTION

Violence directed at healthcare workers (HCW) is not uncommon. In the U.S., 13% of healthcare employees have reported at least one assault,[1] and 1.9 physical assaults resulting in an injury occur for every 100,000 worker hours.[2] The incidence of HCW assault in the U.S. is 1.65[3] or a median of 11 physical attacks per year per site.[4] Physical assaults comprise 6-21%[5] of all threatening behavior to which HCW are exposed, with verbal assaults, threats, and property damage accounting for the balance.[6,7] Clearly, this is not evenly distributed throughout hospitals and provider type. Psychiatric, rehabilitation, and geriatric areas have all been shown to have a higher number of assaults.[8,9] As the emergency department (ED) is the front line for these patients, often in their most decompensated state, the threat of aggression toward HCW is a significant concern for ED

providers.[10] In a survey study, 78% of emergency medicine residents or attending physicians reported being the victim of at least one act of workplace violence.[5]

Many reports of risk factors in the healthcare workplace have focused on the HCW themselves. Females, individuals older than 50 years of age, and staff members with longer tenure reported higher numbers of assaults and of fear.[4,11] Patient-staff conflicts substantially correlated and intra-staff conflict moderately related to frequency of assault.[12] The psychiatric literature has identified a history of violent episodes,[13,14] psychosis,[14] drug misuse,[14] paranoid schizophrenia,[15] and anti-social personality disorder [16,17] as predictors of violence. However, these associations are primarily studied in inpatient psychiatric facilities or general criminal behavior. Predictors in the emergency and acute healthcare setting are lacking. One patient-oriented cause that has been identified is dissatisfaction with care.[18] Unfortunately, often this is not shared with the healthcare team until the violence has occurred. Others have been suggested by interviews of ED personnel, including psychiatric patients, anxiety, staring, mumbling, pacing, and gang violence.[19,20,21,22] The goal of this study was to use data from reported HCW assaults to begin to identify more clearly patient-level risk factors associated with assaultive behavior in the ED or following admission through the ED.

Population Health Research Capsule

What do we already know about this issue?
Assaults in the healthcare setting impact 13% of employees and impact job satisfaction, work attendance and patient outcomes.

What was the research question?
Could patient-level risk factors for in-hospital violence be identified?

What was the major finding of the study?
Most in-hospital assailants had a current or past involuntary psychiatric hold, psychosis, or aggression.

How does this improve population health?
Improving safety in the ED and the hospital is beneficial to healthcare workers, as well as to other potential victims, such as visitors and other patients.

METHODS

Setting

LAC+USC is a large, urban, county hospital with an ED census of 180,000 visits per year. There is a psychiatric ED and an affiliated off-premises inpatient psychiatric facility. In-hospital assaults by patients are reported through a standardized process. Assaults can be reported when they occur anywhere on the hospital grounds, including the medical floor, the outlying affiliated psychiatric facility, the ED, the outpatient clinics, and guest areas.

Patients

We examined all reports of assaults committed by patients from July 2011 through June 2013. We excluded cases if the assailant could not be identified by the report or if there was incomplete information on the assailant in the medical record. If a single patient committed multiple assaults during the same hospital stay, only the first assault was included. For each unique patient, an attempt was made to include two age- and gender-matched controls with an ED visit within three days of the patient. We reviewed medical records of the controls, including a search for any available psychiatric consultations or notes.

Study Design

This was a retrospective case-control study design. We collected cases from the hospital assault database. Once the cases were identified, hospital medical records were acquired and reviewed for further information about the assailant. For each assault, we recorded the assailant's (patient's) past medical and social history, primary medical complaints, ED diagnoses, and medications prescribed. Additionally, presence of an involuntary psychiatric hold and involuntary restraints by either physical or chemical means during the index visit were recorded. We also reviewed prior records for prior assaultive behavior, history of reported illicit drug use, and frequency of visits to same hospital requesting prescription for pain medications. There were three assessors: the study principal investigator (PI), a second ED attending physician, and a student. Both the attending physician and the student received training and oversight by the PI. About 10% of the assault cases were coded by both, and the agreement was assessed. The assessors were not blinded to the study intent. This study was approved by the University of Southern California, institutional review board.

