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Western Journal of Emergency Medicine:

Integrating Emergency Care with Population Health

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Western Journal of *Emergency Medicine*:

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JOURNAL FOCUS

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

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VITAL STATISTICS

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

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MEMC-GREAT 2017

Lisa Moreno-Walton, MD, MS, MSCR, FAAEM

Secretary-Treasurer, AAEM Board of Directors
Executive Chair, MEMC-GREAT 2017

Dear Friends and Colleagues in Emergency Medicine:
It is with great pleasure that I invite you to attend the premier international conference in Emergency Medicine: the Mediterranean Emergency Medicine Congress (MEMC), which will take place this year in Lisbon, Portugal from September 8-10, with pre-congress courses offered on September 6th and 7th. MEMC has a rich history of collaboration between the American Academy of Emergency Medicine (AAEM), our European colleagues in EM, and the Mediterranean Academy of Emergency Medicine. For the past 16 years, AAEM and our partners have sponsored this outstanding conference in Rome, Marseille (France), Kos (Greece), Valencia (Spain), Sorrento (Italy), Nice (France), Sitges (Spain) and Stresa (Italy), featuring the most outstanding speakers in Emergency Medicine. This year, our keynote speaker is Prof. Lee Wallis, a pioneer in establishing EM and EMS is South Africa and sitting President of the International Federation of Emergency Medicine (IFEM). Our plenary speakers will include many of your favorites from AAEM: Dr. Amal Mattu will update us on the most important cardiology research reports that will change your practice, and Dr. Kevin Rodgers, AAEM President, will get you savvy on how the business of EM impacts your practice no matter where in the world you work. An international favorite, Dr. Jim Ducharme, President Elect of IFEM and a world renowned expert on pain management will give you practical advice on the evidence based and sound management of pain, putting you in control of an aspect of your practice that most of us find challenging. The themes of this year's Congress are Diversity and Inclusion and Career Development, and highlighting these themes will be Middle Eastern luminaries Dr. Amin Antoine Kazzi, former president of AAEM and founder of the MEMC, discussing the merits of universal global standards for certification of emergency physicians, and Dr. Eveline Hitti, the Chair of Emergency Medicine at American University of Beirut who is doing ground breaking research on the barriers to the advancement of women in medicine (not just the glass ceiling, but also the "domestic tethers" that represent the uneven distribution of household and child rearing tasks in dual career households). Our newest partner, GREAT Italy (Global Research on Acute Conditions Team) will feature one of the most experienced researchers in cardiac emergencies, Dr. Frank Peacock, who will discuss the impact of highly sensitive troponins on ED practice.

Beyond the plenaries, our educational tracks will bring you the most current practices in toxicology, infectious disease, cardiac emergencies, pulmonary emergencies, EMS, updates in pediatric care, pain management, critical care, and more. We will also explore cutting edge topics such as the newest theories in medical education, ethical issues in the practice of global EM, the role of hyperbaric medicine in the ED, the role of the EP in combat medicine, and success stories from countries where EM is an emerging specialty. World leaders such as Prof. Juliusz Jakubaszko (Poland), Prof. Judith Tintinalli (US), Prof. Robin Roop (National Health Service-Wales), Dr. Jean O'Sullivan (Ireland), Dr. Hari Prasad (India), Dr. Fatima Rato (Portugal), Dr. Kelhan Golshani (Iran), Dr. Lim Swee Han (Singapore) and Dr. Nino Butskhrikidze (Republic of Georgia) will bring expertise from some of the 30 countries that will be represented at MEMC, enhancing our commitment to diversity and inclusion in the development of global emergency medicine. Under the direction of Drs. Mark Langdorf, Ed Panacek and their team, 300 cutting edge original research abstracts by up and coming young EM students, residents and junior faculty will be presented orally and as posters. Come and see the work being done by the colleagues you will be reading about in the coming decades!

This year's pre-courses are an outstanding line up. Dr. Terry Mulligan will return with his very popular course on ED Administration. Dr. Gary Gaddis will again lead his course on how to get your manuscript published, assisted by Editors in Chief of no less than five highly indexed EM publications ready and willing to help you see your manuscript in print. Ultrasound beginner and advanced courses, Amal Mattu's always sold out EKG course, critical care and resuscitation and our new simulation course will be augmented by the never before featured courses on management of chemical and radiation incidents (co-taught by Portuguese experts and AAEM's resident tox expert, Dr. Ziad Kazzi) and how to effectively manage in-flight emergencies (co-taught by Dr. Kumar Alagappan and a team of pilots and flight attendants).

And we want you to leave time to explore lovely, romantic Portugal! This is the land of golden sand beaches with some of the best surfing and swimming on earth; the soulful music of Fado; luscious Port wines; the medieval village of Obedos, perfectly preserved; religious shrines such as Fatima; the UNESCO heritage city of Sintra, where

you will walk in the footsteps of the Emperor Octavius, through the Moorish occupation and the Caliphate of Cordova, the conquest by Crusaders, the reign of King Ferdinand, into the world of modern Portugal. And modern Portugal is a traveler's dream. The Portuguese are foreigner- friendly, engaging, fun loving people. Most Portuguese natives speak fluent English. The country is safe, clean, and incredibly economical, offering the perfect mix of traditional churches and castles with modern night clubs and delightful restaurants and parks. The food is outstanding, and every major wine magazine is extolling the virtues of Portugal's emerging wine market. Be the first to taste the vintages that will soon be the most cherished! Our conference hotel, the Corinthia, is one of the most elegant and luxurious in Europe, and the staff is completely committed to your comfort and enjoyment.

I cannot imagine a better venue to combine education, friendship, family and fun than the MEMC 2017 in Lisbon. For me, the greatest pleasure will be welcoming you. If you are already a part of the MEMC family, it will be a joy to be with you again. If you are not, we invite you to make MEMC a tradition for yourself, your family and your friends, and to join us on the odd numbered years in the sultry Mediterranean for the best mix of learning and fun that you can imagine. Our incredible team will make you feel at home with a handshake, a kiss on the cheek, and a smile. Come and tell us what we can do to make the best conference even better. We want to meet and exceed your every wish for the finest learning experience and the most wonderful vacation. It is my hope that you will become a part of the MEMC family as a conference attendee, an abstract presenter and a speaker. This is not the big, impersonal, "take a number and scan your badge" conference. Every attendee matters to us; everyone is a friend and a colleague. The exchange of ideas, collaborative research, sharing educational resources, providing opportunities for career growth, and lifelong friendships that span continents and languages are what we are about. We embrace the spirit of diversity and inclusion and career development, and we want you to be a part of the inclusive and nurturing environment taking place in one of the most beautiful places on earth. MEMC will not be the same if you are not there. Grace us with your ideas, your talent, your knowledge and experience. Be a teacher and a learner at MEMC. Check us out on our website: www.emcongress.org. I look forward to welcoming you in Lisbon!

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Magnetic Resonance Imaging Utilization in an Emergency Department Observation Unit

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Introduction: Emergency department observation units (EDOUs) are a valuable alternative to inpatient admissions for ED patients needing extended care. However, while the use of advanced imaging is becoming more common in the ED, there are no studies characterizing the use of magnetic resonance imaging (MRI) examinations in the EDOU.

Methods: This institutional review board-approved, retrospective study was performed at a 999-bed quaternary care academic Level I adult and pediatric trauma center, with approximately 114,000 ED visits annually and a 32-bed adult EDOU. We retrospectively reviewed the EDOU patient database for all MRI examinations done from October 1, 2013, to September 30, 2015. We sought to describe the most frequent uses for MRI during EDOU admissions and reviewed EDOU length of stay (LOS) to determine whether the use of MRI was associated with any change in LOS.

Results: A total of 22,840 EDOU admissions were recorded during the two-year study period, and 4,437 (19%) of these patients had a least one MRI examination during their stay; 2,730 (62%) of these studies were of the brain, head, or neck, and an additional 1,392 (31%) were of the spine. There was no significant difference between the median LOS of admissions in which an MRI study was performed (17.5 hours) and the median LOS (17.7 hours) of admissions in which an MRI study was not performed [p=0.33].

Conclusion: Neuroimaging makes up the clear majority of MRI examinations from our EDOU, and the use of MRI does not appear to prolong EDOU LOS. Future work should focus on the appropriateness of these MRI examinations to determine potential resource and cost savings. [West J Emerg Med. 2017;18(5)780-784.]

INTRODUCTION

Although most patients presenting to an emergency department (ED) will subsequently be discharged,[1] many patients with more serious conditions will require admission to the hospital for further evaluation and management. Within the Medicare population, hospital inpatient services represent a significant portion of overall payments for beneficiaries, which has led to increased efforts aimed at enhancing both the value and quality of care delivered.[2]

One solution for optimizing care delivery has been the development and utilization of emergency department observation units (EDOU), a potential disposition option for patients who do not meet the criteria for inpatient admission but who cannot be discharged without additional care.[3-7] More than two million U.S. EDOU admissions were reported in 2011 alone.[1] Observation units provide clinicians additional time to either provide care or order diagnostic testing that can direct further patient management.[8] EDOUs have been shown to reduce overall hospital costs,[5,9] and it is estimated that they may save more than $3.0 billion annually in the U.S.[10] Baugh et al. found that using protocols in EDOUs for patients who present with syncope could save more than $100 million annually at a national level.[5] Although it is estimated that only one-third of EDs in the U. S. have an EDOU,[6-7] the ratio of EDOU stays to inpatient admissions has been rising.[11]

Diagnostic imaging is a critical component of care in both the ED and the EDOU, with nearly half of all ED visits in the U.S resulting in at least one imaging examination in 2011.[1] A 2015 study found that patients admitted to an EDOU were more likely to undergo magnetic resonance imaging (MRI) than those who were admitted as inpatients.[4] However, while the use of advanced imaging is becoming more common in the ED,[12,13] little is known about the utilization of MRI in EDOUs. Therefore, the aim of this study was to characterize the frequency of MRI examinations performed on patients in an EDOU, stratified by anatomical area. The secondary objective was to determine if MRI exam performance affected the length of stay (LOS) in the EDOU.

Population Health Research Capsule

What do we already know about this issue?
More EDs are placing patients in observation units instead of admitting them to the hospital, and some of these patients need MRIs.

What was the research question?
How are MRIs being used in an academic ED's observation unit, and are they adding to the length of stay?

What was the major finding of the study?
Approximately one-fifth of patients had an MRI, and these patients did not have a longer length of stay.

How does this improve population health?
MRIs are regularly performed in observation units, and we should focus on determining which MRIs are appropriate and which can be done as outpatient tests instead.

METHODS

Human Subjects Compliance

This retrospective descriptive Health Insurance Portability and Accountability Act–compliant study was approved by our institution's institutional review board, including a waiver of patient consent.

Study Site

The study was performed at a 999-bed quaternary care academic Level I adult and pediatric trauma center, with approximately 114,000 ED visits annually. Approximately 105,000 ED and EDOU diagnostic imaging studies are performed and interpreted by the division of emergency radiology annually. The EDOU is composed of a 32-bed observation unit with emergency physician supervision and receives over 11,000 admissions annually.

Collection of Patient Data

The study period was from October 1, 2013, to September 30, 2015. We retrospectively retrieved data from the hospital reporting system, including all MRI studies performed in the EDOU. These studies were characterized by anatomical area using the exam description. We also obtained the LOS for each admission in the EDOU, defined as the time elapsed in hours between the patient's admission into the EDOU and their subsequent discharge from the unit.

Outcome Measures

The primary outcome measures for this study were the overall proportion of EDOU admissions that included an MRI examination (MRI utilization), as well as the distribution of these examinations by anatomical area. The secondary outcome measure compared the median EDOU LOS of patients with and without MRI examinations.

Statistical Analysis

Data was imported into Microsoft Excel (Redmond, WA) for further analysis. We used summary statistics to describe overall MRI utilization and MRI distribution by anatomical area.

We performed a two-tailed, Wilcoxon rank-sum test between the median of EDOU LOS for admissions with and without a MRI study. Statistical significance was set at $p<0.05$.

RESULTS

MRI Utilization and Distribution

A total of 22,840 EDOU admissions were recorded during the two-year study period. Among these admissions, 4,437 (19%) included at least one MRI examination. The overall distribution of these exams is depicted in Table 1. The most common exam was MRI of the brain, head, or neck, conducted in 2,730 (62%) examinations, followed by MRI exam of the spine, performed in 1,392 (31%) examinations (Table 2). The MRI examination distribution of the musculoskeletal system and abdomen/genitourinary area is presented in Table 3.

EDOU Length of Stay (LOS*)*

There was no LOS information on five admissions where an MRI study was not performed (0.1%), and these admissions were excluded from this analysis. There was no significant difference between the median LOS of admissions where an MRI study was performed (17.5 hours) and the median LOS (17.7 hours) of admissions where an MRI study was not performed [p=0.33].

DISCUSSION

In the spectrum of clinical care, EDOUs represent a valuable alternative to inpatient admissions. Previous authors have noted that patients in the EDOU are more likely to undergo MRI examination when compared to those admitted to an inpatient service.[4] In this study, we assessed the utilization and distribution of MRI studies performed at one of the largest EDOUs in the U.S. Several of our findings are of interest.

The greatest proportion (62%) of the MRI examinations performed in our EDOU population were studies of the brain, head, or neck. One reason for these findings may be that EDOUs have been shown to be cost-effective for evaluating acute neurologic conditions, specifically transient ischemic attacks (TIAs).[14] Guidelines support use of MRI examinations for appropriate patients with symptoms of TIA.[15] Further, hospitals seeking comprehensive stroke certification from The Joint Commission must have MRI scanner availability 24 hours/day, 7 days/week,[16] highlighting the importance of advanced imaging in patients presenting with acute neurological symptoms. Our institution has specific protocols for patients who present with symptoms of a TIA that suggest they undergo MRI imaging in the EDOU. Having evidence-based protocols in an EDOU, specifically regarding which imaging is best performed in the EDOU and which may be safely performed in an outpatient setting, has been shown to lead to shorter hospital stays and lower overall costs.[17]

In addition, there was no significant difference in the LOS of EDOU admissions for patients with and without MRI examinations. Although we did not fully assess some of the factors associated with the LOS in observation units, including age, type of insurance, reason for EDOU admission, and others,[18] the carefully designed protocols, available personnel, and robust imaging resources of our dedicated observation unit may in part explain the lack of variation in LOS for these patients. Our median LOS for patients who underwent MRI was less than half of the 48-hour limit suggested by the Centers for Medicare and Medicaid Services,[8] suggesting that our EDOU was able to evaluate these patients in an efficient manner – potentially saving inpatient admissions without burdening our ED with prolonged patient work-ups.

LIMITATIONS

This study has several limitations. First, it was a retrospective, single-institution study that may limit generalization of our findings to other institutions. Second, we did not assess patient demographics, patient chief

Table 1. Distribution of MRI examinations performed in the emergency department observation unit by anatomical area.

Anatomical area	N	%
Brain/head/neck	2730	61.5%
Spine	1392	31.4%
Musculoskeletal extremity	232	5.2%
Abdomen	47	1.1%
Pelvis	31	0.7%
Other*	5	0.1%
Total	4437	100.0%

* magnetic resonance angiography aortic arch, MRA upper extremity, 3 studies unknown.

Table 2. Distribution of MRI spine examinations performed in the emergency department observation unit.

Anatomical Area	N	%
Lumbar spine	726	52.2%
Cervical spine	363	26.1%
Thoracic spine	163	11.7%
Entire spine	128	9.2%
Sacrum	11	0.8%
MRA spine	1	0.1%
Total	1392	100.0%

MRA, magnetic resonance angiography; *MRI,* magnetic resonance imaging.

Table 3. Distribution of MRI examinations of the musculoskeletal system and abdomen/genitourinary area, performed in the emergency department observation unit.

Anatomical Area	N	%
Musculoskeletal		
Hip	89	38.4%
Pelvic bone	33	14.2%
Knee	29	12.5%
Foot	29	12.5%
Shoulder	14	6.0%
Leg	11	4.7%
Femur	10	4.3%
Brachial plexus	6	2.6%
Wrist	3	1.3%
Ankle	3	1.3%
Elbow	2	0.9%
Arm	1	0.4%
Humerus	1	0.4%
Hand	1	0.4%
Total	232	100.0%
Abdomen/genitourinary		
Pelvis	31	39.7%
MRCP	26	33.3%
Liver	9	11.5%
Enterography	6	7.7%
Kidney	2	2.6%
Pancreas	2	2.6%
Adrenal	1	1.3%
Rectum	1	1.3%
Total	78	100.0%

MRI, magnetic resonance imaging, *MCRP*, magnetic resonance cholangiopancreatography.

complaint in the ED, or reason for ordering the MRI examination, all which may have influenced the pattern of distribution of MRI imaging and the EDOU LOS. Finally, we did not assess the clinical outcomes of the patients treated in the EDOU and those subsequently admitted to the hospital.

CONCLUSION

In this study, neuroimaging made up the vast majority of MRI examinations from our EDOU, and patients in whom an MRI was performed did not have a longer LOS than those who did not. Future work should focus on the appropriateness of these MRI examinations to determine potential resource and cost savings.

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Trends and Characteristics of Emergency Department Visits for Fall-Related Injuries in Older Adults, 2003-2010

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Introduction: One third of older adults fall each year, and falls are costly to both the patient in terms of morbidity and mortality and to the health system. Given that falls are a preventable cause of injury, our objective was to understand the characteristics and trends of emergency department (ED) fall-related visits among older adults. We hypothesize that falls among older adults are increasing and examine potential factors associated with this rise, such as race, ethnicity, gender, insurance and geography.

Methods: We conducted a secondary analysis of data from the National Hospital Ambulatory Medical Care Survey (NHAMCS) to determine fall trends over time by examining changes in ED visit rates for falls in the United States between 2003 and 2010, detailing differences by gender, sociodemographic characteristics and geographic region.

Results: Between 2003 and 2010, the visit rate for falls and fall-related injuries among people age ≥ 65 increased from 60.4 (95% confidence interval [CI][51.9-68.8]) to 68.8 (95% CI [57.8-79.8]) per 1,000 population (p=0.03 for annual trend). Among subgroups, visits by patients aged 75-84 years increased from 56.2 to 82.1 per 1,000 (P <.01), visits by women increased from 67.4 to 81.3 (p = 0.04), visits by non-Hispanic Whites increased from 63.1 to 73.4 (p < 0.01), and visits in the South increased from 54.4 to 71.1 (p=0.03).

Conclusion: ED visit rates for falls are increasing over time. There is a national movement to increase falls awareness and prevention. EDs are in a unique position to engage patients on future fall prevention and should consider ways they can also partake in such initiatives in a manner that is feasible and appropriate for the ED setting. [West J Emerg Med. 2017;18(5)785-793.]

INTRODUCTION

Falls among older adults (those at least 65 years of age) are frequent with approximately a third of community-dwelling older adults falling each year.[1] The estimated annual direct medical cost of non-fatal fall-related injuries is approximately $31.3 billion and will increase in the future as the population ages.[2] Not only are falls frequent and costly, they are the number one cause of unintentional injury leading to death among the elderly.[3] There are more than 10,000 deaths and 2.6 million nonfatal injuries from falls among older adults annually.[4] Approximately 10% of falls result in significant injury.[5] Falls increase the risk of admission to

nursing homes[6] and future falls,[7,8] and are associated with health decline, social isolation and loss of confidence.[9–11]

In 2006, older adults made more than two million visits to the emergency department (ED) for injurious falls, representing 10% of ED visits among this group.[12] Over two thirds (70.4%) of these patients were discharged after their ED visit, with the remaining 29.6% admitted to the hospital.[12] Annual estimated costs of ED visits for falls is $8.5 billion.[2] Given that falls are a potentially preventable cause of injury, functional decline and traumatic death,[13–15] EDs are in a unique position to evaluate and potentially intervene on behalf of these patients.

Since the number of fall-related emergencies is likely to rise as the population ages, it is important to understand the characteristics and trends of ED fall-related visits among older adults. To date, we are unaware of studies evaluating ED visits in the United States across time for fall-related complaints among the elderly. Our objective was to determine fall trends over time by examining changes in ED visit rates for falls in the U.S. between 2003 and 2010, detailing differences by gender, sociodemographic characteristics and geographic region. We hypothesized that falls among older adults are increasing and examined potential factors associated with this rise, such as race, ethnicity, gender, insurance and geography.

Population Health Research Capsule

What do we already know about this issue?

Older adult falls are costly to both the patient in terms of morbidity and mortality and to the health system, but are a preventable cause of injury.

What was the research question?
To determine fall trends over time by examining changes in ED visit rates for falls in the United States between 2003 and 2010.

What was the major finding of the study?
The overall visit rate for fall-related injuries among people age ≥ 65 increased from 60.4 to 68.8 per 1,000 population (p=0.03).

How does this improve population health?
There is a national movement to increase falls awareness and prevention. EDs are in a unique position to engage patients on future fall prevention in ways that are feasible in an ED setting.

METHODS

Study Design and Setting

We conducted a secondary analysis of data from the National Hospital Ambulatory Medical Care Survey (NHAMCS), publicly available through the Centers for Disease Control and Prevention (CDC). The NHAMCS is a national probability-sample survey of patient visits to selected ambulatory care departments conducted annually since 1992 by the CDC's National Center for Health Statistics (NCHS). For this analysis, we included data solely from the ED visit files of calendar years 2003- 2010 during which a purposeful sample of 386 to 443 EDs were included. Each patient visit was weighted to form national estimates for all components of the survey.[16] The resulting overall, unweighted response weights ranged from 82.5% to 89.2%.