Definitions

We classified any documented evidence of verbal or physical aggression witnessed by staff or reported by observers as aggressive behavior. If occurring in the ED, this was labeled ED aggression and included verbal threats, name-calling toward staff, true physical assaults, and physical gestures interpreted as threatening (e.g.

purposefully swinging IV pole toward provider). In California, an involuntary hold is titled 5150 (or 5585 for children). If this was cited in the chart or ordered, we considered the patient to be on an involuntary hold. The hold itself was then referenced for cause. If the patient had an involuntary hold listed under past medical history in the notes from their reference visit, listed as a diagnosis on the computerized list of medical problems, or cited in a note from a prior visit, then the patient was considered to have a past medical history of a psychiatric complaint.

Illicit drug use was considered positive if patient report of drug use or a positive urine toxicology screen was documented. We did not include marijuana as an illicit drug, as marijuana for medical reasons was legalized in California during the time of data collection. We considered five or more visits requesting opioid pain medication in the year prior to the assault visit as repeat visits for pain medication.

Statistical Analysis

We assessed differences between case and control population by unadjusted odds ratios (OR) using logistic regressions. Statistical analyses were performed using Stata 13 (StataCorp, 2013) using two-tailed tests with α set to 0.05.

RESULTS

In total, we identified 117 assaults by patients. Inadequate documentation resulted in exclusion of 10 patients. We excluded 15 additional records due to multiple assaults by the same patient during the same visit (11 patients had two assaults reported and two patients had three assaults reported), leaving 92 assaults for analysis. The majority of the attacks (93.5%) included a physical component; the remainder were verbal. Males were slightly over-represented (59%), and the assailant age range was 9 - 78 years (mean 39 years). Seven of the patients used medical equipment as a weapon, including charts, pencils, tape, linen hampers, and boxes of gloves. Seven physicians, 18 nursing assistants (NA), and 29 registered nurses were involved in assaults, with the balance comprised of other staff, food service personnel, unspecified multiple staff members, and visitors.

The most common location of reported assaults (37%) was the inpatient psychiatric ward; however, 27% occurred in the medical inpatient areas, and 31% in the ED. The most common historical features of the assailants were a history of an involuntary psychiatric hold (52%) and a history of psychosis (49%). A history of danger to others was documented in 47% and of danger to self in 48%. Forty-five percent had a history of violence in the ED on a prior visit. During the stay in which the assault occurred, 64% of the patients had aggression noted in the ED chart, and 61% were on or under consideration for an involuntary hold for danger to others. Repeat visits for pain medication use (9%) and history of drug use (33%) were statistically more common among assailants, but did not seem to be major drivers of aggression in the medical environment. Agreement between chart reviewers was 70%.

We identified a total of 179 matched controls with complete records. Of these, one patient had a history of psychosis and 11 (6%) had a history of an involuntary psychiatric hold for any reason. Six (4%) were aggressive in the ED, and five (3%) were under consideration or on an involuntary danger to others hold. For all features studied, except for history of anxiety and depression, there was a significant difference between assaultive patients and matched controls. History of psychosis (OR 170.4), history of involuntary hold for danger to others (OR 51.5), ED aggression noted (OR 50.4), and current consideration for involuntary danger to others hold (OR 52.8) all had ORs >50 for committing a reported assault. This data is summarized in Table 1.

When the patients who first assaulted a HCW on the inpatient wards or inpatient psychiatric facility were analyzed separately, 71% were either psychotic or on an involuntary hold for danger to others in the ED (vs 11% of controls); 60% demonstrated aggressive behavior in the ED (compared with 4% of controls); and 50% required code activation for restraints in the ED (vs 2% of controls) (Table 2).

DISCUSSION

Violence against HCW is a problem and, when it occurs, can lead to unacceptable outcomes. It is not unusual for emergency personnel to feel that violence is endemic to the workplace and that acceptance of violence is part of the culture of the workplace.[23] In this study, nearly 94% of attacks reported here were of a physical nature, making it likely that threats and verbal attacks in isolation were under-reported. Violent experiences in the workplace impact workers' commitment to the facility,[24] job satisfaction, and patient outcomes.[25,26] Psychological effects can linger for weeks to months following an incident.[27] Missed work days and legal fees cause financial impact as well. While a few studies have investigated programs to support or train HCW, the problem remains rampant.

Features such as gender and duration of employment of HCW have been identified, but these do not extrapolate to obvious interventions on the level of a physician-patient interaction. In this study, we identified some predictors of HCW assault. The majority of features were not surprising. Patients with a history of psychosis, aggression demonstrated in the ED, or currently or previously on/under consideration of an involuntary hold for danger to others were logically more likely to assault a HCW. This deviates slightly from prior work on community violence only implicating mental illness as a predictor of violence

Table 1. Assault/assailant characteristics of patients with propensity for aggressive behavior.

Characteristic	N (%)	95% CI	Control % (p-value)	OR
Assault type				
Physical	76 (83%)			
Verbal	6 (7%)			
Both	10 (11%)			
Assault location				
Inpatient psychiatric facility	34 (37%)			
Inpatient medical ward	25 (27%)			
ED	29 (31%)			
Public area	3 (3%)			
Radiology	1 (1%)			
Psychiatric history				
Involuntary hold	48 (52%)	41.8-62.6	6% (<0.001)	16.7
Danger to self	44 (48%)	34.7-58.2	6% (<0.001)	14
Danger to others	43 (47%)	36.3-57.1	2% (<0.001)	51.5
Psychosis	45 (49%)	38.5-59.3	1% (<0.001)	170.4
Schizophrenia	27 (29%)	19.9-38.8	5% (<0.001)	7.8
Bipolar	25 (27%)	17.9-36.4	4% (<0.001)	7.8
Depression	18 (20%)	11.3-27.8	11% (0.05)	2
Anxiety	9 (10%)	3.6-16	4% (0.06)	2.7
None	13 (14%)	7.9-21.4	80% (<0.001)	
History of aggressive behavior				
ED	41 (45%)	34.2-54.9	2% (<0.001)	47.2
Inpatient	19 (21%)	12.2-29.1	2% (<0.001)	11.4
Outpatient	7 (8%)	2.1-13.1	0%	
None	48 (52%)	41.8-62.6	98% (<0.001)	
Social history				
Illicit drug use	30 (33%)	22.8-42.4	12% (0.00)	3.6
>5 visits for pain medication/1y	8 (9%)	2.9-14.7	<1%	
ED course of index visit				
Aggression noted	59 (64%)	54.8-74.8	4% (<0.001)	50.4
Hold for danger to others	56 (61%)	51.4-71.7	3% (<0.001)	52.8
Psychosis	49 (53%)	43.3-64.3	6% (<0.001)	16.9
Code team called for restraint	46 (50%)	40.6-61.6	1% (<0.001)	30.3
Psychiatric medications given	45 (49%)	39-60	5% (<0.001)	19.8

CI, confidence interval; *ED*, emergency department; *OR*, odds ratio.

when co-occurring with substance abuse and/or dependence.[28]

The self-evident nature of these risk factors makes assailant identification and implementation of useful interventions easier. Patients with a known disclosure or behavior indicating interest in harming others, psychosis, and aggressive behavior early in the visit may require a higher level of security and an enhanced level of caution on the part of the healthcare providers. While many patients falling into these categories do not commit an assault, and clearly individual rights cannot be infringed upon needlessly, these patients should be flagged as higher risk of assault and appropriate safety measures enacted to protect both patient and staff from violence.

Many of the victims in this data set were NAs, which is likely because NAs are used as sitters at our facility. NAs or comparable staff with no defense training or clear

Table 2. Assaults occurring on inpatient units.