Our subpopulation of interest was patients aged 65 or older whose ED visit was related to a fall. We contacted NCHS to identify the International Classification of Diseases, Ninth Revision (ICD-9) external cause of injury codes used to classify a fall, where each visit can list up to three causes of injury. A variable was created to classify all fall-related visits from the cause of injury variables (using ICD-9 external cause of injury codes 880.0-888.9). Any fall-related causes listed in the three-causes-of-injury data fields were classified as "fall." We stratified all visits to EDs during this time period by age, sex, race, ethnicity, insurance status and region.

The total number of unweighted patient visits from years 2003-2010 among those age 65 or older was 42,089, and the total number of unweighted patient visits among those age 65 or older with a fall-related visit from years 2003-2010 was 5,512. Although we focused only on the subpopulation of those age 65 or older, all observations remained in the analyses in order to correctly calculate the estimates.

We managed and analyzed all data using SAS 9.4 (SAS Institute Inc., Cary, NC) and STATA/IC 13.1. Because we used a publicly available dataset, this study was deemed exempt from review.

Statistical Analysis

We analyzed all data using the sampled visit weights, which account for the specific sampling design of NHAMCS; unweighted numbers were not used to calculate estimates. For the subpopulation age 65 and older, we calculated rates for fall-related ED visits by age, gender. race, region, and source of payment. Rates were calculated for each year from 2003-2010 as the number of weighted visits per 1,000 population. We obtained population data from the U.S. Census Bureau for each rate calculated, depending on the specific subpopulation. For each subgroup, a special weight variable was created using the appropriate population estimate as the denominator. We used SAS survey procedures with the appropriate "cluster" and "strata" design variables to account for the complex

nature of the sample; weighted frequencies and 95% confidence limits were calculated. All visit rates were calculated per 1,000 population. To ensure reliability of estimates reported, we did not include rates if unweighted sample sizes were less than 30.

We used simple linear regression models to assess trends in rates across years 2003-2010. For each model, year was used as the dummy variable and the respective population rate as the dependent variable. We calculated rate differences (RD) over the seven-year period (2003-2010) using a linear regression model to assess the annualized rate change per year, measured as a continuous variable. This is represented as an annual change per 1,000 persons, with significance assessed at the $p<0.05$ level. No adjustments for multiple comparisons were made since the analyses were exploratory in nature.

RESULTS

We found that ED visits for falls in adults 65 years and older increased over the seven-year period by 27%, ranging from 2.2 to 2.8 million visits. Between 2003 and 2010, the visit rate for falls and fall-related injuries increased from 60.4 (95% confidence interval [CI] [51.9-68.8]) to 68.8 (95% CI [57.8-79.8]) per 1,000 population; on an adjusted basis, there was an annual visit rate increase of 2.3 per 1,000 ($p= 0.03$) (Table 1, Figure 1). There was also an increase in the overall visit rate for this population group over time (Figure 2).

Controlling for U.S. population growth, visits rates for falls continued to grow. Specifically, visits by patients age 75-84 years accounted for the greatest rate increase with rates increasing from 56.2 to 82.1 per 1,000 population age 65 and older (annualized RD 4.5 per 1,000, 95% CI [1.8-7.3], $p <.01$),

Table 1. Fall-related emergency department visits in the United States among ages 65 and older, 2003-2010.

	ED visits, unweighted no.		Estimated ED visits, weighted no. in millions		Estimated ED visits per 1000 no. (95% CI)	
	2003	2010	2003	2010	Annualized Rate Difference per 1,000 over time	p value for linear trend*
Total visits (fall)	799	722	2.2	2.8	2.3 (0.3, 5.4)	0.03
Age (years)						
65- 74	257	213	0.7	0.9	2.1 (-1.5, 5.9)	0.20
75- 84	285	289	0.7	1.1	4.5 (1.8, 7.3)	< 0.01
85 and older	257	220	0.8	0.8	1.9 (-4.0,8.3)	0.46
Gender						
Male	266	237	0.8	0.9	1.6 (-1.8, 5.2)	0.29
Female	533	485	1.4	1.9	3.5 (0.1, 6.9)	0.04
Race/ethnicity						
White (non-Hispanic)	678	596	1.9	2.4	3.4 (0.5, 6.4)	<0.01
Black	56	54	0.2	0.2	1.1 (-5.1, 7.6)	0.69
Hispanic or Latino	42	43	0.1	0.2	1.2 (-6.4, 9.4)	0.72
Other race	29	33	0.05	0.08	-6.6 (-15.0, 2.7)	0.10
Region						
Northeast	218	199	0.6	0.6	0.2 (-4.9, 5.5)	0.94
Midwest	184	147	0.5	0.6	1.8 (-2.4, 6.2)	0.35
South	216	239	0.7	1.1	5.3 (0.6, 10.2)	0.03
West	181	137	0.4	0.6	3.2 (-0.3, 6.8)	0.07
Primary source of payment						
Medicare	609	616	0.6	0.6	4.5 (0.5, 8.7)	0.03
Medicaid	27	17	0.03	0.02	-7.3 (-36.0, 34.4)	0.63
Private insurance	114	54	0.1	0.05	-1.8 (-8.5, 5.5)	0.56
Self-pay, other or unknown	49	35	0.05	0.03	-8.0 (-14.4, -1.2)	0.03

CI, confidence interval; *ED*, emergency department.
*P-value based on the linear regression trend from 2003 and 2010

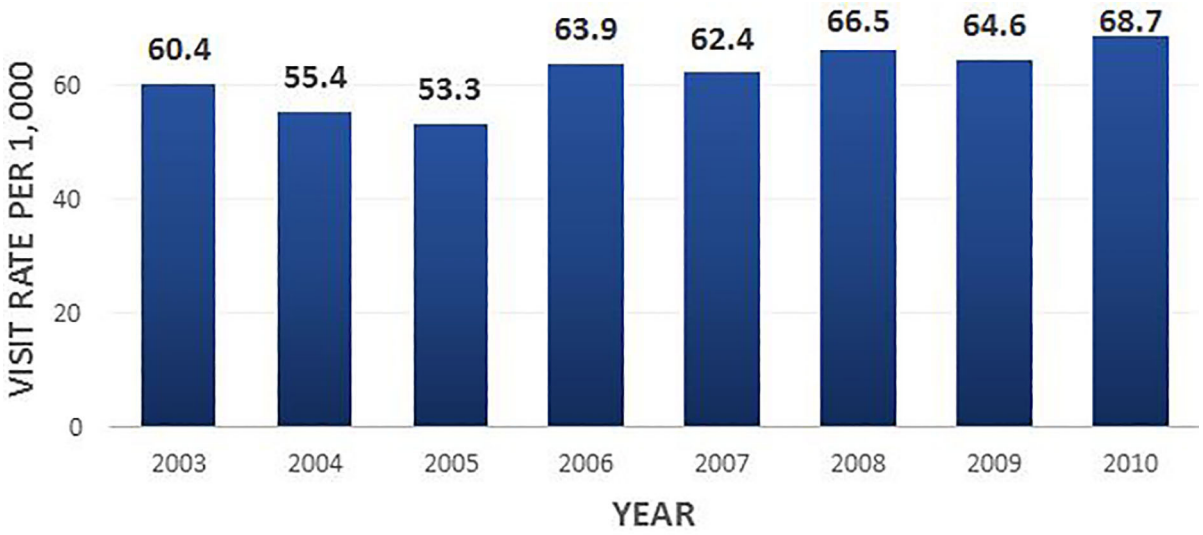

Figure 1. Fall-related ED visit rates by year, for patients 65 and older, 2003-2010.

while visit rates for patients 65-74 years and 85 years and older remained unchanged (Table 1). ED visits by women increased from 67.4 to 81.3 (RD 3.5, 95% CI [0.1-6.9], p = 0.04) while the ED visit rate by men did not change significantly over time. There was also an increased rate of non-Hispanic Whites visiting the ED over time for falls from 63.1 to 73.4 (RD 3.4, 95% CI [0.5-6.4], p < 0.01). By region, older adults from the South had the highest increase in the rate of people who fell, from 54.4 to 71.1 (RD 5.3, 95% CI [0.6-10.2], p=0.03), but overall the Northeast had the highest

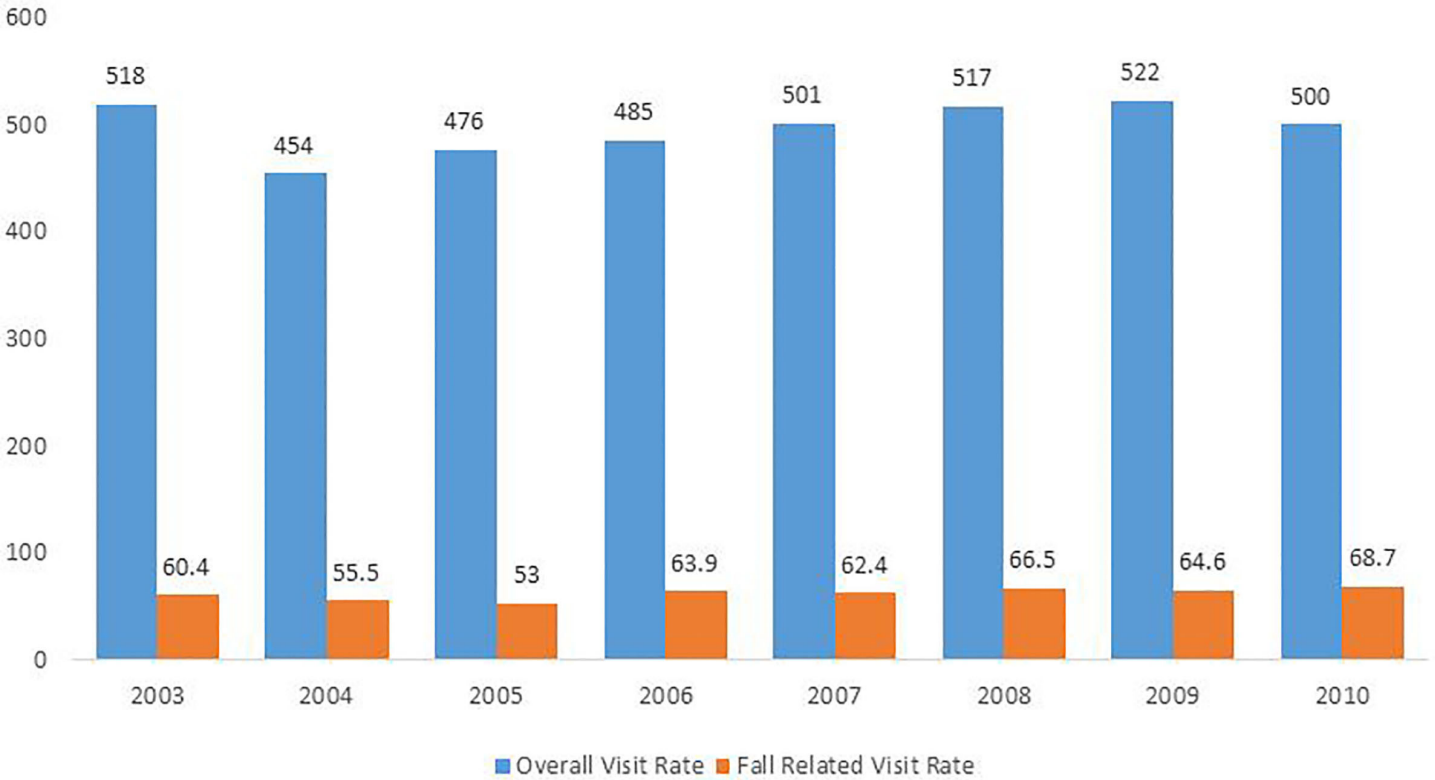

Figure 2. Estimated fall-related ED visits per 1,000 compared to overall ED visits per 1,000 (65 and older)

RATES FOR EACH YEAR, 2003-2010

Table 2. Fall-related emergency department visits per 1,000 population in the United States among ages 65 and older, 2003-2010.

	Estimated ED visits per 1,000 population 65+, no. (95% CI)							
	2003	2004	2005	2006	2007	2008	2009	2010
Total visits (fall)	60.4 (51.9, 68.8)	55.4 (47.6, 63.1)	53 (45.6, 60.3)	63.9 (53.4, 74.3)	62.4 (53.2, 71.6)	66.5 (55.7, 77.4)	64.6 (54, 75.2)	68.7 (57.7, 79.7)
Age (years)								
65- 74	36.5 (29.3, 43.8)	33.4 (27.4, 39.5)	32.6 (26.5,38.8)	39.6 (28.9, 50.3)	32.9 (26.2, 39.7)	33.7 (25.2, 42.1)	42.7 (33.3, 52.1)	39.8 (29.9, 49.6)
75- 84	56.2 (46.1, 66.2)	63 (51.9, 74.2)	61.9 (50.8, 72.9)	67.6 (53.7, 81.5)	65.8 (53, 78.5)	76.2 (63.2, 89.3)	64.7 (51.3, 78)	82.1 (67.1, 97.1)
85 and older	168.1 (133.3, 202.9)	120.4 (96.5, 144.3)	106.8 (82.9, 130.7)	144.9 (115.5, 174.2)	162.5 (134.2, 190.9)	164.5 (130.5, 198.6)	145.2 (110.5, 179.9)	151.4 (124.2, 178.6)
Gender								
Male	50.5 (40, 61)	39.1 (31.4, 46.8)	47.8 (39.2, 56.5)	43.6 (35.5, 51.8)	44.7 (35.8, 53.6)	48.9 (39.1, 58.7)	47.4 (37.8, 57.1)	52.2 (41.8, 62.6)
Female	67.4 (57.8, 76.9)	67 (57, 76.9)	57.6 (48.3, 66.9)	78.5 (64.2, 92.8)	75.3 (63, 87.6)	79.5 (64, 95.1)	77.2 (62.3, 92.2)	81.3 (66.7, 95.8)
Race/ethnicity								
White (non-Hispanic)	63.1 (53.6, 72.6)	55 (46.5, 63.4)	55.3 (46.9, 63.6)	66.1 (54.4, 77.7)	63.9 (54.1, 73.7)	70.5 (58.2, 82.7)	68.3 (56, 80.6)	73.4 (60.4, 86.3)
Black	56.7 (34.6, 78.9)	60.5 (42.1, 78.8)	53.6 (31.3, 76)	56.6 (28.3, 84.9)	79.8 (48, 111.6)	47.2 (27.1, 67.2)	69.4 (43.5, 95.3)	56.9 (29.9, 83.9)
Hispanic or Latino	54.3 (31, 77.6)	61.9 (40.7, 83.2)	44.4 (23.5, 65.3)	55.3 (32.2, 78.4)	46.7 (24.9, 68.5)	75.1 (45.4, 104.8)	38.7 (20.8, 56.6)	59.3 (30.4, 88.1)
Other race	51.5 (20.7, 82.2)	83.1 (35.5, 130.7)	46.2 (3.5, 88.9)	74.3 (33.6, 115)	48.4 (23.5, 73.3)	60.1 (30.9, 89.2)	40.9 (16.2, 65.6)	41.2 (13.7, 68.7)
Region								
Northeast	75.3 (57.8, 92.8)	73 (56.4, 89.5)	58.5 (40.9, 76.1)	74.2 (58.8, 89.7)	56.2 (40.4, 71.9)	91.8 (59.9, 123.7)	64.7 (49, 80.4)	77.1 (60.2, 94)
Midwest	60 (43.4, 76.6)	60.1 (43.2, 77)	60.3 (46.6, 74.1)	60.5 (39.4, 81.7)	75.6 (56.1, 95)	55.1 (34.3, 76)	70.2 (42.3, 98)	62.7 (37.3, 88)
South	54.4 (40.7, 68.1)	43.7 (32.1, 55.4)	45.8 (32.8, 58.9)	65.1 (44.1, 86.1)	62.1 (47.3, 76.9)	57.3 (43.1, 71.5)	65.1 (46.7, 83.5)	71 (50.8, 91.2)
West	56.2 (34.5, 77.9)	52.9 (33.2, 72.6)	51.9 (37, 66.7)	55.3 (34.5, 76.1)	54.5 (30, 79)	71.4 (45.5, 97.2)	57.5 (37.7, 77.4)	65.3 (42.7, 87.8)

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

rate of fallers, ranging from as low as 56.2 to as high as 91.8. ED visit rates among adults with Medicare as their primary insurance also significantly increased in this time period from 51.4 to 65 (RD 4.5, 95% CI [0.5-8.]7, p= 0.03). Patients on Medicaid had higher rates of falls from 2005 to 2007, but visual inspection of the data over the entire 2003-2010 timespan (Table 2) did not reveal a consistent pattern. Visit rates remained unchanged for those with private insurance, and declined for those who were uninsured or had other types of payment methods as their primary insurance (RD -8.0, 95% CI [-14.4- -1.2], p<0.01).

The year 2005 is documented to have the lowest number of total visits for falls with a visit rate of 53 (95% CI [45.6-60.3]), driven by a nadir in the visit rate for adults 85 and older over the seven-year period (Table 2).

DISCUSSION

Between 2003 and 2010, the total annual visits to U.S. EDs for a fall or fall-related injury increased over time by 27% over the seven-year period. This trend was particularly pronounced among patients between the ages of 75-84, female patients, non-Hispanic Whites and patients residing in the South. Compared to existing regional and state-based data on fall trends, our study examines national fall trends over a longer time span and with a larger cohort and also identifies a variety of epidemiological factors that may contribute to this rising number.

One reason for increasing ED fall visits over time may be due to all ED visits increasing in this population despite improvements in primary care access[17] (Figure 2). A recent report released by the American Hospital Association examining trends in ED use by Medicare beneficiaries between 2006 to 2010 showed a number of factors contributing to this, including rising severity of illness of beneficiaries receiving ED care, greater use of ED services by people dually eligible for Medicare and Medicaid who are generally sicker with multiple chronic conditions, and increasing use of ED services by beneficiaries with behavioral health diagnoses who require higher intensity of services.[18] While the number of primary care clinics accepting Medicare remains strong, there is recent evidence to suggest that practices accepting new Medicare patients are dwindling,[19] with many patients still unable to access clinics after business hours.[20] A combination of these factors is likely contributing to the overall increasing ED visit rates for falls as well.

We found that ED visits for falls are particularly increasing among patients between the ages of 75 to 84, after controlling for population growth. Falls are events driven by multiple interacting causes. One explanation for increasing ED visits may be an increase in frailty and disability among older people living at home or in nursing homes. Based on recent population data, life expectancy has increased since 2000,[21] particularly among White males, while death rates for cardiovascular and pulmonary disease have decreased among patients 65 years and older compared to the 1990s. However, death rates from unintentional injuries such as falls have increased over time for this age bracket.[22] If improved medical care and interventions help people to live longer with diseases that historically would have caused them to die, then more people are living with underlying comorbidities contributing to their overall frailty and fall risk. There is one study demonstrating an increase in frailty and disability of patients living at home over time, but this was based on self-report.[23]

We found an increase in ED fall visits by women over our study period. In contrast, it does not appear that the ED visit rate of male fallers has changed over time. This could be due to a number of reasons. First, women tend to live longer than men. This phenomenon has not changed over time and may be reflected in a larger numerator or in the continued increased willingness of women to go to an ED to seek care than men. It is also possible that men may come to the ED with more detrimental injuries from a fall and only present with one serious injury-related visit versus women who tend to suffer recurrent falls.[4,24] There are data suggesting men are more likely to die from a fall, possibly because they suffer from more comorbid conditions than women of the same age or they are potentially partaking in riskier activities such as climbing ladders, which is not changing over time.[25] Lastly, it is possible that men are seeking emergency care for injuries but not endorsing or being coded for a fall.

The finding that non-Hispanic Whites are at a higher risk of falling has been documented in prior studies and this predisposition does not appear to have changed over time. [26–28] The literature demonstrating the surface upon which patients land also differs with Black individuals landing on more indoor-type and non-Hispanic White individuals tending to land on outdoor-type surfaces.[29] If riskier activities involving walking while hurrying, working in the yard or garden, or carrying something bulky impart a higher overall likelihood of falling,[30] it is possible that non-Hispanic Whites have fewer mobility issues to allow them to partake in more outdoor, risk-taking behaviors, which contributes to their higher rate of falls. What is unclear is why there is a trend towards increasing rates of ED visits for this group as compared to other races. It is possible this is due to an increase in any given fall risk factor, such as heart disease, medications, an increase in risky behavior, decreased ED access for minorities or limited uptake of fall prevention programs, as described above. Due to the serial cross-sectional nature of this data, interpretations are limited and the findings are not controlled for other factors.[31,32] Further studies are needed to assess longitudinally what factors are driving this finding.

Older adult patients residing in the South are also increasingly visiting EDs for falls. As falls are strongly associated with fractures, especially among osteoporotic patients, our findings are consistent with data indicating that

fractures of the hip, spine and extremity are also higher in the South. One explanation may be from intrinsic patient factors that are increasing a patient's risk for a fall.[33–37] Lauderdale et al. studied regional variations for hip fractures and found that patients who grew up primarily in the South had an increased risk of fractures versus patients who only resided in the South in their older years. The author postulates that determinants present at a younger age, such as lifestyle or poor nutrition in the southern region, are driving this overall risk.[38] These determinants may also be contributing to the higher risk of falls in the South over time; however, studies are needed to further elucidate this.