Characteristic	Assaults (N=59)	Controls (N=114)	p value
Age (years)	38.3	38.3	0.99
Female (%)	49	49	0.99
Psychosis or DTO hold in ED	71%	11%	<0.001
Aggressive behavior in ED	60%	4%	<0.001
Activation for restraints in ED	50%	2%	<0.001

DTO, danger to others; *ED*, emergency department.

support plan should not be left alone with the responsibility of sitting for patients at high risk of assaulting a HCW. Targeting certain patients for a higher level of security would have identified the majority of assailants in this study. This pilot study provides some preliminary predictive features to guide in the identification of which patient require heightened security.

LIMITATIONS

Clearly, documentation of many of the data points was highly dependent on the patient's primary complaint. Patients seen for psychosis often had an extensive psychiatric history documented; those presenting with medical complaints frequently did not. While prior records were helpful, visits to other hospitals were not assessed. With these limitations, the reported histories of aggression and psychiatric disorders were likely underestimated, although the underestimation was likely greater in the control population.

Additionally, it is likely that not all assaults are reported via this system. Healthcare workers may not feel it necessary or take the time to report more minor or aborted attempts at violence. The nature of self-report tends to select for more significant assaults and may bias the data to include patients with a stronger history of violence and mental health issues. Prior literature cites reporting rates as low as 19%.[29] The rate of physical assault in this study is much higher than that reported in survey and interview-based literature. Likely the most significant assaults were more frequently reported, while verbally aggressive and threatening patients were overlooked.

CONCLUSION

Patients with a history of psychosis or of an involuntary psychiatric hold, as well as those expressing aggression in the ED and those on or under consideration of an involuntary psychiatric hold for danger to others should be considered a higher risk group for committing an assault against a healthcare worker. Resources should be dedicated to the observation and intervention of this patient population.

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Involuntary Psychiatric Holds in Preadolescent Children

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Introduction: Little is known about the use of involuntary psychiatric holds in preadolescent children. The primary objective was to characterize patients under the age of 10 years on involuntary psychiatric holds.

Methods: This was a two-year retrospective study from April 2013 – April 2015 in one urban pediatric emergency department (ED). Subjects were all children under the age of 10 years who were on an involuntary psychiatric hold at any point during their ED visit. We collected demographic data including age, gender, ethnicity and details about living situation, child protective services involvement and prior mental health treatment, as well as ED disposition.

Results: There were 308 visits by 265 patients in a two-year period. Ninety percent of involuntary psychiatric holds were initiated in the prehospital setting. The following were common characteristics: male (75%), in custody of child protective services (23%), child protective services involvement (42%), and a prior psychiatric hospitalization (32%). Fifty-six percent of visits resulted in discharge from the ED, 42% in transfer to a psychiatric hospital and 1% in admission to the pediatric medical ward. Median length of stay was 4.7 hours for discharged patients and 11.7 hours for patients transferred to psychiatric hospitals.

Conclusion: To our knowledge, this study presents the first characterization of preadolescent children on involuntary psychiatric holds. Ideally, mental health screening and services could be initiated in children with similar high-risk characteristics before escalation results in placement of an involuntary psychiatric hold. Furthermore, given that many patients were discharged from the ED, the current pattern of utilization of involuntary psychiatric holds in young children should be reconsidered. [West J Emerg Med. 2017;18(6)1159-1165.]

INTRODUCTION

Pediatric psychiatric emergencies are increasingly common, even in the very young.[1-6] Large studies have found that more than 20% of visits for pediatric psychiatric emergencies occur in children under the age of 13 years.[7,8] One recent study found that from 2008 to 2015, the percentage of encounters at children's hospitals for suicidality/self-harm more than doubled with 5-11 year olds accounting for 12.7% of visits.[9] Despite these findings, little has been published about the nature and severity of psychiatric complaints in young children.

A subset of children seen in emergency departments (ED) for psychiatric complaints are on involuntary psychiatric holds for danger to self or others, or grave disability due to a mental health condition. These involuntary holds are often initiated in the prehospital setting in the midst of a volatile situation, but in reality patients may or may not represent a true and imminent threat to self or others or be gravely disabled. To our knowledge, there is no data published on the use of involuntary psychiatric holds in young children. The effectiveness of involuntary psychiatric holds on stabilizing patients with acute psychiatric

emergencies has not been evaluated in adults or adolescents, much less in young children.[10]

The number of patients of any age placed on involuntary psychiatric holds annually in the U.S. is not reliably known.[10] One might expect the use of involuntary psychiatric holds to be rare in young children because young children rarely have the means to seriously harm themselves or others, and suicide or homicide committed by young children is very uncommon.[11,12] The objectives of this study were to quantify and characterize patients under the age of 10 years on involuntary psychiatric holds seen in one urban public ED in Los Angeles and to determine the ED disposition of these patients.

Population Health Research Capsule

What do we already know about this issue?
Pediatric mental health emergencies are commonly seen in the ED and the frequency of these visits is increasing.

What was the research question?
Our goal was to characterize preadolescent patients on involuntary psychiatric holds and report their ED dispositions.

What was the major finding of the study?
Most patients were male, 42% had a history of child protective services contact, and most were discharged home.

How does this improve population health?
The results highlight the need for evaluations of outpatient mental health services and the process of initiation of involuntary psychiatric holds in young children.

METHODS

This was a retrospective study of patients presenting to one ED during a two-year period from April 2013 – April 2015. We conducted the study using established methodology for retrospective chart reviews,[3,14] and included all patients under the age of 10 years (pre-adolescent per the World Health Organization definition) on an involuntary psychiatric hold at any point during their ED visit. Patients were identified by querying the electronic medical record for all patients under the age of 10 with "behavioral precautions," which is noted for all patients with a recognized psychiatric or behavioral complaint. The University of Southern California Institutional Review Board approved the study with waiver of consent.

Study Setting

LAC+USC Medical Center is an academic urban county hospital in Los Angeles; it has a dedicated pediatric ED with approximately 24,000 pediatric visits per year. Approximately 1,850 patients under the age of 18 years with psychiatric or behavioral complaints were seen annually during the study period. There are no inpatient psychiatric beds for children on-site, so all children requiring psychiatric inpatient treatment must be transferred to an inpatient psychiatric facility.

In Los Angeles County, children may be placed on an involuntary psychiatric hold by police or parole officers, dedicated psychiatric emergency response teams and designated healthcare providers for grave disability, danger to self or danger to others due to a mental health condition.[15] The initial hold is valid without judicial review for a period of 72 hours. There is no lower age limit specified in the involuntary psychiatric hold statute for minors. Four psychiatric hospitals in Los Angeles County admit children under the age of 12 years for inpatient treatment.

Data Collection

We developed a data dictionary prior to initiation of data collection, and data was abstracted by two of the authors, both pediatric emergency attending physicians. The two authors (IC, GS) developed the abstraction protocol together and initial chart abstraction was done with both abstractors present to ensure that abstraction methods were consistent. We collected data using an online system (Survey Gizmo, Boulder, CO) with questions arranged based on the location of data points in the chart. Medical records, including ED records, the involuntary hold, and psychiatric consultations were reviewed. Data collected included the following: basic demographic information; site of hold initiation; reason for hold; living situation; current and prior outpatient psychiatric care; current and prior outpatient psychiatric medication(s); prior psychiatric hospitalizations; and final diagnosis and disposition. For patients admitted to the inpatient pediatric medical service, we collected further details about the reason for admission, admitting diagnoses and laboratory tests. If there was a discrepancy in information in the medical records, we abstracted details of the hold from the legal hold and details of the patient's history from the psychiatry note. If multiple psychiatry notes existed and had conflicting information, the last child psychiatry note detailing the pertinent information was abstracted.

Data Analysis

We used descriptive statistics to characterize the patients. Ten percent of charts were abstracted by both abstractors and a weighted Cohen's kappa co-efficient was calculated for three variables to measure inter-rater agreement. We conducted statistical tests in STATA 13 (StataCorp, 2013) using two-tailed tests with α set to 0.05.