A second explanation may be due to extrinsic factors beyond the patient's control. There is evidence to suggest that poorer socioeconomic status is associated with a higher risk of falls in part due to poor housing, roads and sidewalks and surrounding environments.[39–41] Based on U.S. Census data the South has had the highest percentage of poverty as compared to the rest of the country since 1950,[42] which may be contributing to the increasing rate of falls in this area; however, further research is needed to assess this association and understand if other factors are mediating this effect.

Interestingly, it appears that there is an increasing rate of falls despite national falls-prevention initiatives. Many of these initiatives involve linking to community falls programs and incorporating screening algorithms into office-based practice. Such initiatives are challenging to implement due to their cost, time requirements, need for adaptation and limited use by the community. Despite the potential effectiveness of fall-prevention programs, participation ranges from 15% to 50% with women having higher enrollment and completion rates than men.[43,44] With such low participation rates, it appears that such barriers are not easily resolved and their positive effects over time may not be captured during the time frame of this data.[45,46]

Despite low participation it is clear that EDs have a unique window of opportunity to educate these patients on the morbidity and mortality associated with falls while they are still being treated for their fall-related injury, as well as motivate ED providers to collaborate with primary care and community-based organizations to reduce future falls. Such interventions may include involving physical or occupational therapists in the ED to evaluate, educate and potentially introduce use of assistive devices such as walkers or canes, providing handouts or showing short videos, referring to a dedicated falls clinic and engaging with community partners who run evidence-based balance and strength classes for fall prevention.

LIMITATIONS

Our study had a number of limitations. First, the NHAMCS surveys use the U.S. Census Bureau as the field data collection agent, which can introduce error into the dataset. We were specifically concerned with the falls rate increase from 2005 to 2006 and the reported data on Medicaid. This issue was somewhat mitigated through completeness checks on receipt of the data by NHAMCS itself. In terms of the falls rate from 2005 and 2006, we specifically asked the CDC and evaluated the data collection tools spanning across all the years to assess whether the falls documentation changed over time. The last reported changes in the way injuries were coded were in 1997 and confirmed through phone conversations with the CDC and NHAMCS specialists and thus do not offer a clear explanation for this finding. The Medicaid data are difficult to interpret due to the wide confidence intervals, suggesting a small sample size. We report these data for the sake of completeness but acknowledge we cannot make any statements regarding the size or the trends of this number.

Second, NHAMCS surveys themselves may include inaccuracies in the data fields as the responses are self-reported; however, there is low probability of differential misreporting over time to bias our results. Third, as NHAMCS data are cross-sectional, we do not know if new patients are frequenting the ED for falls or the increased trend is derived from individual patients presenting with repeat falls. Previous studies have demonstrated an 18% recidivism[47] rate within one year, which may account for our numbers; however, we would expect to see this reflected across all the years, which would not account for the overall upward trend. We also do not know how the trend in use of EDs for falls relates to a shift away from office practices for fall-related visits or if patients are sustaining more injurious falls over time, which would account for an upward trending ED visit rate. Fourth, we analyzed available data from 2003 to 2010. Since the initial analysis began, two more years' worth of data has been made available and would be worthwhile for future studies to reassess these trends.

CONCLUSION

Our findings suggest that over time, older adults are presenting to the ED with falls at an increasing rate. While many of the characteristics we examined cannot be changed, ED fall patients can be risk stratified to prevent subsequent falls. EDs are generally involved with the treatment of the acute injury as a result of the fall but are infrequently involved in any prevention activities or referrals, especially if these older adults are discharged back to the community. As older-adult falls are becoming a more widely discussed public health issue through various policies, the CDC's recent development of the Stopping Elderly Accidents, Deaths and Injuries (STEADI) toolkits[48] and a large national movement for fall prevention,[49] EDs have a potential opportunity to engage in future fall-prevention interventions given their fall visit volume and unique teachable moments. Further research should assess what types of interventions are appropriate and feasible to be initiated in the ED setting.

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Prevalence of Intracranial Hemorrhage after Blunt Head Trauma in Patients on Pre-injury Dabigatran

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Introduction: Dabigatran etexilate was the first direct-acting oral anticoagulant approved in the United States. The prevalence of intracranial hemorrhage after blunt head trauma in patients on dabigatran is currently unknown, complicating adequate ability to accurately compare the risks and benefits of dabigatran to alternative anticoagulants. We aimed to determine the prevalence of intracranial hemorrhage for patients on dabigatran presenting to a Level I trauma center.

Methods: This is a retrospective observational study of adult patients on dabigatran who presented to a Level I trauma center and received cranial computed tomography (CT) following blunt head trauma. Patients who met inclusion criteria underwent manual chart abstraction. Our primary outcome was intracranial hemorrhage on initial cranial CT.

Results: We included a total of 33 eligible patient visits for analysis. Mean age was 74.8 years (SD 11.2, range 55-91). The most common cause of injury was ground-level fall (n = 22, 66.7%). One patient (3.0%, 95% confidence interval [CI] 0.[1-15.8%]) had intracranial hemorrhage on cranial CT. No patients (0%, 95% CI [0-8.7%]) required neurosurgical intervention. One in-hospital death occurred from infection.

Conclusion: To our knowledge, this is the first study to evaluate the prevalence of intracranial hemorrhage after blunt head trauma for patients on dabigatran presenting to the emergency department, including those not admitted. The intracranial hemorrhage prevalence in our study is similar to previous reports for patients on warfarin. Further studies are needed to determine if the prevalence of intracranial hemorrhage seen in our patient population is true for a larger patient population in more diverse clinical settings. [West J Emerg Med. 2017;18(5)794–799.]

INTRODUCTION

Dabigatran etexilate is a direct thrombin inhibitor first approved in October 2010 for primary prevention of stroke in patients with atrial fibrillation.[1] It is the first of several direct-acting oral anticoagulants (DOAC) to market. These agents have gained popularity due to the simplicity of dosing and the fact that they do not require routine laboratory testing.[2] In fact, a recent cohort study of patients started on anticoagulation medications for atrial fibrillation indicated that up to 62% were prescribed a DOAC.[3]

Each year traumatic brain injury results in approximately 1.4 million emergency department (ED) visits at an annual cost of U.S. $60 billion.[4] An increasing proportion of these patients are elderly and taking anticoagulant medications.[5] Patients on pre-injury warfarin or clopidogrel have significant risk of traumatic intracranial hemorrhage, even in

cases with low-impact mechanisms of injury.[6]

In addition to the increased risk of intracranial hemorrhage, pre-injury use of warfarin also significantly increases mortality in elderly patients after head trauma. Early data suggest that this may not be the case for patients on DOACs, although the data for dabigatran is mixed.[10-12] Additionally, management of trauma patients on dabigatran is especially challenging due to questions regarding coagulation testing and reversal strategies.[13]

Despite Food and Drug Administration approval six years ago, the true prevalence of intracranial hemorrhage after head trauma for patients on dabigatran is still unknown. Furthermore, there is a paucity of evidence regarding monitoring of the level of anticoagulation in trauma victims on dabigatran. In this study we aimed to determine the prevalence of intracranial hemorrhage for patients on pre-injury dabigatran presenting to a Level I trauma center after blunt head trauma.

Population Health Research Capsule

What do we already know about this issue?
Clinical trial data suggests an improved bleeding profile for dabigatran when compared to warfarin. There are limited data regarding the intracranial hemorrhage risk after head trauma.

What was the research question?
What is the prevalence of intracranial hemorrhage after blunt head trauma for patients on dabigatran?

What was the major finding of the study?
Dabigatran appears to have a similar prevalence of intracranial hemorrhage after blunt head trauma as has been reported for warfarin.

How does this improve population health?
If validated, these findings suggest that previously established guidelines regarding fall- and trauma-risk assessment and warfarin use could be applied to dabigatran.

METHODS

Study Setting and Design

This is a retrospective observational study of all patients presenting to a university-based, urban Level 1 trauma center between November 1, 2010 and February 28, 2015. The study was approved by the site's institutional review board.

Selection of Participants

All patients who received cranial computed tomography (CT) as part of their ED evaluation and were reported to be on dabigatran during the study period were evaluated for study inclusion. Inclusion criteria were as follows: 1) patient reported head trauma or physical examination findings of head trauma were documented in the ED history and physical examination, and 2) patient was over the age of 18 years at the time of ED presentation. We excluded from the final analysis prisoners, patients who were transferred from an outside hospital, and pregnant patients.

Data Collection and Processing

Manual chart abstraction from the electronic medical record was performed by a single abstractor for all patients who met inclusion criteria. Standard chart review methodology was followed for all data abstraction.[14] Investigators agreed upon all inclusion/exclusion criteria and definitions prior to chart abstraction. All patient baseline data were abstracted prior to abstraction of CT results. A second abstractor reviewed approximately 20% of charts to measure interrater reliability for the presence of trauma (inclusion/exclusion criteria), intracranial hemorrhage on cranial CT, and the initial Glasgow Coma Scale (GCS) score.

Baseline factors including age, sex, and indication for anticoagulation (atrial fibrillation, deep venous thrombosis, pulmonary embolism, other, or unknown) were recorded. Data regarding the mechanism of injury, initial GCS score, international normalized ratio (INR), and activated thromboplastin time were abstracted from the electronic medical record. For all patients admitted to the hospital we calculated an abbreviated injury severity score (ISS).[15]

Outcome Measures

The primary outcome of interest was the presence of intracranial hemorrhage on initial cranial CT as interpreted by a board-certified/eligible radiologist. The presence of intracranial hemorrhage as well as the type and extent of injury were directly abstracted from the final radiology report. Specific treatments including attempted reversal (defined as either administration of prothrombin complex concentrates, plasma, recombinant factor VIIa, or dialysis for the specific purpose of reversing the effects of dabigatran), neurosurgical intervention, and hospital length of stay (in days) were abstracted. Final disposition as reported on hospital discharge summary was also recorded.

Primary Data Analysis

We reported normally distributed continuous data as the mean with standard deviations (SD), and we described ordinal or non-normally distributed continuous data as

medians with interquartile (25%-75%) ranges (IQR). Interrater reliability is reported as Cohen's kappa. We performed all statistical analyses using STATA 14.1 (STATA Corp., College Station, TX).

RESULTS

Characteristics of Study Participants

During the study period there were a total of 98 ED visits by 85 patients taking dabigatran during which cranial CT was performed. Of the 98 visits, 33 met inclusion/exclusion criteria and were included in the final study population. We excluded 49 visits because there were no history or physical exam findings of trauma. Eleven patients with traumatic injuries were excluded because they did not sustain head trauma. We excluded an additional five patients were excluded because they were transferred from outside facilities (Figure).

Baseline characteristics for the study population are provided in Table 1. Mean age was 74.8 years (SD 11.2, range 55-91). The most common cause of injury was ground-level fall (n = 22, 66.7%). Initial GCS scores were all either 14 (n=4) or 15 (n=29). A total of 19 patients (57.6%, 95% CI 39.2-74.5%) were admitted to the hospital with a median ISS of 6 (IQR 3-9). Treatment and outcomes are reported in Table 2. Initial INR measurements were available in 24 patients, and activated partial thromboplastin time (aPTT) measurements were available in 23 patients. Median INR was 1.2 (IQR 1.1-1.3) and mean aPTT was 38.8 (SD 12.9, range 14.3-66.1). Thirteen (54%, 95% CI [33-74%]) patients had INR measurements greater than the upper limit of normal (1.18) for the study site, and 13 (57%, 95% CI [34-77%]) had aPTT measurements greater than the upper limit of normal (36.7) for the study site.

One patient was found to have an intracranial hemorrhage on cranial CT (3.0%, 95% CI [0.1%-15.8%]) following a motorcycle collision. This patient had an intra-ventricular hemorrhage on CT and was also noted to have pelvic, cervical spine, and rib fractures. After a hospital stay of 19 days this patient was discharged to a skilled nursing facility. There were no patients that required neurosurgical intervention (0%, 95% CI [0-8.7%]).

Patients also suffered the following major injuries: spinal fractures (n=3), long bone fractures (n=2), rib fractures (n=2), and pelvic fracture (n=1). The median hospital length of stay was two days (IQR 1-7 days) for those admitted, and one in-hospital death was identified following infectious complications after a hospital stay of 19 days.

Reversal of anticoagulation was attempted in two patients. One patient received both 4-factor activated prothrombin complex concentrate (FEIBA©) and dialysis following a cervical spine fracture. The second patient received a combination of fresh frozen plasma, FEIBA©, and dialysis for intracranial hemorrhage, pelvic fractures, rib fractures, and a cervical spine fracture.

Interrater reliability

To measure interrater reliability of data abstraction, 20 patients had duplicate abstraction for presence of trauma, intracranial hemorrhage on cranial CT, and initial GCS score. There was perfect agreement for presence of trauma and the presence of intracranial hemorrhage on cranial CT (kappa=1.0, 95% CI [0.63-1]). There was excellent agreement for initial GCS (kappa=0.78, 95% CI [0.30-1.0]).

DISCUSSION

In this study we found that the risk of intracranial hemorrhage after blunt head trauma in patients taking dabigatran is similar to the prevalence previously reported for warfarin.[16] Furthermore, we have demonstrated that many patients who report taking dabigatran at the time of ED presentation have normal clotting parameters (PT and aPTT), suggesting either non-compliance or a poor correlation between dabigatran effects and currently available anticoagulant tests. There were a significant number of patients who required intensive care unit monitoring. However, a majority of patients were discharged home and the mortality rate was low.

The relatively low prevalence of intracranial hemorrhage in patients initially presenting to our institution is surprising. Given the large CI, it may be true that a larger sample size would reveal a higher "true" prevalence. It could also partially be explained by the fact that a majority of patients had ground-level falls and low ISS. Previous studies of patients with mild head injury found a prevalence of intracranial hemorrhage of 4.3% if the patient was on pre-injury warfarin.[6]

Dabigatran is the first of several DOACs to receive approval by the FDA. It exerts its action by directly binding to thrombin. When it first entered the market it was touted for its benefits of not requiring routine lab testing and very few drug-drug interactions. Initial experience with hemorrhaging patients on dabigatran raised concerns regarding the lack of ability to accurately determine the degree of anticoagulation and unclear method of reversal.[12,17] Fortunately, with the recent approval of idarucizumab, a dabigatran-specific antibody fragment, the ability to treat bleeding patients on dabigatran is likely to improve.[18] The impact of this agent on patient outcomes or patient need for dialysis, however, is still unknown.

Bleeding risk remains the main concern associated with anticoagulant use. The Randomized Evaluation of Long-Term Anticoagulant Therapy (RE-LY) study upon which initial approval of dabigatran was based demonstrated that patients taking dabigatran have a lower risk of major bleeding than patients taking warfarin.[2] In this study of 18,113 patients, 46 cases of traumatic intracranial hemorrhage were identified, 24 in patients on warfarin and 22 in the dabigatran groups.[19] However, this study did not report the number of patients with

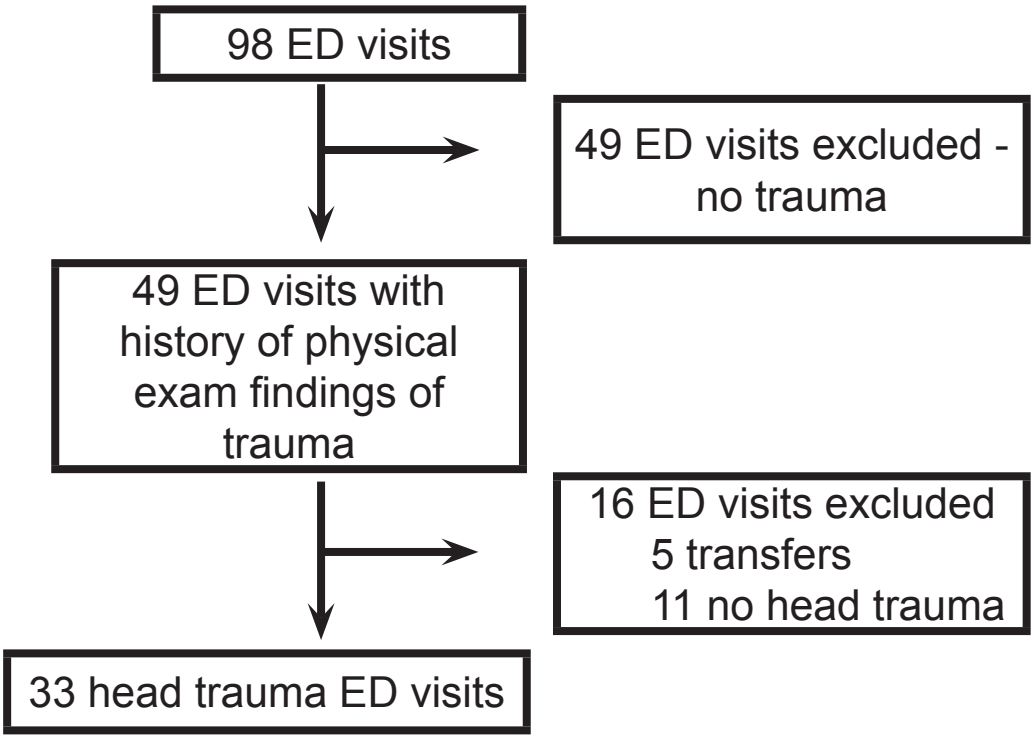

Figure. Flow of patients in a study of the prevalence of intracranial hemorrhage after blunt head trauma for patients on dabigatran. *ED*, emergency department.

Table 1. Demographics and injury characteristics.

	No.	%
Sex		
Female	18	54.5
Male	15	45.5
Indication for dabigatran		
Atrial fibrillation	27	81.8
Deep venous thrombosis	2	6.1
Pulmonary embolism	1	3.0
Unknown	1	3.0
Other	2	6.1
Mechanism of injury		
Assault	1	3.0
Auto vs pedestrian	1	3.0
Ground-level fall	22	66.7
Motorcycle collision	2	6.1
Motor vehicle collision	3	9.1
Other	4	12.1
ICH	1	3.0

ICH, intracranial hemorrhage.

Table 2. Treatment and outcomes of patients with blunt head trauma who were taking dabigatran at time of arrival to Level I trauma center.

	No.	%
Reversal Agent		
None	30	93.9
aPCC	2	6.1
Transfused with Plasma	1	3.0
Dialysis	2	6.1
PRBC Transfusion	1	3.0
ED disposition		
Discharged from the ED	14	42.4
Ward	5	15.2
Telemetry	6	18.2
ICU	8	24.2
Final Hospital/ED disposition		
Died	1	3.0
Skilled Nursing facility	5	15.2
Home	24	72.7
Other	3	9.1

aPCC, activated 4-factor prothrombin complex concentrate; *PRBC*, packed red blood cells; *ED*, emergency department

blunt head trauma without resultant intracranial hemorrhage. Additional case reports of intracranial hemorrhage have been reported in the literature with some raising concern that pre-injury dabigatran use could result in significant hemorrhage expansion.[17] In an animal model, Schaeffer et al. analyzed the size of hemorrhage produced in a standardized fashion in rats given pre-injury dabigatran or warfarin. This study showed smaller hematoma size in rats given dabigatran; however, no differences in neurologic outcomes at day 21 were identified.[20]

To date, only one human study has evaluated the prevalence of intracranial hemorrhage in patients on dabigatran. This study included elderly patients (>65 years) with ground-level falls who were admitted to a trauma service. The authors compared the intracranial hemorrhage prevalence in the dabigatran group to patients on warfarin and found no difference (13.6% (warfarin) vs. 8.2%(dabigatran)).[21] However, this study excluded patients discharged from the ED and included patients transferred to the study site. Both of these factors could result in overestimation of the risk of intracranial hemorrhage after trauma.

LIMITATIONS

This was a retrospective analysis, which has inherent limitations. We attempted to minimize potential bias from the design by adhering to best practice guidelines for retrospective reviews.[14] However, because all abstractors were part of the initial study design, they were not blinded to the study hypothesis. The potential bias that this lack of blinding could introduce is mitigated by the fact that the primary study outcome is an objective finding on cranial CT. We also demonstrate excellent interrater reliability enhancing the reliably of the data.

We selected only those patients undergoing cranial CT scanning in the ED, resulting in an inability to identify patients with minor trauma treated without cranial imaging. We used this criterion as it gave us the greatest chance of identifying all head trauma patients. It is normal practice in the study site's ED to image patients with head trauma who are on anticoagulation medications.[16] We believe that the bias this decision introduced might have increased the reported prevalence of intracranial hemorrhage due to exclusion of patients at lowest risk. However, there is the possibility that there were patients who did not receive initial imaging and subsequently presented to other centers with traumatic intracranial hemorrhage.

Due to the fact that this was a single-center study, we were unable to evaluate for later presentations for delayed bleeding. Our methods would have discovered any patients that re-presented to the ED during the study period, but could not evaluate for patients who later presented to alternate sites. The single-center nature of this study also resulted in a small sample size, which limits the generalizability of our results.

Finally, because we are a tertiary-care referral center, we excluded patients transferred from outside facilities to allow for determination of a "true" prevalence of intracranial hemorrhage in patients presenting to the ED. Two of the five excluded patients were transferred to the study site because they had intracranial hemorrhages. Neither of these patients died during hospitalization at the study site and only one required neurosurgical intervention. Including these patients would have falsely increased the reported prevalence of intracranial hemorrhage on CT.

CONCLUSION

In our study, intracranial hemorrhage after blunt head trauma in patients on pre-injury dabigatran was rare. The incidence in our study is similar to previous reports for patients on warfarin, although the wide confidence interval and different methodology make direct comparison difficult. Further studies are needed to determine if the prevalence of intracranial hemorrhage seen in our patient population is true for a larger patient cohort in more diverse clinical settings.