RESULTS

We identified 356 patients under the age of 10 years with psychiatric and behavioral complaints. On chart review, we found that 48 patients were not on an involuntary psychiatric hold during their visit and excluded them from the study. These excluded patients were generally patients with co-existing medical and psychiatric diagnoses who were presenting with medical complaints or patients presenting voluntarily for psychiatric medication refills or psychiatric evaluations. A total of 308 visits by 265 unique patients remained for analysis. Of these, 232 patients had one visit during the study period, while 33 patients (12.5%) had repeat visits: 26 patients with two visits, four patients with three visits and three patients with four visits.

Patient characteristics are presented in Table 1. Patients ranged in age from 4-9 years, with 8- and 9-year-old children accounting for 62% of the visits. Of note, 75% of visits were by males. Only 70% were living at home with their parents, and over 40% of the cohort had a known history of child protective services involvement.

At the time of their ED visit 61% of patients were receiving outpatient mental health services, just over half had a history of taking psychiatric medications, and nearly three quarters had received prior mental health treatment. Almost one third of patients reported a prior psychiatric hospitalization. Prior mental health treatment of the study population is presented in Table 2.

Details of the involuntary psychiatric holds are presented in Table 3. The majority of holds were for danger to self or for both danger to self and others. Almost 90% of holds were initiated in the prehospital setting. Holds initiated in the prehospital setting were initiated by police, school police or one of the psychiatric emergency response teams in Los Angeles County.

More than half of patients were discharged home and only 42% were transferred to an inpatient psychiatric facility. The median length of stay (LOS) was 4.7 hours for discharged patients and 11.7 hours for patients transferred to psychiatric hospitals. Further details on disposition are presented in Table 4.

Four patients were admitted to the pediatric medical service. Their median length of stay in the ED was 33.6 hours. One 7-year-old was admitted for observation after a possible overdose of his own medication. An 8-year-old patient was admitted after a 40-hour ED stay in which he was restrained multiple times, refused to eat for over 24 hours and developed mild rhabdomyolysis (creatinine kinase = 1246). Another 7-year-old patient was admitted for mild rhabdomyolysis (creatinine kinase = 2208) after spending more than 24 hours in the ED and having multiple behavioral outbursts. A 9-year-old patient with autism and behavioral problems was admitted to the ward after a nearly four-day ED stay because the father was uncomfortable taking the patient home and no alternate placement could be identified.

When reviewers were compared, the weighted kappa was 0.89 for current psychiatric medications, 0.83 for prior hospitalizations and 0.65 for current living situation.

DISCUSSION

While involuntary psychiatric holds are a valuable resource in the appropriate setting, they come at a cost both financially and in potential for medical adverse events and psychological repercussions for children and caregivers. Children may be stigmatized, the use of involuntary holds may lead to distrust of social and emergency services by the parents and child, and parents may avoid seeking help in future crisis situations if they feel the hold was not

Table 1. Characteristics of preadolescent patients by visit to the emergency department (ED) for psychiatric and behavioral complaints (N=308).

	N	%
Age (years)		
4	3	1.0
5	23	7.5
6	39	12.7
7	53	17.2
8	82	26.6
9	108	35.1
Sex		
Male	231	75.0
Female	77	25.0
Race/ethnicity		
Hispanic/Latino	173	56.2
African-American	78	25.3
White, non-Hispanic	34	11.0
Asian	6	1.9
Other	9	2.9
Unknown	8	2.6
Living situation		
Home	215	69.8
Foster home	55	17.9
Temporary congregate care (child protective services)	15	4.9
Group home	9	2.9
Other	13	4.2
Unknown	1	0.3
Known current or prior child protective services involvement	128	41.6
New child protective services report made in ED	25	8.1

Table 2. Prior mental health treatment of preadolescent patients by visit (N=308).

	Yes; N (%)	No; N (%)	Unk; N (%)
In outpatient treatment at time of visit	189 (61.4)	103 (33.4)	16 (5.2)
On psychiatric medications at time of visit	140 (45.5)	162 (52.6)	6 (1.9)
Any history of psychiatric care (inpatient or outpatient)	225 (73.1)	70 (22.7)	13 (4.2)
Any history of psychiatric medications (current or past)	161 (52.3)	129 (41.9)	18 (5.8)
Prior psychiatric hospitalization	100 (32.5)	190 (61.7)	18 (5.8)

Table 3. Details of involuntary psychiatric holds (N=308).

	N	%
Reason for hold		
Danger to self	112	36.4
Danger to others	51	16.6
Danger to self and others	131	42.5
Gravely disabled (including co-diagnosis)	6	1.9
Unknown	8	2.6
Setting where hold initiated		
Prehospital	276	89.6
LAC+USC psychiatric outpatient clinic	4	1.3
LAC+USC emergency department	27	8.7
Unknown	1	0.3

Table 4. Disposition of visits (N=308).

	N	%
Disposition		
Discharged	174	56.5
Transferred to a psychiatric hospital	130	42.2
Admitted to the pediatric medical ward	4	1.3
LOS by disposition, in hours	Median	Range
Discharged	4.7	1.09 – 95.25
Transferred to a psychiatric hospital	11.7	0.4 – 243.25
Admitted to the pediatric medical ward	33.6	7.21 – 93.1

LOS, length of stay.

beneficial. Depending on insurance coverage, parents may be responsible for a substantial bill for ambulance transport and ED services. Further research into reasons for placement of involuntary holds, alternative methods of managing behavioral and psychiatric complaints in the prehospital setting and provision of urgent mental health services is warranted.

It would be ideal if alternative methods such as targeted psychiatric screening and improved outpatient resources for at-risk youth could decrease the need for placement of involuntary psychiatric holds. An important trend noted in this study was child protective services involvement. Nearly a quarter of the children in our population were living in a foster home or child protective services temporary congregate

care, and over 40% had a known history of child protective services involvement. Children in foster care have a high rate of mental health problems[16] and account for a disproportionate number of psychiatric hospitalizations.[17]

Children permanently removed from their homes due to child abuse have been shown to be five times more likely than their peers to have an ED visit for suicide-related behavior.[18] Foster children requiring psychiatric inpatient care are more likely to be re-hospitalized,[19] and children removed from their homes have an increased risk of suicidality and suicide attempts.[20,21] While it is not surprising that a high percentage of preadolescent children on involuntary psychiatric holds in our population were in foster care, this is an accessible population that might benefit greatly from early and frequent mental health and behavioral screening. Additionally, patients with prior psychiatric hospitalizations were highly represented in this cohort. Sixty-one percent of patients in this sample were receiving outpatient mental health care, and 73% had received mental health care in the past. While inpatient hospitalization is sometimes unavoidable, it is possible that more frequent visits, afterhours emergency access, different types of therapy, medications, or other outpatient services could be helpful in preventing acute decompensations.

A re-evaluation of the process by which holds are justified in preadolescent children may be needed. The patients in this sample frequently had mood disorders, adjustment disorders, attention deficit hyperactivity disorder (ADHD) and impulse control disorders. Psychotic disorders were relatively uncommon in this sample. ADHD and impulse control disorder alone are not disorders that typically require inpatient treatment, again raising the question of whether some of these holds were truly indicated.

In this sample, males accounted for 75% of the visits in this cohort of patients. A study of adults on involuntary psychiatric holds documented a slight predominance of men.[22] Prior literature on the gender of pediatric patients presenting with psychiatric emergencies is mixed with some studies finding a female predominance and others finding a male predominance.[2,5,8,23,24] However, none found such a striking predominance of one gender. It is notable that childhood-onset developmental and psychiatric disorders such as ADHD, autism and conduct disorders show a male predominance, while there is a female predominance in mood and anxiety disorders, which more commonly present in adolescence.[25] Boys tend to display more externalizing symptoms,[26] which may contribute to the placement of involuntary psychiatric holds. This population was replete with stories of young boys acting out or drawing battles, and being placed on involuntary holds. One child, in particular, was directly quoting a popular children's television series, resulting in an involuntary hold for "danger to others."