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Congratulations, You're Pregnant! Now About Your Shifts . . . : The State of Maternity Leave Attitudes and Culture in EM

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Introduction: Increasing attention has been focused on parental leave, but little is known about early leave and parental experiences for male and female attending physicians. Our goal was to describe and quantify the parental leave experiences of a nationally representative sample of emergency physicians (EP).

Methods: We conducted a web-based survey, distributed via emergency medicine professional organizations, discussion boards, and listservs, to address study objectives.

Results: We analyzed data from 464 respondents; 56% were women. Most experienced childbirth while employed as an EP. Fifty-three percent of women and 60% of men reported working in a setting with a formal maternity leave policy; however, 36% of women and 18% of men reported dissatisfaction with these policies. Most reported that other group members cover maternity-related shift vacancies; a minority reported that pregnant partners work extra shifts prior to leave. Leave duration and compensation varied widely, ranging from no compensated leave (18%) to 12 or more weeks at 100% salary (7%). Supportive attitudes were reported during pregnancy (53%) and, to a lesser degree (43%), during leave. Policy improvement suggestions included the development of clear, formal policies; improving leave duration and compensation; adding paternity and adoption leave; providing support for physicians working extra to cover colleagues' leave; and addressing breastfeeding issues.

Conclusion: In this national sample of EPs, maternity leave policies varied widely. The duration and compensation during leave also had significant variation. Participants suggested formalizing policies, increasing leave duration and compensation, adding paternity leave, and changing the coverage for vacancies to relieve burden on physician colleagues. [West J Emerg Med. 2017;18(5)800-810.]

INTRODUCTION

The dramatically shifting demographics of medicine has been well documented in recent decades. Over the last 50 years, the number of women in medicine has climbed steadily. In 1970, fewer than 10% of medical students were female, while in 2013 47% of medical school matriculants were women.[1] Women represented 38% of U.S. medical school faculty in 2013, up from 32% in 2003 and less than 10% in the 1970s.[2] This trend has been noted within the specialty of emergency medicine (EM) as well, with a rise in female residents from 28% in 2001 to 38% in 2013.[3] As gender balance has continued to evolve in medicine, issues related to

childbearing – in particular to pregnancy, maternity leave, and early childhood care – have risen to the forefront.

Concurrent with the notably increased presence of women in medicine has been the growing number of physicians representing *Generation X*, those born between 1964 and 1980, and *Millennials,* also known as *Generation Y* (born between 1980 and 1999). Currently, Generation Xers make up 30% of practicing physicians.[4] Millennials represent only 5% of practicing physicians, but will clearly play a growing role in the future.[4] These two generational cohorts both tend to place increased value on work-life balance compared to prior generations.[5-6] Maternity leave exemplifies an issue that is supremely important both to women and to physicians who highly value work-life balance.

Increasing awareness of physician burnout and the subsequent focus on physician wellness lends importance to the issue of maternity leave and parental leave in general. Traditionally, maternity leave has been more likely to be clearly defined and accepted in professions outside of medicine and in countries outside of the United States.[7-9] However, with growing numbers of physicians beginning their careers who value family, career flexibility and wellness, these types of issues are likely to become a more important component of the medical landscape in the U.S. Moreover, effective maternity leave policies could become an important organizational strategy to address physician wellness.[6]

Despite the fact that maternity leave inevitably impacts many practicing physicians, little scientific literature on the issue exists. While multiple authors have addressed maternity leave as it affects resident physicians[10-11] and specialties outside of EM,[13-14] our review revealed only one EM-specific article relating to maternity leave.[15] Lewin focused primarily on the dearth of policies relating to family leave during residency and suggested some parameters for an ideal policy. Further complicating the current discussion is the associated confusion between parental- and family-leave policy nomenclature. For the purposes of this article, maternity and paternity leave refer specifically to maternal and paternal time away from work due to pregnancy and delivery. Family leave, although beyond the scope of this discussion, refers to time away from work due to personal or family illness of various etiologies. Adoption leave policies are also considered distinctly from maternity leave. While there is clearly a paucity of data regarding maternity leave practices in EM, there is even less knowledge regarding how these issues affect male physicians.

To address these gaps, we sought to assess the composition of existing maternity leave policies, as well as to evaluate for differences in physicians' experiences with maternity leave based upon gender and work setting. Additionally, we investigated the attitudes and opinions of a national sample of emergency physicians (EP), both male and female. Lastly, we asked for suggestions regarding how the current maternity leave landscape could be enhanced so that administrators and policy makers can continue to provide high job satisfaction given the changing demographic of EPs.

Population Health Research Capsule

What do we already know about this issue?
Despite implications for health, wellness, burnout prevention, and work-life balance, very little is known about the maternity leave experiences of attending emergency physicians.

What was the research question?
What are the experiences and attitudes regarding maternity leave for United States emergency physicians?

What was the major finding of the study?
Emergency physicians' maternity leave experiences and beliefs varied widely and there were many suggestions to improve the current state of parental leave.

How does this improve population health?
Maternity leave policies may be an important wellness and burnout prevention strategy to ensure a robust emergency physician workforce is available to provide high-quality patient care.

METHODS

Study Design

We performed this descriptive study with the development and use of a web-based survey to collect data regarding attitudes and policies related to maternity leave for physicians in EM. The study was reviewed and determined to be exempt by the Maine Medical Center Institutional Review Board.

Selection of Participants

Chapter executives from six state chapters of the American College of Emergency Physicians (ACEP) agreed to distribute the survey link to their memberships electronically using the web-based survey tool SurveyMonkey® (Survey Monkey, Palo Alto, CA). Participating state chapters included Maine, Massachusetts, Missouri, Ohio, Utah and Virginia. While we contacted all ACEP state chapters for inclusion in the study, ultimately six state chapters agreed to participate and comprised the final convenience study sample. In

addition, the survey link was distributed via an electronic listserv for the American Association of Women Emergency Physicians (AAWEP). The survey was sent to all members of these professional organizations who provided electronic mail addresses to their membership offices.

Methods and Measurements

The survey was created by the study investigators following a comprehensive review of the existing scientific literature and was designed to collect data with regard to four main topics of consideration: a) to identify maternity leave policies currently available to EPs, b) to determine the individual experience of pregnancy and maternity leave for EPs, c) to assess attitudes of colleagues and supervisors in relation to maternity leave, and d) suggestions to improve parental leave policies. Items pertaining to each of these main concepts were developed and revised for clarity after review by fellow EPs.

We developed two versions of the survey, one for men and one for women. Participants' responses to initial demographic questions determined which of the two versions would be administered. The female survey included 42 questions while the male survey included 28 questions. For the female survey, we collected the following data: a) age, b) number of children, c) having children while employed as an EP, d) delivering or taking leave prior to 37 weeks gestation, e) structure of respondent's work week, f) the average number of clinical hours per week, g) practice and group type (academic/community/other, private/hospital/other and gender ratio), and h) whether the respondent was the primary source of income for her family.

For the male survey, we collected the following data: a) age, b) number of children, c) having children while employed as an EP, d) whether a female colleague had a child while the respondent was employed as an EP, e) structure of respondent's work week, f) the average number of clinical hours per week, g) practice and group type (academic/community/other, private/hospital/other and gender ratio), and h) whether the respondent was the primary source of income for his family.

Both the female and male versions of the survey included specific questions regarding the respondent's current maternity leave policies, as well as their attitudes towards these policies and their attitudes towards colleagues who have taken maternity leave.

Data Collection

We collected data anonymously using a modified version of Dillman's approach.[16] A series of three electronic mail messages was distributed with the survey link to potential participants over a period of approximately eight weeks in 2011. These included an initial message explaining the study and including the survey link, a reminder message two weeks later, and a final reminder e-mail one week after that. Responses to the survey were accepted for several more weeks following the final electronic message.

Study participants received an initial message from their professional organization that explained the objective of the study and included a link to the survey. Upon opening the web-based survey, an informational page further explained the study objectives and reviewed the voluntary, anonymous nature of the study. No identifiers were collected. We excluded potential study subjects if they were still in residency or were medical students. Surveys that were opened and submitted without responses were also excluded from analysis.

Statistical Analysis

We downloaded raw study data from the SurveyMonkey® website into a Microsoft Excel (Microsoft, Inc., Redmond, WA) spreadsheet. Quantitative analysis was completed using SPSS version 22 (SPSS, Inc., Chicago, IL) statistical software. We described categorical data with numbers and percentages. Qualitative responses were evaluated for common themes, which were organized into thematic categories.

RESULTS

Characteristics of the Study Participants

A total of 530 participants opened the survey link, provided informed consent, and completed at least part of the study survey. We excluded 66 participants (64 resident physicians and two medical students), leaving data from 464 responding attending physicians for analysis. The study sample was comprised of 256 (56%) women and 204 (44%) men; respondents most frequently reported being between 30 and 39 years old (42%, n = 189) and having two children (35%, n = 158). The majority of respondents experienced the birth of at least one child while employed as an EP, including 65% of women (n = 163) and 70% of men (n = 138). Sixty-eight percent of women (n = 166) and 91% of men (n = 180) reported being the primary earner for their household, with 78% of women (n = 187) and 92% of men (n = 183) reporting working full time. Distinctions between full-time and part-time work status were left to the discretion of the study respondents. Regarding work settings, female and male respondents most frequently reported being a hospital employee (44% and 37% respectively), and both female and male respondents reported working in a community setting most often (39% and 56% respectively). Additional detail regarding the characteristics of the study subjects is available in the Table.

Maternity Leave Policies

Fifty-three percent of women (n = 129) and 60% of men (n = 119) reported working in a setting with a formal maternity leave policy; however 36% of women (n = 82) and 18% of men (n = 35) reported dissatisfaction with those policies.

Table. Characteristics of emergency physician participants in a survey regarding maternity leave policies.

Characteristic	Female n = 256	Male n = 204
Age range, n (%)		
20-29 years	2 (0.8)	1 (0.5)
30-39 years	132 (52.4)	57 (28.6)
40-49 years	65 (25.8)	65 (32.7)
50-59 years	42 (16.7)	47 (23.6)
60-69 years	10 (4.0)	25 (12.6)
70-79 years	1 (0.4)	3 (1.5)
Primary household earner, n (%)		
Yes	166 (68.3)	180 (91.4)
No	77 (31.7)	17 (8.6)
Number of children, n (%)		
None	60 (23.7)	24 (12.1)
Currently pregnant	4 (1.6)	0 (0)
One	57 (22.5)	25 (12.6)
Two	89 (35.2)	69 (34.8)
Three	36 (14.2)	51 (25.8)
Four	4 (1.6)	18 (9.1)
Five	2 (0.8)	9 (4.5)
Six	1 (0.4)	1 (0.5)
Seven	0 (0)	1 (0.5)
Had child while in EM, n (%)		
Yes	163 (64.7)	138 (69.7)
No	89 (35.3)	60 (30.3)
Workweek structure, n (%)		
Full time	187 (77.6)	183 (92.0)
Part time	50 (20.7)	14 (7.0)
Per diem	4 (1.7)	2 (1.0)
Clinical hours per week		
None	6 (2.5)	2 (1.0)
< 20 hours	24 (10.0)	15 (7.6)
20-29 Hours	76 (31.5)	44 (22.3)
30-39 Hours	97 (40.2)	89 (45.2)
40-49 Hours	34 (14.1)	38 (19.3)
≥ 50 hours	4 (1.7)	9 (4.6)
Years of EM practice, n (%)		
None	2 (0.8)	1 (0.5)
>1 – 5 Years	98 (40.1)	47 (23.6)
6 – 9 Years	47 (19.5)	25 (12.6)
10 – 15 Years	42 (17.4)	34 (17.1)
16 – 19 Years	9 (3.7)	20 (10.1)
20 – 25 Years	28 (11.6)	28 (14.1)
26 – 30 Years	11 (4.6)	23 (11.6)
>30 Years	4 (1.7)	23 (11.6)
Primary employer type, n (%)		
Academic practice	86 (35.4)	45 (22.7)
Community practice	97 (39.9)	110 (55.6)
Community/academic	55 (22.6)	40 (20.2)
Other	5 (2.1)	3 (1.5)
Group structure, n (%)		
Contract group	74 (30.5)	62 (31.1)
Hospital employee	108 (44.4)	74 (37.2)
Private practice	39 (16.0)	49 (24.6)
Other	22 (9.1)	14 (7.0)
Percent female in group, n (%)		
None	0 (0)	5 (2.6)
<5% Female	3 (1.3)	0 (0)
5 – 10% Female	23 (9.9)	30 (15.3)
11 – 20% Female	55 (23.6)	50 (25.5)
21 – 30% Female	63 (27.0)	48 (24.5)
31 – 40% Female	41 (17.6)	36 (18.4)
41 – 50% Female	32 (13.7)	23 (11.7)
51 – 60% Female	8 (3.4)	1 (0.5)
61 – 70% Female	3 (1.3)	0 (0)
71 – 80% Female	3 (1.3)	0 (0)
81 – 90% Female	0 (0)	0 (0)
91 – 100% Female	1 (0.4)	0 (0)
Unsure	1 (0.4)	3 (1.5)

EM, emergency medicine.

Seventeen percent of women and 21% of men were unaware of whether there was a formal maternity leave policy at their current place of employment. Most respondents reported that vacant shifts created by maternity leave were covered by other group members working extra shifts (76% female, n = 191; 75% male, n = 149), with a minority reporting that pregnant partners work extra shifts prior to maternity leave (17% female, n = 42; 10% male, n = 19). Maternity leave duration and compensation varied widely, ranging from no compensated leave (18%, n = 21) to 12 or more weeks at 100% salary (8%, n = 8). Many participants reported needing to use paid time off (23%, n = 53) or vacation time (43%, n = 99) to cover their maternity leave, and others (13%, n = 13) cited the Family Medical Leave Act as the basis for their maternity leave policy. Twenty-one percent of respondents (n = 26) believed that their institution's maternity leave policy had been implemented or reviewed within the prior five years, while

65% (n = 79) were unsure in this regard. Payback of shifts missed during maternity leave was reported as being required by 10% (n = 23) of women. Additionally, survey respondents also reported that working extra shifts in advance of maternity leave was not an option 14% of the time (n = 31). Figure 1 provides information regarding the manner in which participants reported that vacant shifts are covered in their departments.

Individual Experiences of Pregnancy and Maternity Leave for Emergency Physicians

Forty-six percent of female participants reported feeling guilt or other negative emotions during their maternity leave. In particular, the experience of pregnant EPs and perceived support of colleagues and supervisors varied significantly when disclosing their pregnancy (Figure 2). Eight percent of women reported considering leaving a job due to maternity leave policies and 17% delayed pregnancy due to leave policies.While 61% of women reported that maternity leave policies are slightly to very important to them, 41% of men reported the same. (Figure 3).

Emergency Physician's Beliefs and Attitudes

Fifty-three percent of women reported supportive attitudes from colleagues during pregnancy, and 43% reported supportive attitudes during maternity leave (Figure 4). Seventy percent of participants worked extra shifts for a colleague during her maternity leave with 80% of those respondents reporting neutral or positive attitudes about covering the vacancy. The majority of survey participants (78%) reported slightly supportive to very supportive attitudes during colleagues' pregnancies. This is consistent with the fact that 71% of participants rated their level of supportiveness during colleagues' maternity leaves as slightly to very supportive.

Suggestions to Improve Parental Leave Policies

Almost uniformly, respondents recognized the importance of establishing clear and formal maternity leave policies so that female EPs would have realistic expectations of their pregnancy and maternity leave. Another common suggestion was the need for clear paternity leave policies as well. Other recommendations included increasing parental leave duration and compensation; adding a component for adoption; adding support for those physicians working extra shifts to cover colleagues' leave; and addressing breastfeeding issues for women returning to work. Representative comments are included in Figure 5.

DISCUSSION

Parental leave continues to gain national attention. During the first White House Summit on Working Families, President Obama highlighted that the United States is the only developed country that does not offer paid maternity leave.[7]

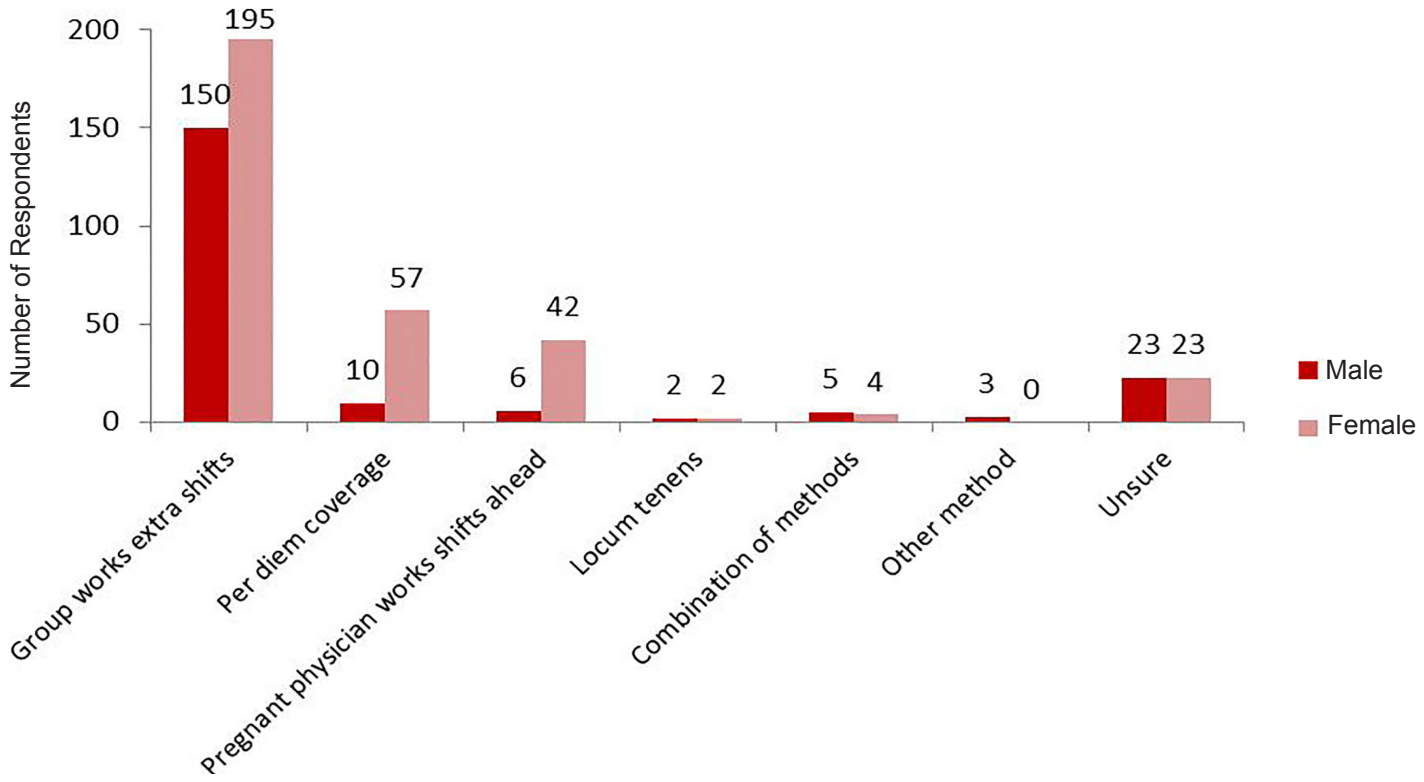
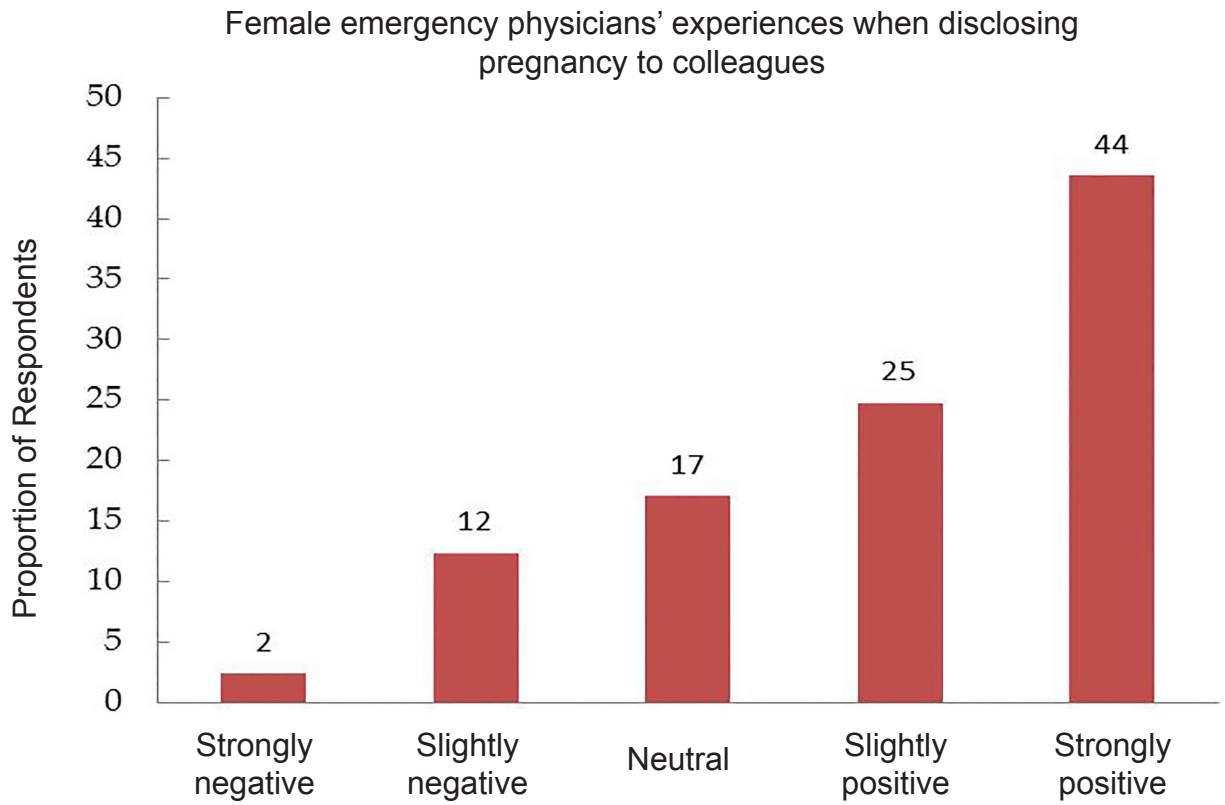


Figure 1. Methods for covering shift vacancies as reported by male and female respondents in survey regarding parental leave policies.



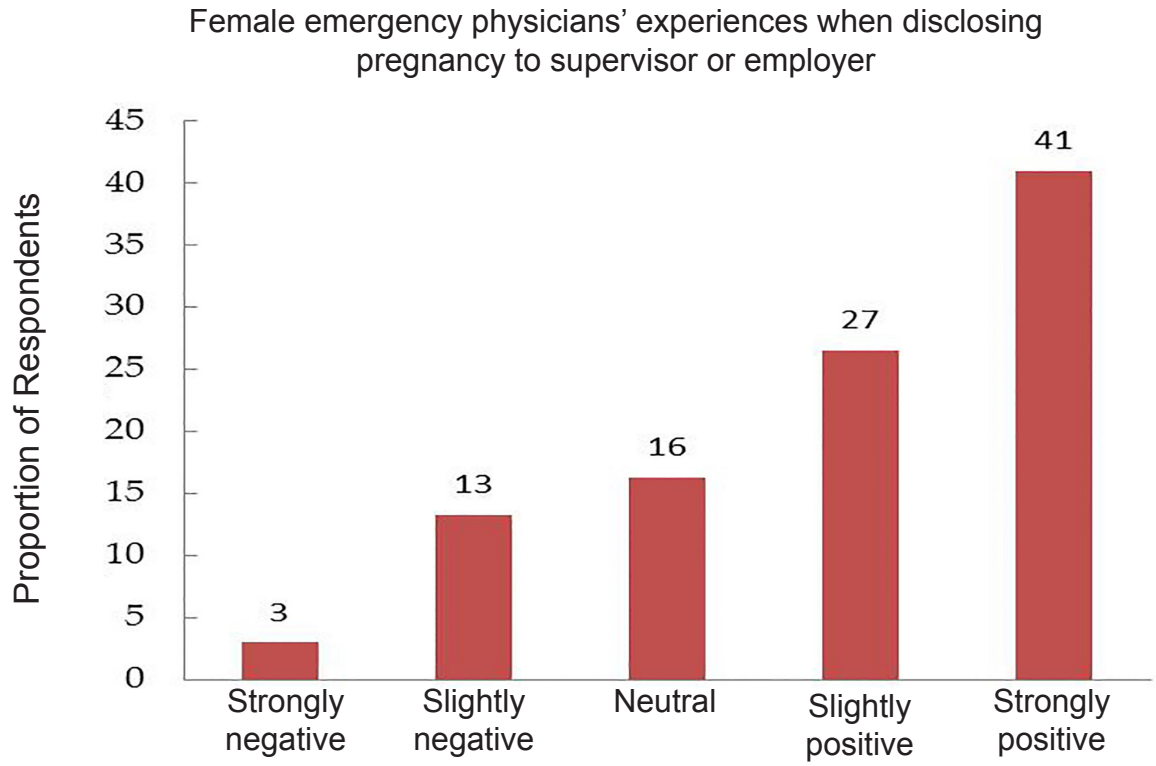


Figure 2. Emergency physician experiences with pregnancy disclosure.

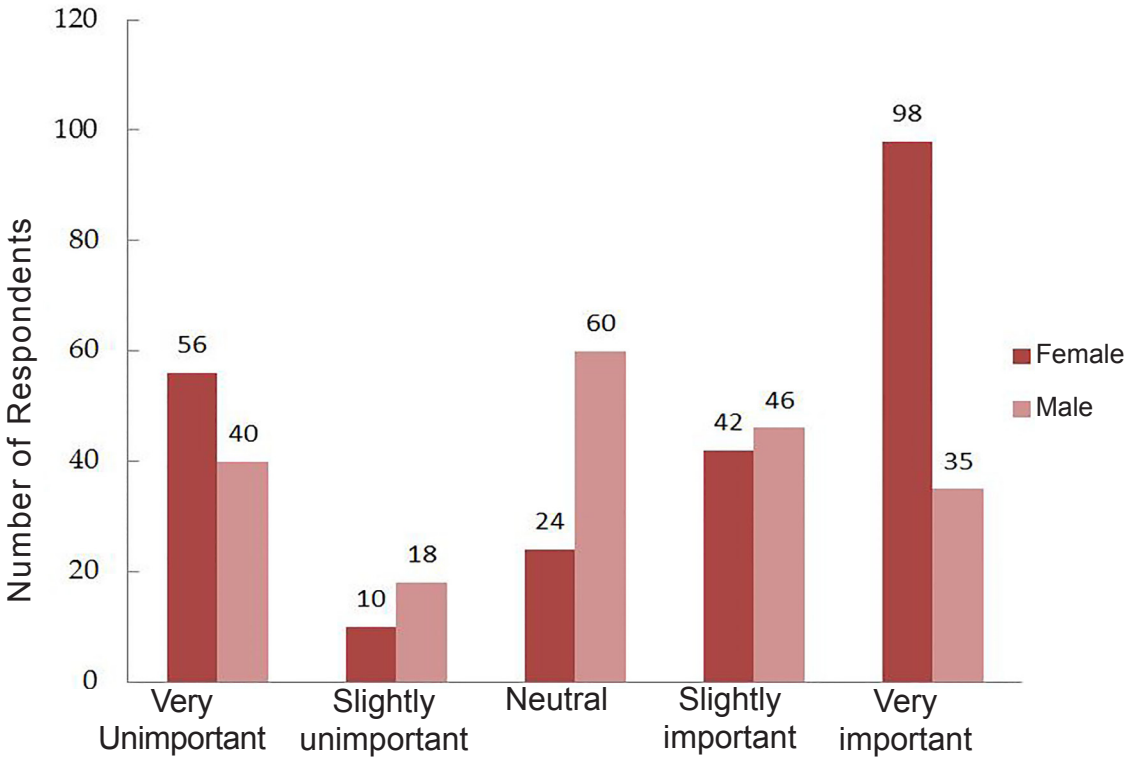


Figure 3. Importance of maternity leave policies for emergency physicians.

In medicine and particularly EM, a specialty that thrives on changing schedules, the way to accomplish paid parental leave is unclear and potentially more challenging.

This study represents the first nationally representative survey to our knowledge of male and female EPs regarding the subject of maternity leave policies. We addressed maternity leave policies, including individual experiences with current policies, beliefs and attitudes of EPs and suggestions for improved parental leave policies. About half of our respondents work in a setting with a formal leave policy. Many of these physicians, however, are dissatisfied with their policies. Maternity leave duration and compensation varied widely in our sample – ranging from no compensated leave to 12 or more weeks at 100% salary. One curious finding from our study was a difference in perceived attitudes. Most physicians reported that they have worked extra shifts for colleagues on leave and the majority of those reported neutral or positive attitudes about covering the vacancy. This is contradictory to the perceived attitudes of physicians who have taken maternity leave where only half of women reported supportive attitudes from colleagues during pregnancy and maternity leave. It is unclear why this discrepancy exists; however, the development of formal policies may help women feel more supported during leave when following agreed-upon hospital or departmental policies.

Overall, we found that maternity leave is an important topic to both those taking and covering for leave. In fact, some women reported considering leaving a job due to a maternity leave policy. These findings are reflected in multiple other studies, which have also demonstrated the importance of parental leave policies to practicing physicians.[17-19] Our respondents suggested improvements in policies including enhancing leave duration and compensation; adding a component for adoption; adding support for those working extra shifts to cover colleagues' leave; and addressing breastfeeding issues for women returning to work.

Our respondents reported variability in the presence, length and compensation for maternity leave. Although literature is scarce covering parental leave policies, it echoes our findings of inconsistency.[19] This lack of consistency suggests the need for clear, formal policies. While there is little data on how to establish parental leave policies, some essential components include involving key hospital administrators as well as physicians and maintaining a focus on the financial implications for both.

Compensation for family leave also varies, and in 18% of our study sample there was no compensation for family leave at all. This compensation, however, can be an important source of employee satisfaction. A survey of over 1,300 female EPs investigated career satisfaction. They found that important personal predictors of satisfaction were schedule flexibility, supportive colleagues, and fairness of financial compensation.[20]

While we did not set out to look specifically at paternity

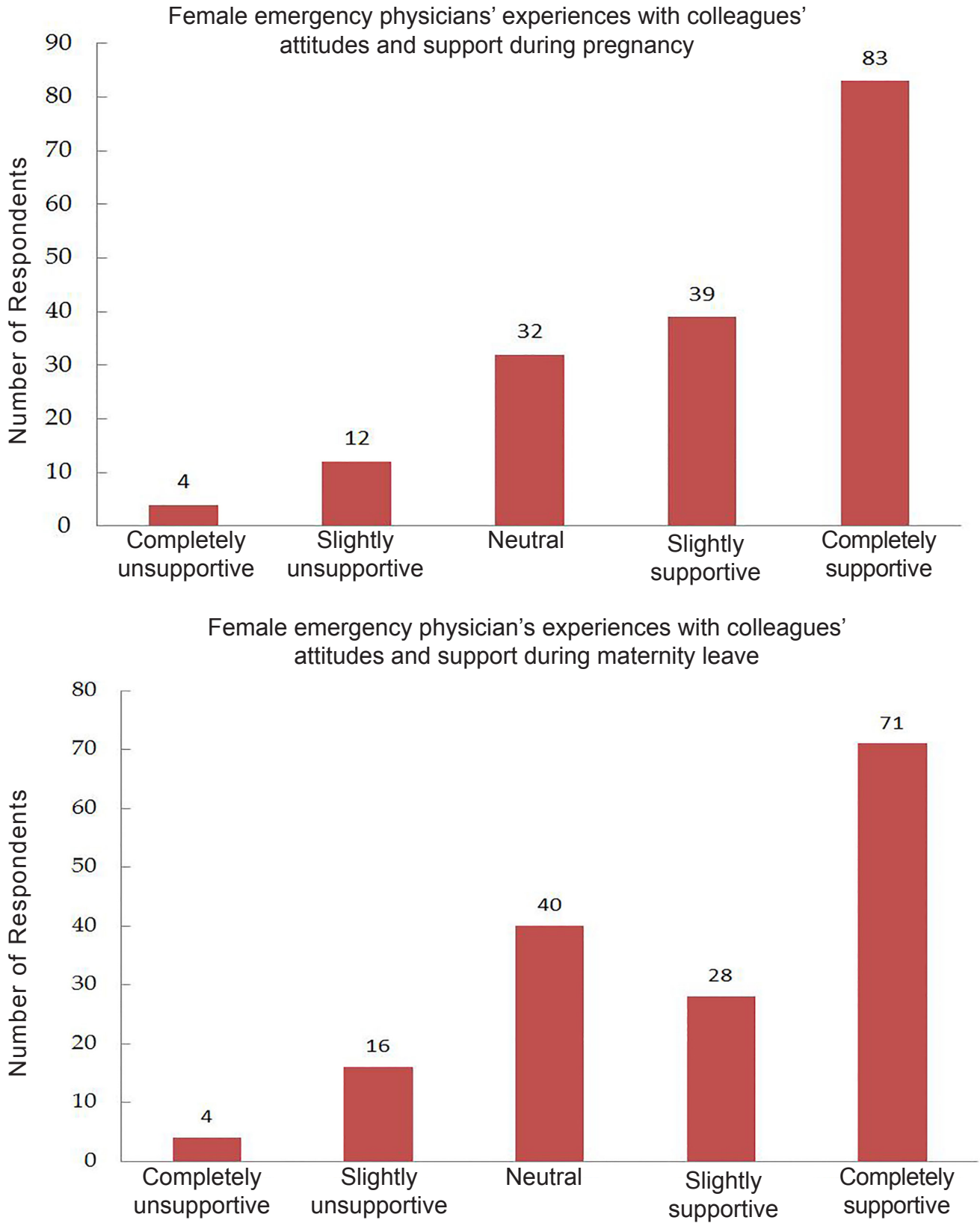


Figure 4. Emergency physicians' experiences regarding colleagues' attitudes and support.

Comment
"I actually left a job in the past where I was asked to write down when I would get pregnant and how many times that I planned to get pregnant in the future. I feel very strongly that we work in a flexible specialty and should be able to provide a long maternity leave for pregnant colleagues."
"While I support colleagues' decisions to have children, it is tough to balance fair compensation for their time out with fairness to the group to not only cover shifts but also to additionally pay that person for work not performed."
"Having children is a choice. There is no dearth of human beings in the world. Physicians, as opposed to women in other fields, have the means to support themselves when they make this choice. I do not believe that maternity leave is important."
"What about PATERNITY leave? It's very important for the child, the father-child relationship, the couple relationship, the father, and ultimately, society."
"I had two complicated pregnancies: one with preterm labor taking me out at 24 weeks, one with cardiac complications that lasted until 31 weeks (against physician's orders to stop working at 27 weeks). Both were met with strongly negative reactions . . . Several colleagues actually yelled at me that I was screwing up their schedules."
"How about addressing support systems in the place of employment for working mothers who come back to work, i.e., those working mothers who are still nursing? Are there adequate numbers of lactations rooms to where you work?"

Figure 5. Examples of participant comments in response to the question, "Is there anything else you would like to add?"

leave policies, this topic was mentioned by numerous respondents. In concert with this, there has been a recent rise in awareness of paternity leave policies and we would be remiss not to mention their importance. Companies such as Yahoo are acknowledging the importance of paternity leave by offering fathers eight weeks of paid parental leave. This kind of policy is rare in the U.S. where only 13% of employers offer any paid paternity leave.[21] The absence of clear paternity leave policies places the U.S. far behind other countries where paternity leave is an accepted and established practice. For example, in Sweden 85% of fathers take parental leave.[22] Even for physicians, it is more common for men in other countries to take paternity leave. In England, 50-96% of male physicians take paternity leave.[23] This demonstrates that it is possible for paternity leave to be accepted and supported.

Another prominent concern in our survey was shift coverage for vacancies during an EP's maternity leave. This was covered by a variety of methods. The majority of respondents reported that coworkers worked extra shifts to fill these vacancies. Other methods included additional per diem staff coverage and working a heavier shift load prior to maternity leave. Although there is no single correct means for covering shifts, it is clear that coverage for parental leave in a fair and uniform means is an essential adjunct to the implementation of a successful maternity leave policy.

LIMITATIONS

Our study has several limitations to consider. As with most surveys, there may be a tendency of those with strong opinions to participate, which may bias the responses. Additionally, this study is limited by the fact that our data collection was a convenience sample of state chapters of ACEP. We surveyed six state chapters, selected due to the fact that these were the states whose administrators responded to our original e-mail requesting distribution of our survey. Although these six chapters (Maine, Massachusetts, Missouri, Ohio, Utah and Virginia) were ultimately quite diverse in geographic location, it is possible that our results are biased due to the inability to survey all state chapters. We also included AAWEP, which due to its mission and membership may have biased the sample towards those concerned about maternity leave issues. It should be noted that there were more participants who reported being involved with academic practice, at least to some degree, and therefore our findings may not fully represent the perspectives of community-based EPs. Another potential limitation of our study is that we asked respondents about the maternity leave policies at their current place of employment, as opposed to the site of their practice when they had children. We did this with the intention of surveying the current state of maternity leave policies, but it is possible that we missed historical perspectives on maternity leave that may have informed the respondents' current opinions.

Our inability to calculate an accurate response rate may limit the generalizability of our results. State chapter executives were unable to accurately report the total number of chapter members, so our study participants represented an unknown percentage of each chapter's membership.

The final limitation of our study is due to its initial design. We were unable to use a formally validated survey instrument as none were available in the literature. We therefore designed our survey independently, based upon questions and topics raised

during an extensive literature review. It is possible, however, that our questions did not fully explore all the intended content areas regarding attitudes and policies related to maternity leave for physicians in EM.

CONCLUSION

Given the changing environment of our workforce and the generation shift to more Millennials, establishing formal parental leave policies will only become more important. We expect that as beliefs and attitudes continue to shift, this issue will become more important and will look differently, perhaps bringing more attention to associated concerns like paternity leave. Our study of male and female EPs found that the number of formal policies, satisfaction with leave policies, duration of and compensation for leave, as well as physician attitudes surrounding leave, vary considerably. Future research and efforts should focus on establishing guidelines for formal parental leave policies in EM. Along with the respondents in our study, we suggest that future policies include consistent and improved leave duration and compensation, paternity leave, adoption leave, and potentially address breastfeeding. Improvements in these policies will benefit not only physicians taking parental leave, but also have a significantly positive impact on colleagues, EM practice groups and the culture of emergency medicine as a whole.

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Emergency Department Use across 88 Small Areas after Affordable Care Act Implementation in Illinois

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Introduction: This study analyzes changes in hospital emergency department (ED) visit rates before and after the 2014 Affordable Care Act (ACA) insurance expansions in Illinois. We compare the association between population insurance status change and ED visit rate change between a 24-month (2012-2013) pre-ACA period and a 24-month post-ACA (2014-2015) period across 88 socioeconomically diverse areas of Illinois.

Methods: We used annual American Community Survey estimates for 2012-2015 to obtain insurance status changes for uninsured, private, Medicaid, and Medicare (disability) populations of 88 Illinois Public Use Micro Areas (PUMAs), areas with a mean of about 90,000 age 18-64 residents. Over 12 million ED visits to 201 non-federal Illinois hospitals were used to calculate visit rates by residents of each PUMA, using population-based mapping weights to allocate visits from zip codes to PUMAs. We then estimated n=88 correlations between population insurance-status changes and changes in ED visit rates per 1,000 residents comparing the two years before and after ACA implementation.

Results: The baseline PUMA uninsurance rate ranged from 6.7% to 41.1% and there was 4.6-fold variation in baseline PUMA ED visit rates. The top quartile of PUMAs had >21,000 reductions in uninsured residents; 16 PUMAs had at least a 15,000 person increase in Medicaid enrollment. Compared to 2012-2013, 2014-2015 average monthly ED visits by the uninsured dropped 42%, but increased 42% for Medicaid and 10% for the privately insured. Areas with the largest increases in Medicaid enrollment experienced the largest growth in ED use; change in Medicaid enrollment was the only significant correlate of area change in total ED visits and explained a third of variation across the 88 PUMAs.

Conclusion: ACA implementation in Illinois accelerated existing trends towards greater use of hospital ED care. It remains to be seen whether providing better access to primary and preventive care to the formerly uninsured will reduce ED use over time, or whether ACA insurance expansion is a part of continued, long-term growth. Monitoring ED use at the local level is critical to the success of new home- and community-based care coordination initiatives. [West J Emerg Med. 2017;18(5)811-820.]

INTRODUCTION

The 2014 Affordable Care Act (ACA) insurance expansions were designed to increase access to care and potentially lower hospital costs associated with undiagnosed, unaddressed health care problems that often result in visits to a hospital emergency department (ED). By increasing access to primary care, it was hoped that ACA insurance expansions might, at least over time, reduce ambulatory care sensitive hospital use.[1] The ACA's 2010 private insurance expansion for young adults has been associated with reduced ED use,[2] and some studies have found no increases in ED use after the first year of the ACA.[3,4] Other studies have found that ED use for young adults with non-discretionary conditions increased,[5] and previous state-level insurance expansions and even county-level access to care programs that include the older uninsured population have often resulted in significant increases in ED use.[6-12] Gaining health insurance is associated with significant financial, mental health, access to care, self-reported health status and mortality gains.[13-19] Although reducing ambulatory care sensitive ED use was one aim of ACA insurance expansions, the literature on prior insurance and access to care expansions generally predicts higher ED use when newly insured patients pursue a backlog of previously unaddressed health issues.[20]

A recent statewide analysis of ACA effects on Illinois ED visits for the 18- to 64-year-old population found an approximate 5% increase in ED visits above and beyond pre-existing time series trends in the two years after full implementation of the ACA.[21,22] This follow-up study presents findings on how the 2014 ACA insurance expansions affected ED visit rates cross 88 Public Use Micro Areas (PUMAs) in Illinois. PUMAs, with an average of about 90,000 age 18-64 residents, reflect a remarkable range of pre-existing ED use rates across diverse urban, suburban and rural community areas of Illinois. We used the 88 Illinois PUMAs, the lowest level of aggregation for U.S. Census data on insurance status, to correlate changes in population-level insurance status with concurrent changes in area ED use at 201 Illinois hospitals between 2012 and 2015. We present methods that are replicable for any state with publicly available, zip-coded ED hospital claims data.

We first analyzed census estimates of area changes in insurance status, rarely analyzed at the small-area level. We then describe correlations with concurrent changes in ED use rates across a wide variety of urban, suburban and rural community areas in Illinois between 2012 and 2015. While further documenting the association between insurance expansion and ED use in Illinois, findings provide insight into the striking variation in ED use across socioeconomically diverse communities. The methods used here for Illinois here can be replicated for any state by mapping state zip-coded hospital ED visit claims to PUMA-level census data. While many studies are appropriately focused on inter-state comparisons, the advent of ACA insurance expansions in 2014 provides a unique lens on small-area dynamics in hospital emergency care utilization.