Laws regarding involuntary psychiatric hospitalization vary greatly from state to state.[10] In Los Angeles County, 72-hour involuntary psychiatric holds may be initiated by a variety of professionals including police and parole officers and psychiatric emergency response teams.[15] In our patient population, psychiatric holds were most frequently placed by police, school police and psychiatric emergency response teams. In Los Angeles County, there are many separate police agencies and psychiatric emergency response teams, making uniform training and application of hold criteria challenging. The training and comfort level with psychiatric emergencies in general and especially pediatric psychiatric emergencies likely varies greatly by type of responder. It is possible that psychiatric emergency response teams with specialized training in pediatric behavioral, developmental and mental health would be able to de-escalate more emergency calls without requiring placement of an involuntary psychiatric hold.

The final question that arises is whether the child ultimately benefited from the hold placement. While not directly addressed in this study, the median ED LOS for discharged patients was 4.7 hours. While this LOS does represent a burden on ED resources, it is hard to imagine that meaningful psychiatric stabilization and treatment could occur in such a short time period. Prior data would indicate that boarding is non-therapeutic for the majority of psychiatric patients.[27] This relatively short LOS and the fact that over half of the involuntary holds were overturned in the ED raises the question of whether these holds were truly necessary. It is possible that in some cases involuntary holds could be avoided if more robust urgent outpatient services were available so that prehospital psychiatric response teams could instead link patients and families to appropriate services rather than placing a hold.

Clearly, further study is necessary to assess the benefit of targeted screening and referral in preventing involuntary holds. Involuntary hold criteria may need to differ by age and developmental level. Young children have lower rates of suicide and homicide and can generally be supervised by parents or other caretakers. Given these differences from an adult population, if intensive outpatient services were available urgently for children in crisis, perhaps this would be a better alternative, particularly for young children. This may be especially true for the patients already receiving outpatient care as their caretakers have shown a willingness to seek mental health treatment for their child. Significant gaps in outpatient mental health resources for children have been documented, due in part to reimbursement issues.[28] Investment in pediatric outpatient mental health services would likely be beneficial to patients and might decrease the need for costly ED and inpatient services resulting from psychiatric and behavioral crises leading to involuntary psychiatric holds.

LIMITATIONS

Although we generally followed the methodologies for conducting a retrospective review outlined by Kaji

et al. and Gearing et al.,[13,14] the abstractors were study investigators. We felt that blinding of the abstractors to the study hypothesis was not necessary since this was purely a descriptive study of characteristics of the population and detailed abstraction protocols were developed a priori.

This study is limited by the biases of a retrospective chart review. Ideally, we would have compared this population of patients to patients presenting with non-psychiatric complaints. However, as detailed social histories are not generally documented on patients presenting with non-psychiatric complaints, this would have clearly introduced bias in favor of the identified characteristics. Even in the patients presenting with psychiatric and behavioral complaints, historical details were not always immediately available and therefore may not have been documented. For example, the reason for prior hospitalization or outpatient treatment was not reliably documented. The 33 patients with a documented repeat visit represent only patients who had a repeat visit to our ED during the study period and before the age of 10. This number almost certainly underestimates recidivism, as patients with subsequent involuntary psychiatric holds would have been missed if their subsequent visit occurred after the study period or in another ED or psychiatric inpatient facility.

Hispanic patients comprised 56% of the visits in this sample, which is close to the expected based on the demographics of Los Angeles County. At the time of the 2010 census, 47.7% of the county's population was of Hispanic or Latino origin.[29] The hospital serves an overwhelmingly Hispanic/Latino population, with approximately 70% of the patients being of Hispanic/Latino descent. This data represents the patients seen in one urban county ED with a high proportion of Hispanic/Latino patients and may not be representative of other populations.

CONCLUSION

We have presented the first characterization of preadolescent children on involuntary psychiatric holds, many of whom were ultimately managed as outpatients. Given the potential for harm, the lack of proven benefit,[10] and the fact that most holds in this population were overturned, the current pattern of utilization of involuntary psychiatric holds in young children should be reconsidered. Further research is needed to identify effective means of proactively providing services to avoid the need for involuntary psychiatric holds, ED visits and short-term emergency hospitalizations. In particular, foster children and those who have had contact with child protective services or the inpatient mental health system in the past might benefit from aggressive screening and intervention if mental health issues are identified.

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