Population Health Research Capsule

What do we already know about this issue?
Like previous insurance expansions, implementation of the Affordable Care Act (ACA) in 2014 led to an increase in emergency department (ED) visits for the 18- to 64-year-old population in Illinois.

What was the research question?
This study examines large variations in ED visit rate changes across 88 socioeconomically diverse areas of Illinois.

What was the major finding of the study?
Areas with the largest increases in Medicaid enrollment experienced the largest growth in ED use.

How does this improve population health?
Better access to emergent care for the previously uninsured may be one reason why state insurance expansions have been found to improve population mortality rates.

METHODS

This study analyzes PUMA-level annual American Community Survey (ACS) insurance estimates and PUMA-level changes in ED visits, including hospitalization through the ED, across 88 Public Use Micro Areas (PUMAs) in Illinois. The effect of ACA insurance expansion was measured by the change in average monthly ED visit rates per 1,000 PUMA residents between the 24-month pre-ACA (2012-2013) period and the 24-month post-ACA (2014-2015) period. We analyzed the correlation between PUMA-level change in population insurance status and concurrent change in PUMA-level ED visit rates.

American Community Survey Population Estimates of Area Insurance Status

PUMAs are the lowest level of aggregation for census population level insurance status estimates from the annual American Community Survey (ACS) for the years 2012-2015.[23] Annual ACS insurance population estimates are based on approximately 100,000 interviews in Illinois each year and

have <2% statewide margin of error for insurance status estimates of the 18-64 population. PUMAs had an average of just over 90,000 residents age 18-64. The number of residents age 18-64 who reported being uninsured, or being primarily covered by Medicaid, Medicare (disability), private insurance or other coverage (e.g. VA or TRICARE) were derived for each PUMA in Illinois from 2012-2015 annual ACS estimates.[23] Because some residents reported multiple insurance coverage, combined estimates of all insurance categories resulted in a small over-count. We also obtained cross-sectional estimates of the percent of area residents below poverty level the number who were disabled and/or non-citizens and the area median household income, from 2010-2014 five-year PUMA-level ACS estimates.

Hospital Administrative Data on ED Visits

Hospital administrative data from 201 non-federal Illinois hospital EDs were obtained from the Illinois Hospital Association Comparative Health Care and Hospital Data Reporting Services (COMPdata) database. We analyzed records for patient demographics, hospital ED visits, and admissions through the ED for all patients age 18-64 with Illinois zip codes from January 2012 through December 2015, a 48-month study period. Patient zip codes were used to impute median household income using census estimates from zip code tabulation areas (ZCTA) from the five-year (2009-2013) ACS. Low-income zip codes were defined as having median household income below $35,000. All data were de-identified and the study was ruled exempt by the Northwestern University Institutional Review Board.

Mapping Zip Codes to PUMAs and Calculation of Monthly ED Visit Rates

We used the geographic cross-mapping utility of the University of Missouri Census Data Center to identify census ZCTAs whose boundaries overlapped more than one Illinois PUMA.[24] We weighted hospital ED data at the ZCTA level so that ED visits for patients living in boundary-crossing ZCTAs could be apportioned to PUMAs based on 2012 estimates of the proportion of each ZCTA's residents living in each PUMA. Thus, if one ZCTA had 80% of its population living in one PUMA and 20% living in a second PUMA, 80% of ED visits of residents of that ZCTA were attributed to the first PUMA and 20% to the second. Rates per 1,000 PUMA residents were then calculated from monthly visit data numerators and PUMA age 18-64 annual total and insurance status population denominators.

Statistical Analysis

ED visit rates per 1,000 residents for each of the 88 Illinois PUMAs were aggregated monthly and for each separate insurance primary payer over the 48-month study period for each PUMA's 18-64 population. We compared average monthly ED visit rates during the 24-month, pre-ACA period to the same rates observed in the 24-month post-ACA period. For each PUMA, we calculated the mean ED visit rate difference between time periods as a difference in absolute numbers, the absolute rate difference per 1,000 residents, and as a percent change difference from the baseline rate. Pearson correlation coefficients tested the significance of bivariate associations between ACA-related PUMA population change in each insurance status and change in PUMA residents' monthly ED use rates. Using linear regression, we tested the effects of simultaneous change in insurance (Medicare disability, Medicaid, uninsured, private and other/unknown) across all categories, and controlled for fixed estimates of PUMA sociodemographic characteristics (percent of area residents below poverty level who were disabled, who were non-citizens, and area median household income). Analyses were performed with SPSS Version 22, Chicago, Illinois and SAS Version 9.4, Cary, North Carolina.

RESULTS

Changes in Insurance Status Across Illinois

In the pre-ACA period, approximately 70% of Illinois residents age 18-64 reported private insurance coverage, 18% reported being uninsured and just over 10% reported Medicaid coverage. However, there was wide variation across PUMAs. Only 31.5% of residents from Chicago's West Side Lawndale, Humboldt Park and Garfield Park PUMA reported private coverage, and 41.1% reported being uninsured. This compared to 90.3% reporting private coverage and only 6.7% reporting being uninsured in Western Kane County in exurban Chicago. Only 2.0% of residents in the Near North, Loop and Near South Side in downtown Chicago reported Medicaid coverage as compared to 29.9% of residents of the Chicago Lawn, Englewood and Grand Crossing neighborhoods on the South Side of Chicago.

Averaged statewide-census insurance status estimates of changes between 2012-2013 and 2014-2015 were modest, with a +2.8% increase in private and a 3.3% change in Medicaid coverage, a 4.7% decline in uninsurance, and virtually no change (0.1%) in Medicare disability coverage. However, these average change data mask much more significant variation in insurance transitions across PUMAs, as shown in Figure 1 for the uninsured and for residents covered by Medicaid. This figure maps ACS estimates by quartiles of the absolute number of PUMA residents with insurance status changes between the pre- and post-ACA periods. The darkest red PUMAs in Figure 1 had the largest absolute declines in the number of uninsured residents; conversely, the lightest blue areas had the largest absolute increases in Medicaid enrollment between periods. Changes in insurance coverage ranged from less than a 1% decline in uninsurance in suburban Plainfield and Lockport townships in suburban Will County to a 15.8% decline in Aurora. Changes in Medicaid enrollment ranged between a 1%

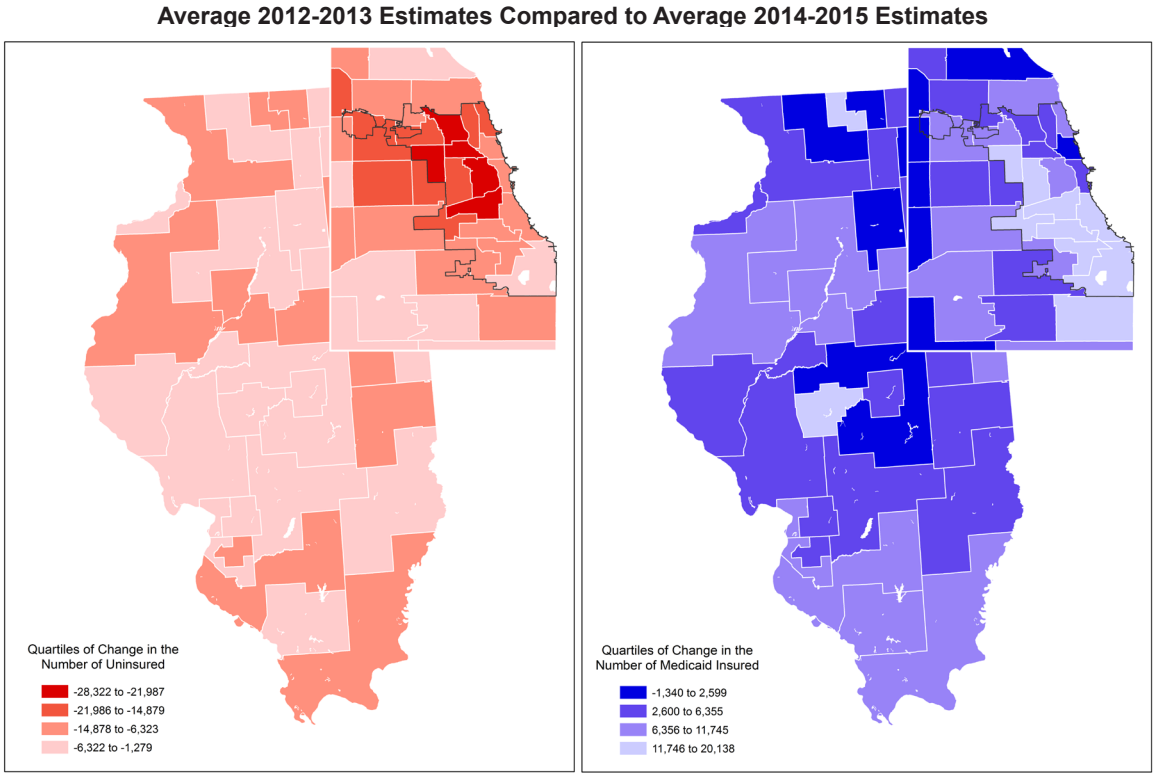

Figure 1. Quartiles of change in annual American community survey estimates of residents age 18-64 (A) uninsured, or (B) with Medicaid coverage for 88 Illinois public use micro areas.

decline in affluent areas of suburban Lake and Will counties to a 10.6% increase in the South Side Chicago neighborhoods of Auburn-Gresham, Roseland, Chatham, Avalon Park and Burnside. Six PUMAs had greater than 20,000-person declines in uninsured residents, and another 10 PUMAs had over 15,000-person declines. Conversely, six PUMAs had more than a 15,000 resident increase in Medicaid coverage and nine others had an over 10,000 resident increase. Figure 1B provides a PUMA map of Illinois and Chicago area changes in private insurance coverage; the darkest purple areas had a >5,000 resident gain in privately insured residents.

Changes in Emergency Department Visit Rates

There were over 12.28 million ED visits for Illinois residents age 18-64 over the 48-month study period. The proportion of visits that resulted in hospitalizations through the ED actually decreased from a mean of 11.75% of visits pre-ACA to 11.2% post-ACA; mean monthly ED admissions increased very slightly from 29,031 in 2012 to 29,503 in 2015. Pre-ACA average monthly ED visit rates per 1,000 (Figure 2) ranged from 13.5 in the Lake View and Lincoln Park neighborhoods on Chicago's North Side to 62.3 in the Lawndale, Humboldt Park and Garfield Park neighborhoods on Chicago's West Side. Across all areas, for 18-64 year old residents, average monthly ED visit rates increased from 31.2 per 1,000 from 2012-2013 to 36.6 per 1,000 in 2014-2015, while ED admission rates per 1,000 residents actually decreased slightly. Figure 3 maps quartiles of change in average monthly ED visit rates for uninsured and Medicaid patients between 2012-2013 and 2014-2015. The darkest red PUMAs had *declines* in uninsured visits of >5.9 per 1,000 while the lightest blue PUMAs had *increases* in Medicaid visits of >7.6 per 1,000.

The greatest overall post-ACA decline in average monthly visit rates was -3.0 per 1,000 in downstate Montgomery, Bond, Clinton, Fayette and Effingham counties, while the largest overall increase was 10.8 per 1,000 in the Lawn, Englewood, and Grand Crossing neighborhoods of Chicago's South Side. Statewide, average monthly visit rates for the uninsured fell by 3.1 per 1,000 in 2014-2015 while average monthly Medicaid visits increased by 3.6 per 1,000. The largest decline in average monthly visits for uninsured residents (-11.3) was in Adams, Pike, Brown, Schuyler and Mason counties in western Illinois and the largest increase in monthly Medicaid visits was in Rockford and surrounding Winnebago County (+12.0). Figure 3B provides the same map for changes in all ED visits for Illinois- and Chicago-area PUMAs, with the lightest purple

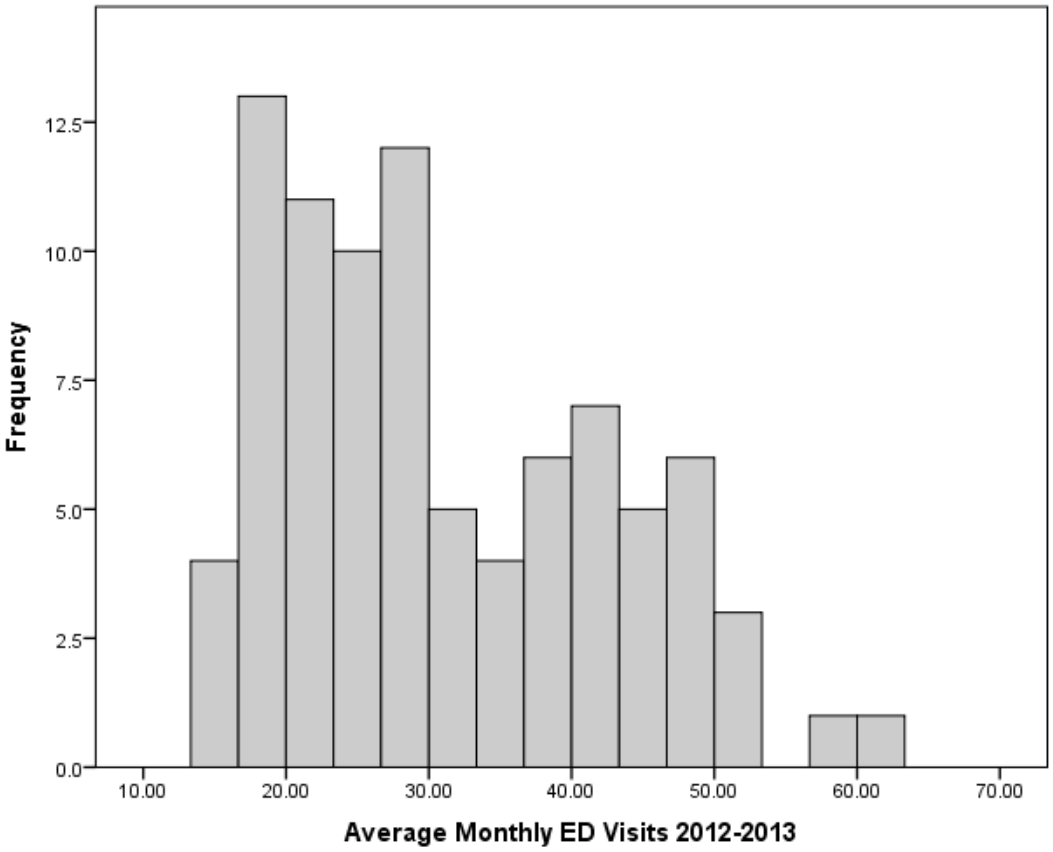

Figure 2. Average 2012-13 monthly emergency department (ED) visits per 1,000 residents age 18-64 in 88 Illinois public use micro areas.

areas reflecting overall monthly ED visit increases of over 4.7 visits per 1,000.

Associations between Changes in Population Insurance Status and Changes in Visit Rates

Average monthly Medicaid ED visits rose from 8.6 per 1,000 (SD=5.2) to 12.2 per 1,000 (SD=7.6), a 41% increase over the pre-ACA baseline, and had by far the highest correlation (r=0.63, p<0.001) between changes in coverage and changes in ED visit rates (Figure 4). The table displays PUMA-level insurance-specific changes in average monthly ED visit rates in the first column, showing a larger than offsetting increase in the Medicaid visit rate as compared to the decrease in uninsured visits. The second column of the

Table. Correlations between changes in insurance coverage for residents age 18-64 and changes in average monthly emergency department (ED) visits between 2012-13 and 2014-15 across 88 Public use micro areas in Illinois.

	Change in average monthly ED Visit rates per 1000 residents between 2012-13 and 2014-15 (range)	Bivariate correlations with percent changes in area insurance coverage		Linear regression of percent changes in total monthly ED visits(1)		
		Pearson correlation coefficient	p value	b	SE	p value
Uninsured	-42 (-68 to -10)	-0.12	0.26	0.09	0.09	0.32
Medicaid	+42 (+76 to -19)	0.63	<0.001	0.63	0.10	<0.001
Private insurance	+10 (+83 to -14)	0.20	0.06	0.008	0.01	0.91
Medicare (disability)	-5 (+30 to -22)	0.13	0.24	0.37	0.46	0.93

ED,emergency department; *SE*, standard error.
(1) R^2=0.33 Change in other or unknown insurance is the reference category.

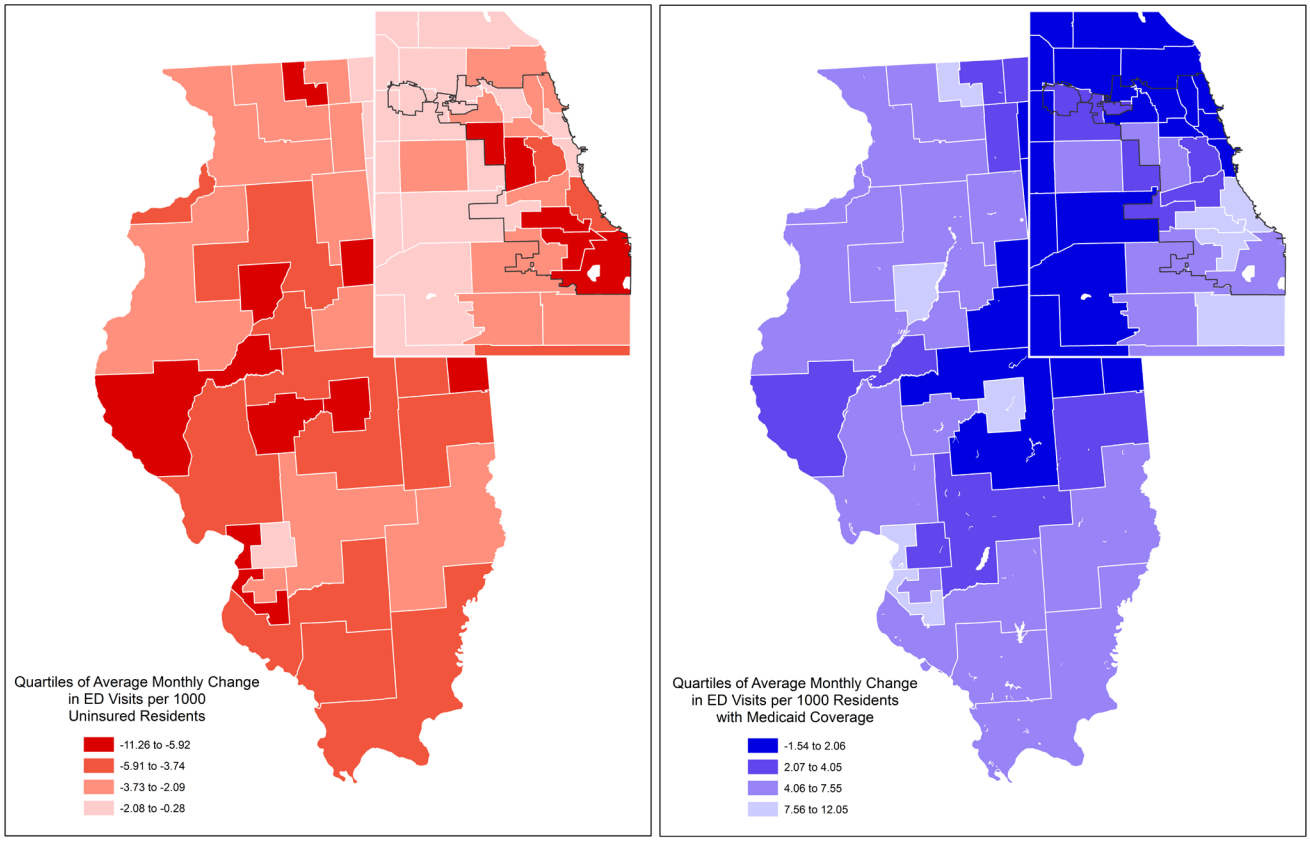

Figure 3. Quartiles of change in emergency department (ED) visits per 1,000 residents age 18-64 (A) uninsured or (B) with Medicaid coverage across 88 Illinois public use micro areas.

table presents bivariate correlations between the percent change in each insurance population and pre-post ACA change in ED average monthly visit rates for all PUMA residents. Changes in ED visit rates for the uninsured and residents covered by Medicare disability were not significantly correlated with change in their coverage, while change in the ED visit rate by the privately insured (+1.1, SD=1.7) was modestly but non-significantly correlated with change in PUMA private insurance coverage (p=0.06).

The final columns of the table present linear regression results for the association of all insurance- population changes simultaneously with change in total average monthly ED visit rates. PUMA cross-sectional census characteristics were tested in an initial model of change in total ED visit rates, before entering what were expected to be highly correlated insurance status changes. PUMA percent poverty (p=0.08) and percent disabled (p=0.05) were modestly correlated with ED visit rate changes, but after entering insurance status changes, all cross-sectional census characteristics became non-significant (and had virtually no effect on insurance status coefficients, data not shown). Only change in Medicaid coverage was significantly associated (p<0.001) with change in overall average monthly ED visit rates in the multiple regression model. Change in insurance status explained about a third of the variance in overall ED visit rate change across PUMAs.

DISCUSSION

ACA Insurance Expansion and the Long-Term Increase in ED Use

The regional differences we describe within Illinois provide insight into long-debated policy issues about the role of hospital emergency care in the U.S. healthcare system.[25] ED use among non-elderly adults, especially for "primary care treatable" or lower acuity conditions, was already higher and has been growing most quickly for Medicaid patients.[26-28] NHIS data for the 18-64 population indicate that in 2014, 35.2% of respondents with Medicaid, 14.3% with private coverage and 16.6% who were uninsured reported visiting the ED one or more times that year.[29] This disparity reflects both differences in health status and enduring barriers to timely office- or home-based acute care for low-income patients, as well as numerous care-coordination failures for patients with chronic or end-of-life illness.[30-32]

Like other states, Illinois has seen the growth of managed

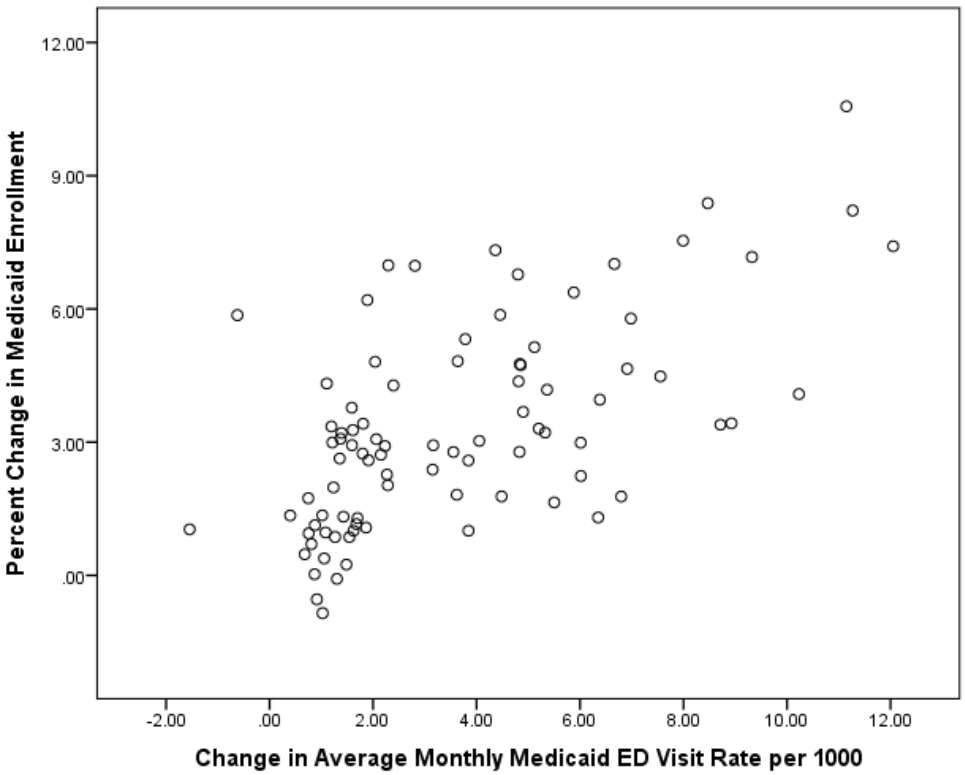

Figure 4. Correlation between change in Medicaid enrollment and change in average monthly Medicaid emergency department (ED) visits before (2013-14) and after (2014-15) Affordable Care Act insurance expansion.
r=0.63, p<0.001.

care providers and patient-centered medical home efforts, which seek to reduce ED use.[33] There has also been a rapid increase in non-hospital urgent and immediate care centers, although these disproportionally serve higher-income areas and do not seem to affect hospital ED rates.[34,35] Yet in Illinois and other states, lower-income, uninsured, underinsured and Medicaid patients, including many individuals with unaddressed psychosocial dimensions to multimorbidity, continue to experience major obstacles to accessing timely primary and behavioral healthcare.[36]

In the U.S. primary care is often inaccessible during work-week evenings and weekends,[37] and a greater proportion of ED care is being devoted to managing high-acuity visits by patients with undifferentiated complaints, in part because time-pressured primary care providers are increasingly sending medically and socially complex patients to the ED for diagnosis and treatment.[38,39] Reducing financial barriers to ED care with ACA insurance expansion in Illinois, which has a relatively fixed supply of ED beds, appears to have exacerbated existing trends towards increasing ED visit rates.

A recent study of claims data from 126 investor-owned hospitals also found a significant post-ACA increase in ED use in Medicaid expansion states, as opposed to nonexpansion states.[40] Of note, this study found that Medicaid patients in expansion states experienced a 6.2% decreased travel time to hospitals, almost certainly concentrated among the newly insured. This decrease in travel time was pronounced for Medicaid patients with more severe, non-discretionary conditions, two thirds of whom do not arrive by ambulance. Increased ED use may thus be a potentially important factor underlying the observed mortality reductions that accompany insurance expansions.[16]

Small Area Variation in ED Use

This study provides two years of post-ACA data to evaluate change in ED use in Illinois. Our PUMA-level analysis shows that changes in ED use related to the ACA in Illinois are rooted in wide differences in local and regional ED use rates, with the underlying variation in area ED visit rates poorly understood. There have been few recent studies of community differences in ED use, and fewer longitudinal studies of area-level changes in ED rates over time.[41]

The variation in ED use across Illinois PUMAs reflects, in part, the well-studied variation in small-area medical and surgical hospitalization rates.[21] Explanations of variation in small-area hospital use remain divided about the extent to which use rates reflect supplier-induced demand for hospital care, as opposed to area differences in illness[42] or higher

healthcare use by low-income residents within hospital market areas.[43]

Writing over a decade ago about a 20-fold variation in ED use within Robert Wood Johnson Community Tracking Study communities, Cunningham et al. found correlations between ED use and area primary care physician- and hospital-supply characteristics, but little correlation between ED use and the number of uninsured area residents.[41] Variation in ED admission rates across small areas also reflects the impact of local medical norms on clinical policy.[44-46] Recently**,** Pines et al. found that county-level differences in admissions through the ED were negatively correlated with primary care physician supply,[44] but the role of primary care physician "density" remains controversial and differs between geographic units.[46]

Implications for Delivery System Reform

Administrative and copayment financial sanctions to reduce "non-acute" ED care have largely failed and may be unethical.[47,48] Recent population health incentives have highlighted ED-based care coordination interventions targeted to patients who receive the most fragmented care and have the highest likelihood of hospital admission through the ED.[49] These efforts will need to directly address social services and social determinants of health as they manifest in highly local settings.[50] It is worth considering how shifting to a delivery system based on home- and community-care coordination may change ED use and ED practice in coming years, and how such changes can be tailored to particular community values.[51-53] For Illinois communities, this report serves as a benchmark for future initiatives seeking to reduce ED use and makes clear which areas are most in need of care coordination investment and infrastructure.

LIMITATIONS

There are several potentially significant limitations to this study. ACA Medicaid expansion began in Illinois in January 2013 with a federal waiver for early ACA Medicaid enrollment in Cook County. By mid-2014, over 100,000 people in the Chicago area had become newly enrolled, and some new Chicago-area Medicaid enrollees were receiving services in 2013. While this biases ED use estimates upwards for the pre-ACA period analyzed here, it makes the January,2014 ACA cut off more appropriate since by then newly registered patients were already obtaining services from new county Medicaid-managed care programs.

Illinois hospital claims data, which reflect multiple visits by the same patient, will not be commensurate with self-reported National Health Interview Study (NHIS) data on the number of respondents reporting they visited the ED during the previous year.[4] One national 2013-2014 NHIS study shows a 5% decrease in Medicaid ED visits, a 3.3% decline in uninsured ED visits and a 3.9% increase in privately insured ED visits,[54] and based on trends over 2010-2014, residents of Medicaid expansion states had modestly higher post-ACA ED visits and overall hospitalization rates.[4]

Repeated use of the ED represents a substantial proportion of all visits and especially Medicaid visits.[55,56] Our visit data are not patient-identified and we cannot speculate on ACA effects on frequent ED use, nor distinguish use by patients newly enrolled in Medicaid. Nor do we have claims or census data, which differentiate employer-sponsored privately insured vs. self-purchased policies. We excluded ED visits for non-Illinois residents, which represent about 2.5% of all visits to Illinois hospitals; also excluded were a smaller number of ED visits by Illinois residents to hospitals in other states.

CONCLUSION

We found that areas with the greatest increases in Medicaid enrollment had the highest overall ED visit rate increases. Our findings on ED use in Illinois support the hypothesis that because insured patients gain the financial security to use the ED for previously unaddressed health issues, there will be an expected ED use spike after access expansions remove financial barriers to care.[20] It remains to be seen whether eventually providing better access to primary and preventive care to the formerly uninsured will reduce ED use over time, or whether ACA insurance expansion is just a small part of continued long-term growth.

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Head CT for Minor Head Injury Presenting to the Emergency Department in the Era of Choosing Wisely

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Introduction: The Choosing Wisely campaign currently recommends avoiding computed tomography (CT) of the head in low-risk emergency department (ED) patients with minor head injury, based on validated decision rules. However, the degree of adherence to this guideline in clinical practice is unknown. The objective of this study was to evaluate adherence to the Choosing Wisely campaign's recommendations regarding head CT imaging of patients with minor head injury in the ED.

Methods: We conducted a retrospective cohort study of adult ED patients at a Level I trauma center. Patients aged ≥ 18 years who presented to the ED with minor head injury were identified via International Classification of Diseases, 9th Revision, Clinical Modification codes. Medical record abstraction was conducted to determine the presence of clinical symptoms of the NEXUS II criteria, medical resource use, and head CT findings. We used descriptive statistics to characterize the study sample, and proportions were used to quantify guidelines adherence.

Results: A total of 489 subjects met inclusion criteria. ED providers appropriately applied the Choosing Wisely criteria for 75.5% of patients, obtaining head CTs when indicated by the NEXUS II rule (41.5%), and not obtaining head CTs when the NEXUS II criteria were not met (34.0%). However, ED providers obtained non-indicated CTs in 23.1% of patients. Less than 2% of the sample did not receive a head CT when imaging was indicated by NEXUS II.

Conclusion: ED providers in our sample had variable adherence to the Choosing Wisely head-CT recommendation, especially for patients who did not meet the NEXUS II criteria. [West J Emerg Med. 2017;18(5)821-829.]

INTRODUCTION

According to a report by the Institute of Medicine, approximately $750 billion of healthcare spending annually results in no benefit to patients in the United States (U.S.).[1] Minor head injury is a common concern prompting emergency department (ED) visits. In 2010 the number of ED visits in the U.S. for traumatic brain injury (TBI) exceeded 2.5 million.[2] It has been estimated that approximately 75% of TBIs are considered mild.[3] Streamlined assessment of patients presenting with minor head injury to identify those who require imaging, in order to further risk stratify the need for neurosurgical

management could result in a significant reduction in healthcare spending.

Computed tomography (CT) of the head is commonly used to assess patients presenting to the ED with head injury. Approximately 80 million CTs are performed in the U.S. each year, with approximately one third of these performed in emergency settings.[4] For patients with obvious signs of TBI, such as evidence of skull fracture on physical exam, or neurologic changes, obtaining head CTs has clear benefit, as advanced imaging may be necessary to guide medical and neurosurgical interventions.[5] However, for patients without obvious signs of TBI, the decision to perform a head CT requires more deliberation. Many non-clinical factors influence a provider's decision to obtain a CT in patients with minor head injury. These include patient expectations, patient and provider anxiety, fear of litigation, fear of missed diagnoses, and desire to expedite diagnoses.[6-8] Conversely, providers may hesitate to order CTs due to concerns such as increased door-to-discharge times, increased length of hospital stay, harm and cost from incidental findings on imaging, and risk of cancer due to exposure to ionizing radiation.[9,10] A balanced approach is required to ensure ordering of head CTs when necessary, while mitigating the potential downsides of over-imaging.

The American Board of Internal Medicine Foundation launched the Choosing Wisely initiative in 2012 with the goal of advancing dialogue about avoiding wasteful or unnecessary medical tests and procedures.[11] The American College of Emergency Physicians (ACEP) joined this group with five recommendations, one of which is to "[a]void computed tomography (CT) scans of the head in emergency department patients with minor head injury who are at low risk based on validated decision rules."[12] Many patients with minor head injuries receive unnecessary CTs in the ED that provide no clinical benefit. In an era of increasing medical expenditures, growing ED wait times, and concern for cancers caused by excessive diagnostic radiation exposure, the Choosing Wisely campaign attempts to improve care and decrease costs by avoiding unnecessary testing. However, there is sparse evidence regarding actual rates of adherence to the Choosing Wisely campaign recommendations on avoiding head CTs in low-risk patients.

Choosing Wisely cites the Canadian Computed Tomography Head Rule (CCHR) and the New Orleans Criteria as validated decision-making tools used to identify low-risk patients for whom CT head imaging may be safely avoided. Another widely used validated decision–making tool is the NEXUS (National Emergency X-Ray Utilization Study) II rule.[13-17] The NEXUS II rule has been shown to have the highest reduction rate for CTs, with comparable sensitivities and specificities in identifying clinically important brain injury. The NEXUS II criteria also largely match those of the 2008 ACEP clinical policy regarding use of CTs in head trauma patients with no loss of consciousness or post-traumatic amnesia.[18] In addition, the NEXUS II rule consists of binary criteria, an added convenience and advantage in our study design using standardized medical record review and data abstraction. In summary, we chose to use the NEXUS II rule due to its general consistency with other validated decision rules and ACEP clinical policy, acceptable sensitivity and specificity in identifying clinically significant head trauma, convenience of binary criteria in chart review, as well as its ease of application in the ED setting. To evaluate whether common ED practice aligns with Choosing Wisely recommendations, we performed chart reviews on a sample of ED patients with minor head injury to determine if they met NEXUS II criteria, and if they received head CTs. Our first aim was to describe adherence to the NEXUS II rule by determining the proportion and level of agreement between patients who received a CT of the head and whether or not the CT was indicated by the NEXUS II guidelines. Secondly, we aimed to describe physician non-adherence to the NEXUS II guidelines by determining the proportion of patients for whom a CT was not indicated and not obtained compared to patients for whom a head CT was not indicated but obtained. Lastly, we evaluated on a case-by-case basis characteristics of patients for whom a head CT was indicated by the NEXUS II guidelines but not obtained.

Population Health Research Capsule

What do we already know about this issue?
Several validated decision rules are available to determine the need for head CTs in minor trauma, and we know that application of these rules can reduce unnecessary CT use.

What was the research question?
To what extent are providers using decision rules for CT use in minor head trauma in light of the Choosing Wisely ACEP guidelines?

What was the major finding of the study?
While application to a decision rule was quite good, there was a portion of head CTs that could have been avoided through application of a CT decision rule.

How does this improve population health?
Increasing awareness about Choosing Wisely and demonstrating clear benefits to the broad application of a CT decision rule in minor head trauma could continue to reduce CT use.

METHODS

Study Design

This was a retrospective medical record review study of patients presenting to the University of Rochester Medical Center's Strong Memorial Hospital's ED between January 1, 2013 and December 31, 2013.

Study Setting and Population

The Strong Memorial Hospital ED treats over 100,000 patients annually, is the region's tertiary academic medical center, and is an American College of Surgeons-verified Level I trauma center. The institution's Research Subjects Review Board approved the conduct of this study with a waiver of informed consent.

Study Protocol

We queried the ED electronic medical record (EMR) system (for patients (age ≥18 years) with minor head injury using *International Classification of Diseases, 9th Rev., Clinical Modification* (ICD-9-CM) external cause of injury codes. Specific codes used in participant selection were the following: *959.01* (Head injury, not otherwise specified); *850.0-850.9* (Head injury, with and without loss of consciousness); *920.0* (Head contusion); and *873.0-873.9* (Scalp laceration). We selected a random sample of subjects from the initial query. (See sample size calculation under Statistical Analysis.)

We excluded patients if there was an inappropriate application of an ICD-9-CM code or if there was no documentation of head injury to correspond with the ICD-9-CM code (e.g., chief complaint of dental pain). Subjects were also excluded if application of the NEXUS II rule was inappropriate, defined as patients who were at high risk of severe head injury and CT was warranted based on initial ED presentation, or the presence of any of the following: 1) alcohol intoxication; 2) moderate or severe head injury (GCS <14); 3) trauma team activation; or 4) physician ordering a "Multi CT scan"

We conducted a standardized medical record review on all subjects. A data collection form was created with a corresponding data abstraction guide. The data abstraction guide defined each of the variables to be abstracted, including specific details for how to abstract the variable and where in the EMR each variable should be located. The data collection form and abstraction guide were developed through an iterative process with the physician-abstractors (JD, VL, HT, PB). All abstractors collected data concurrently and met regularly to discuss questions, and discrepancies were resolved via consensus review with the investigative team.

Measurements

Variables abstracted included patient demographics, presenting chief complaint, symptoms including those outlined by the NEXUS II guidelines (Figure 1), whether or not a head CT was obtained and the corresponding results of the scan, neurosurgical interventions, and ICD-9-CM codes. We performed a review of nursing, resident, advanced practice provider, and attending notes, updated medication lists, medical history, and laboratory results linked to the relevant patient encounter to determine whether components of the decision rule were present for each study subject.

NEXUS II Criteria:

Head CT not required if ALL of the following are absent:

- Age > 65yr
- Evidence of significant skull fracture
- Scalp hematoma
- Neurologic deficit
- Altered level of alertness
- Abnormal behavior
- Coagulopathy
- Recurrent or forceful vomiting

Figure 1. National Emergency X-Ray Utilization Study (NEXUS II) is a validated decision-making tool to aid in determining if computed tomography is necessary in cases of head trauma.

Data Analysis

We used descriptive statistics to describe the study sample, including patient demographics, presenting neurological symptoms, and CT use. Our primary objectives were to describe adherence to ACEP Choosing Wisely imaging recommendations using NEXUS II as our validated decision rule and determine the extent to which ED providers deviated from this rule. We classified subjects into one of two groups according to the NEXUS II criteria: 1) head CT indicated; and 2) head CT not indicated. These two groups were further stratified based on whether the ED provider actually ordered and obtained a head CT: 1) head CT obtained; and 2) head CT not obtained. Due to the paired nature of the data, a McNemar's test and Cohen's kappa coefficient were calculated to determine the extent of agreement between the NEXUS II indications for head CT vs. physician order for head CT.

Our secondary objective was to describe provider non-adherence to the NEXUS II guidelines. We compared demographic and clinical characteristics in subjects for whom a head CT was not indicated and not obtained with subjects for whom a head CT was not indicated but obtained. We used chi-square tests and Fisher's exact test where appropriate. This comparison allowed us to evaluate whether certain subgroups were subject to higher risk of

provider non-adherence to the NEXUS II rule. Among patients for whom head CTs were not indicated but were obtained, we determined the proportion of those with significant findings on head imaging and described the nature of these findings (e.g., depressed skull fracture, intracranial hemorrhage). Additionally, we determined whether these injuries resulted in any neurosurgical intervention (e.g., intracranial pressure monitoring). Thirdly, we categorized the characteristics of those subjects for whom a head CT was indicated by the NEXUS II rule, but was not obtained.

The sample size for the current study was based on a McNemar's test. We needed 783 subjects to estimate the proportion of subjects for whom the provider adhered to the NEXUS II guidelines with 80% power and type I error of 5%. We conservatively estimated the discordance between NEXUS II-indicated head CT vs. actual provider order for head CT as 10% in the CT indicated but not obtained group, and 15% in the CT not indicated but obtained group. Based on previous experience, we anticipated that a considerable number of subjects would present with alcohol intoxication and subsequently be excluded after the EMR review was initiated. To account for this, as well as other potential exclusions, missing data and incomplete records, we oversampled by a factor of 25%. As such, we began our standardized medical record review with 1,000 randomly selected subjects from the initial pool of patient encounters meeting inclusion criteria.

RESULTS

The initial medical record query resulted in 4,382 cases of minor head injury that met our ICD-9-CM criteria for inclusion in the study. Of the 1,000 randomly selected participants, 489 met eligibility criteria (Figure 2). The majority of the sample was less than 65 years of age (78.1%), male (54.6%), self-identified as White (76.9%), and of non-Hispanic origin (94.3%) (Table 1). Four patients showed evidence of a skull fracture on physical exam (0.8%), and 104 patients presented with a scalp hematoma (21.3%). Fifteen patients had a neurological deficit (3.1%), 35 exhibited abnormal behavior (7.2%), and 14 experienced excessive or recurrent vomiting (2.9%).

Emergency physicians appropriately applied NEXUS II criteria in 75.5% of subjects (Table 2). Head CTs were obtained when indicated for 203 patients (41.5%). Conversely, head CTs were not obtained when the criteria were not met for 166 patients (33.9%). However, ED providers obtained non-indicated CTs in 23.1% of patients who did not meet the NEXUS II criteria (113 patients). Cases where CTs were indicated by NEXUS II but were not obtained occurred in seven patients (1.4%). Overall, there was a statistically significant difference in the pattern of indicated head CTs vs. obtained head CTs with a kappa coefficient of 0.51 (95% confidence interval [CI] [0.46-0.60]). This is indicative of fair adherence to the NEXUS II criteria. Of those for whom CTs were obtained in non-indicated situations (113 patients), only two revealed significant head injury, and none required neurosurgical intervention.

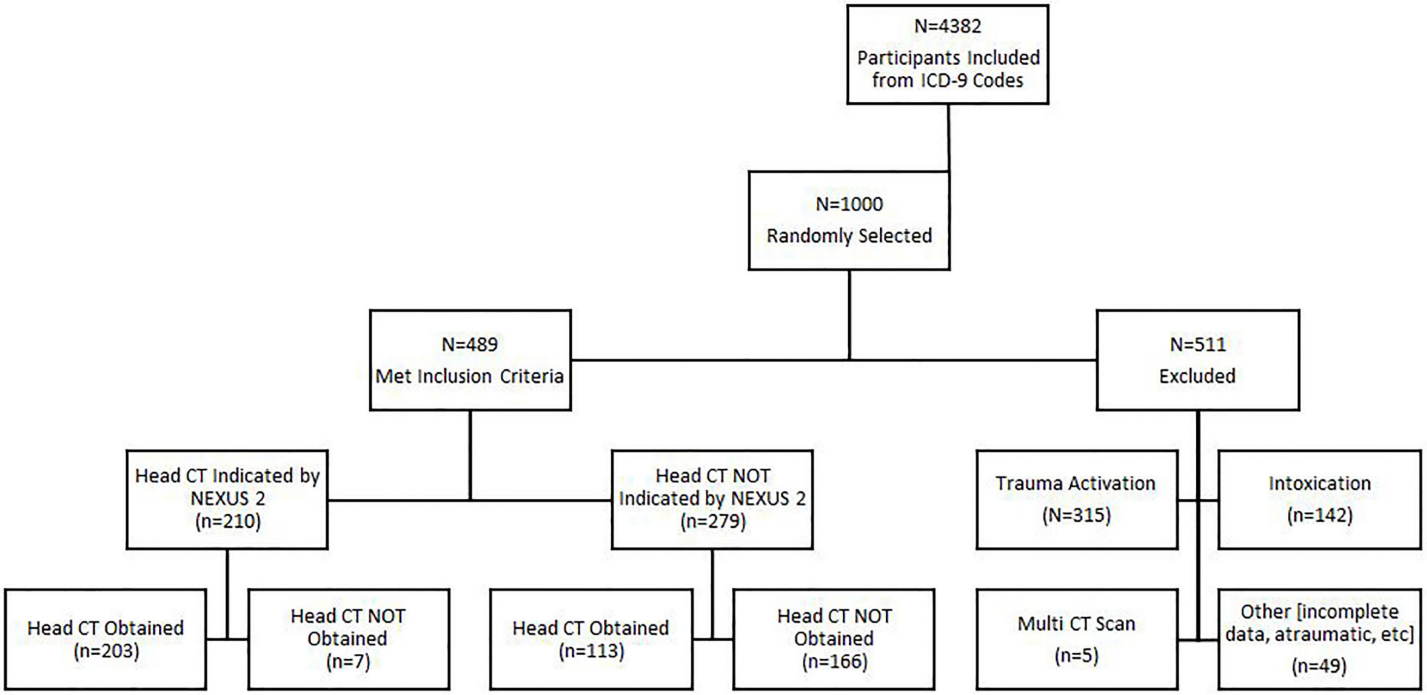

Figure 2. Eligibility criteria for inclusion in study examining providers' adherence to (computed tomography) CT decision rules in minor head injury.

Table 1. Subject characteristics (N=489).

Subject characteristic	N (%)
Age	
≥65	107 (21.9)
<65	382 (78.1)
Sex	
Female	222 (45.4)
Male	267 (54.6)
Race	
American Indian	1 (0.2)
Asian	7 (1.4)
Black	95 (19.4)
Native Hawaiian	1 (0.2)
Other	9 (1.8)
White	376 (76.9)
Ethnicity	
Hispanic or Latino	28 (5.7)
Not Hispanic or Latino	461 (94.3)
Evidence of skull fracture on physical exam	
Yes	4 (0.8)
No	485 (99.2)
Scalp hematoma	
Yes	104 (21.3)
No	385 (78.7)
Neurologic deficit	
Yes	15 (3.1)
No	474 (96.9)
GCS <15	
Yes	19 (3.9)
No	470 (96.1)
Abnormal behavior	
Yes	35 (7.2)
No	454 (92.8)
Platelets <50 10^3/uL	
Yes	1 (0.2)
No	488 (99.8)
INR >1.5	
Yes	8 (1.6)
No	481 (98.4)
Coagulopathy	
Yes	20 (4.1)
No	469 (95.9)
Recurrent vomiting	
Yes	14 (2.9)
No	475 (97.1)
Anticoagulant medication use	
Yes	11 (2.3)
No	478 (97.7)
Platelet inhibitor use	
Yes	58 (11.9)
No	431 (88.1)

GCS, Glasgow Coma Scale; INR, international normalized ratio.

Table 3 shows the characteristics of patients who did and did not receive a head CT among those for whom a head CT was not indicated. There were no statistically significant demographic or clinical differences, with the exception of patient sex: 55.8% were female and 44.3% were male (p=0.0002). Of the seven encounters where CTs were indicated but not obtained, four patients had documented hematomas, one was on an anti-platelet agent, and three were over the age of 65. These patients should have had CT head imaging in accordance with NEXUS II criteria (Table 4). All seven subjects had low-energy traumatic mechanisms, and none returned to the hospital for the same injury.

DISCUSSION

Despite evidence suggesting that the use of validated clinical decision rules can be used to identify patients with minor head injuries in whom it is safe to forgo a CT of the head, the use of CT is still widespread among this low-risk patient population. Adherence to the 2012 Choosing Wisely recommendation to avoid head CT in ED patients with minor head injury who are at low risk for TBI based on validated decision rules was unknown. By retrospectively applying NEXUS II, a validated decision rule, to a sample of patients with minor head injury, we aimed to assess adherence to the Choosing Wisely campaign's recommendation regarding head CT.

The Choosing Wisely campaign does not specify that any particular decision rule be used in the evaluation of ED patients with minor head injuries. Although the CCHR is the most extensively tested decision rule, with a somewhat higher sensitivity than NEXUS II in identifying injuries that require neurosurgical intervention, the CCHR's exclusion criteria make it difficult to apply universally.[19] For this, and the aforementioned reasons in the background section, we chose to use the NEXUS II rule instead. As previously stated, the CCHR would have been especially difficult to apply retrospectively in our study sample. For example, the CCHR criteria regarding duration of retrograde amnesia and fall height may not always be documented in the medical record. Furthermore, when applied, the NEXUS II rule has been shown to result in the highest reduction in CTs performed compared to other decision rules.[13]

Table 2. Concordance of CT indicated and CT obtained.

	CT obtained		
CT indicated	Yes	No	Total
Yes	203	7	210
No	113	166	279
Total	313	176	489
		n	%
CT indicated and obtained		203	41.5
CT not indicated and not obtained		166	40.0
Overall concordance		369	75.5
CT indicated and not obtained		7	1.4
CT not indicated and not obtained		113	23.1
Overall discordance		120	24.5

Kappa= 0.5161, 95% CI [0.4619-0.5954].
CT, computed tomography.

In our study, a considerable number of head CTs were obtained without meeting formal NEXUS II criteria (23.1%). ED providers had variable adherence to the NEXUS II head CT recommendation (kappa coefficient of 0.52). Of the 279 patients for whom head CT was not indicated, CTs were obtained in 113 patients (40.5%), with no discernable change in course of care. This indicates that there is room for improvement in the clinical application of the NEXUS II guidelines. However, as previously noted, the decision to obtain a CT of the head may be influenced by numerous clinical and non-clinical factors.[9,10] Because this was a retrospective study relying on EMR review, the exact reasons for obtaining a head CT are unknown. ED providers may not have adequately documented their thought process, or the factors contributing to their ultimate decision to obtain a CT in the medical record. Therefore, providers in the study at the time of care were free to use any decision rule that they felt appropriate, or a gestalt. There is not currently a policy at our center that emphasizes use of one rule.

An unexpected and concerning finding of our study is that seven patients for whom a head CT was indicated by the NEXUS II rule did not receive one. However, none of these patients appeared to have significant injuries based upon individual chart review. Again, the exact reasons to forgo CT in these patients may be difficult to determine from a chart review. Further, due to small sample size and inability to follow up with some of these patients, their long-term outcomes are unknown. We also recognize that while Choosing Wisely recommends that a decision rule be used, it does not specify which one. Clinicians could have used rules other than NEXUS II and still have complied with the recommendation. We were unable to account for all decision rules and may have missed instances where other rules were applied. Instead we used one that is both commonly applied and conducive to our method of retrospective chart review.

In summary, we found that application of the NEXUS II decision rule in an urban Level I trauma center in accordance with Choosing Wisely recommendations for avoiding imaging in minor head injury remains variable. While it appears that practitioners are using NEXUS II criteria appropriately to indicate the necessity of CT imaging, there is room for improvement in use for avoiding CT imaging. This would support the Choosing Wisely campaign's stance that physicians can continue to make better clinical decisions that are likely to improve care, perhaps by reducing possibly harmful ionizing radiation, resource utilization, and costs associated with unnecessary imaging tests. While it is true that rules such as NEXUS II, the CCHR, and the New Orleans Criteria have been discussed extensively for the past 10 years, the advent of Choosing Wisely and ACEP's contribution to its recommendations put these rules into a different context. There is now more incentive to use these rules to protect patients and conserve resources. Therefore, it is important to quantify how the rules were applied both before and after Choosing Wisely was published. Future studies may potentially examine head-injured patients who are under the influence of alcohol, since almost 50% of our initial sample was excluded due to its presence.

LIMITATIONS

Although we started with 1,000 patients, more than 50% were excluded. The reasons for their exclusion are outlined in Figure 2. We believe that these exclusions were appropriate and necessary to address our research question in the most rigorous way possible.

Less than 2% of our sample did not receive a head CT when one was indicated by the decision rule, limiting our ability to accurately describe this population. A larger sample size may be able to better characterize these subjects. The frequency of indicated but non-obtained head CTs is likely low in actuality, but does warrant future evaluation.

We also recognize that by identifying patients through the use of ICD-9-CM codes we may have missed patients with minor head injuries who may have otherwise been qualified for inclusion into our study. It is unclear how or if these patients would differ with respect to meeting the clinical decision rules and obtaining head CTs. In addition, the total number of patients with minor head trauma may be an underestimate. A different ICD-9-CM code may have been assigned after NEXUS II criteria resulted in a CT and intracranial hemorrhage was identified.

The proportion of subjects who met the decision rule is dependent on the accuracy of medical record documentation as well as data abstraction. We attempted to mitigate potential inaccuracies through our choice of NEXUS II for the decision rule, as the individual criteria outlined in this rule are frequently and consistently documented in our EMR. We also

Table 3. Differences in characteristics of patients not meeting criteria for a head CT, who did and did not receive a CT (n = 279).

	CT not indicated and obtained (n = 113)	CT not indicated and not obtained (n = 166)	
	N (%)	N (%)	p value
Age			NS
<65	0 (0.00)	1 (0.60)	
≥65	113 (100.0)	165 (99.4)	
Sex			0.0002
Female	63 (55.8)	55 (33.1)	
Male	50 (44.3)	111 (66.9)	
Race			0.0909
Asian	5 (4.4)	1 (0.6)	
Black	26 (23.0)	41 (24.7)	
Other	5 (4.4)	3 (1.8)	
White	77 (68.1)	121 (72.9)	
Ethnicity			NS
Hispanic or Latino	10 (8.9)	15 (9.0)	
Not Hispanic or Latino	103 (91.2)	151 (91.0)	
Evidence of skull fracture			
No	113 (100.0)	166 (100.0)	
Scalp hematoma			NS
Yes	1 (0.9)	0 (0.0)	
No	112 (99.1)	166 (100.0)	
Neurological deficit			
No	113 (100.0)	166 (100.0)	
GCS <15			
No	113 (100.0)	166 (100.0)	
Abnormal behavior			
No	113 (100.0)	166 (100.0)	
Platelets <50 10^3/uL			
No	113 (100.0)	166 (100.0)	
INR >1.5			
No	113 (100.0)	166 (100.0)	
Coagulopathy			
No	113 (100.0)	166 (100.0)	
Recurrent vomiting			
No	113 (100.0)	166 (100.0)	
Anticoagulant medication			
No	113 (100.0)	166 (100.0)	
Platelet inhibitor			NS
Yes	3 (2.7)	2 (1.2)	
No	110 (97.3)	164 (98.8)	

GCS, Glasgow Coma Scale; INR, international normalized ratio; CT, computed tomography.

Table 4. Characteristics of subjects for whom a head CT was indicated but not obtained (N=7).

Subject characteristic	N (%)
Age	
≥65	3 (42.9)
<65	4 (57.1)
Gender	
Female	5 (71.4)
Male	2 (28.6)
Race	
White	7 (100.0)
Ethnicity	
Not Hispanic or Latino	7 (100.0)
Treating provider level of training	
Resident	1 (14.3)
Other/unknown	6 (85.7)
Evidence of skull fracture	
No	7 (100.0)
Scalp hematoma	
Yes	4 (57.1)
No	3 (42.9)
Neurological deficit	
No	7 (100.0)
GCS<15	
No	7 (100.0)
Abnormal behavior	
No	7 (100.0)
Platelets <50 10^3/uL	
No	7 (100.0)
INR >1.5	
No	7 (100.0)
Coagulopathy	
No	7 (100.0)
Recurrent vomiting	
No	7 (100.0)
Anticoagulant medication use	
No	7 (100.0)
Platelet inhibitor use	
Yes	1 (14.3)
No	6 (85.7)

GCS, Glasgow Coma Scale; INR, international normalized ratio.

developed a detailed data abstraction guide and performed consensus review on any questionable data fields for specific cases. However, as previously addressed in our discussion, we could not control for the use of this rule alone. Clinicians may have used any decision rule or gestalt at time of care, which introduces unknown bias into the results.

The retrospective nature of our study was not ideal for determining adherence to a specific decision rule. A blinded prospective study in which all providers were instructed to use only NEXUS II in determining whether to perform head CTs for minor head trauma would have been ideal. However, the importance of quantifying adherence to these decision-making rules only became apparent after Choosing Wisely was published.

Lastly, we acknowledge that practice patterns differ significantly across regions. As seen in other reviews, such as the Dartmouth Atlas,[20] our experience in a single trauma center may not be representative of practice patterns at other institutions. As such, the external validity of our findings should be confirmed in future research and independent samples.

CONCLUSION

In our sample of patients with minor head injury, ED utilization of head CT aligns with clinical guidelines for the majority of patients. However, a significant proportion of subjects received head CTs when not indicated by NEXUS II criteria. Further investigation of factors that influence physician decision-making surrounding the use of head CTs for patients with minor head injury is warranted.

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Emergency Physician-performed Transesophageal Echocardiography in Simulated Cardiac Arrest

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Introduction: Transesophageal echocardiography (TEE) is a well-established method of evaluating cardiac pathology. It has many advantages over transthoracic echocardiography (TTE), including the ability to image the heart during active cardiopulmonary resuscitation. This prospective simulation study aims to evaluate the ability of emergency medicine (EM) residents to learn TEE image acquisition techniques and demonstrate those techniques to identify common pathologic causes of cardiac arrest.

Methods: This was a prospective educational cohort study with 40 EM residents from two participating academic medical centers who underwent an educational model and testing protocol. All participants were tested across six cases, including two normals, pericardial tamponade, acute myocardial infarction (MI), ventricular fibrillation (VF), and asystole presented in random order. Primary endpoints were correct identification of the cardiac pathology, if any, and time to sonographic diagnosis. Calculated endpoints included sensitivity, specificity, and positive and negative predictive values for emergency physician (EP)-performed TEE. We calculated a kappa statistic to determine the degree of inter-rater reliability.

Results: Forty EM residents completed both the educational module and testing protocol. This resulted in a total of 80 normal TEE studies and 160 pathologic TEE studies. Our calculations for the ability to diagnose life-threatening cardiac pathology by EPs in a high-fidelity TEE simulation resulted in a sensitivity of 98%, specificity of 99%, positive likelihood ratio of 78.0, and negative likelihood ratio of 0.025. The average time to diagnose each objective structured clinical examination case was as follows: normal A in 35 seconds, normal B in 31 seconds, asystole in 13 seconds, tamponade in 14 seconds, acute MI in 22 seconds, and VF in 12 seconds. Inter-rater reliability between participants was extremely high, resulting in a kappa coefficient across all cases of 0.95.

Conclusion: EM residents can rapidly perform TEE studies in a simulated cardiac arrest environment with a high degree of precision and accuracy. Performance of TEE studies on human patients in cardiac arrest is the next logical step to determine if our simulation data hold true in clinical practice. [West J Emerg Med. 2017;18(5)830-834.]

INTRODUCTION

Emergency physicians (EP) routinely use transthoracic echocardiography (TTE) in the evaluation of critically ill patients, including those in cardiac arrest, to aid in diagnosis and guide therapy. Despite the diagnostic value of TTE, it is frequently limited by patient habitus, ongoing cardiopulmonary resuscitation (CPR) efforts, mechanical ventilation, and interference from monitoring equipment. Transesophageal echocardiography (TEE) is an established and accurate method of evaluating heart anatomy and function that, due to its indwelling location, is not affected by the common limitations associated with TTE. These characteristics have shown to be beneficial in cardiac arrest; by helping to identify causes and guiding CPR efforts.[1-4] TEE has many potential advantages over TTE for the patient in cardiac arrest, including the ability to image the heart in real time during active CPR. Furthermore, TEE has a well-established safety profile in the elective setting.[5] Yet despite these advantages, EPs have been slow to implement TEE in their practice.[6-7]

The ability to learn TEE skills on simulators has been demonstrated in a several specialties.[8-13] However, prior studies have not examined the ability of emergency medicine (EM) residents to acquire and retain TEE skills, nor have they demonstrated the ability of trainees to identify pathologies commonly seen during cardiac arrest. Thus, the following study was designed as a prospective, simulation-based study that aimed to evaluate the ability of EM residents to perform TEE. During the study, participants had to learn and retain TEE image-acquisition techniques and demonstrate those skills to diagnose common pathological conditions during simulation on a high-fidelity TEE model.

Population Health Research Capsule

What do we already know about this issue?
Transesophageal echocardiography is a technique that may provide superior diagnostic capabilities in cardiac arrest, but its use is limited.

What was the research question?
Can emergency medicine residents learn limited TEE views and diagnose common cardiac arrest pathologies in simulation?

What was the major finding of the study?
EM residents can rapidly perform TEE studies in a simulated cardiac arrest environment with high degree of precision and accuracy.

How does this improve population health?
Dissemination of this technique may facilitate further studies into its effect on cardiac arrest outcomes.

METHODS

This was a multicenter trial in which 40 EM resident physicians took part in a didactic- and simulation-based educational initiative that took place in four consecutive weekly sessions. Each session was 30 minutes in length and took place at the simulation center of each institution. An ultrasound (US) faculty member with a Registered Diagnostic Cardiac Sonographer certification and TEE experience taught each session. The institutional review boards of both institutions approved the study protocol.

Residents who were able to complete all four sessions were identified for inclusion. All residents had training in basic emergency bedside US and standard TTE imaging, a two-day introductory US course at a minimum, but they had varying levels of cardiac experience, as residents from all three post-graduate years of training were included. None had any prior TEE experience.

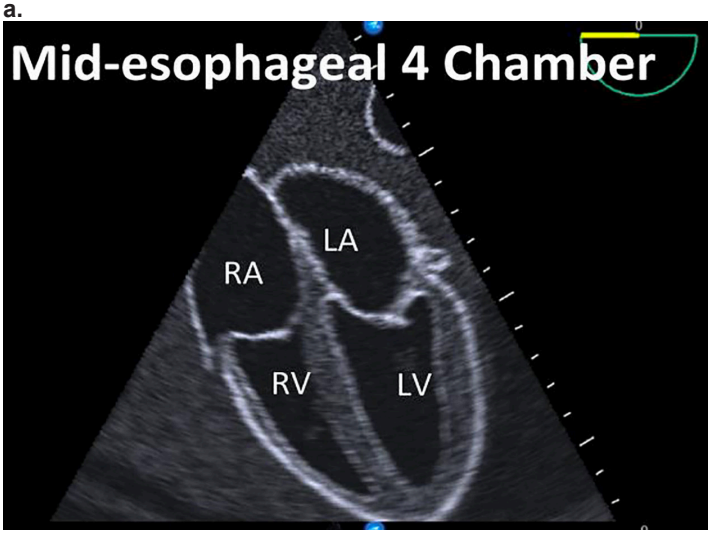
The first session included a 15-minute didactic lecture given by an EP with experience in TEE and outlined information on transesophageal US, including transducer manipulation, image acquisition, and emergency applications. Participants were taught a quick look two-view protocol including both the mid-esophageal four-chamber (ME4C) and the mid-esophageal two-chamber (ME2C) views (Figure).

After the didactic lecture, each resident was given instruction and a tutorial of the high-fidelity simulator and TEE probe (Vimedix, CAE Inc). Each participant was then instructed how to obtain both the mid-esophageal four- and two-chamber views and allowed to learn the controls of the TEE probe. Comparison anatomy to TTE was provided to the participants to aid in knowledge retention.

The study participants were then brought back for a second and third session in two subsequent consecutive weeks, and engaged in proctored image acquisition of pre-determined pathology. Each participant was required to insert the probe, obtain each of the required two views and then name the pathology to the instructor. This process was repeated with multiple pathologies, including cardiac tamponade, asystole, acute myocardial infarction MI (severely diminished ejection fraction, regional wall motion abnormalities), fine ventricular fibrillation (VF), and normal images.

Assessment was performed during the fourth and final session. Each participant was individually tested to determine his/her ability to quickly perform the required views and make the critical diagnosis. They were instructed to insert the probe and obtain a four-chamber view, a two-chamber view and identify the

a.



b.

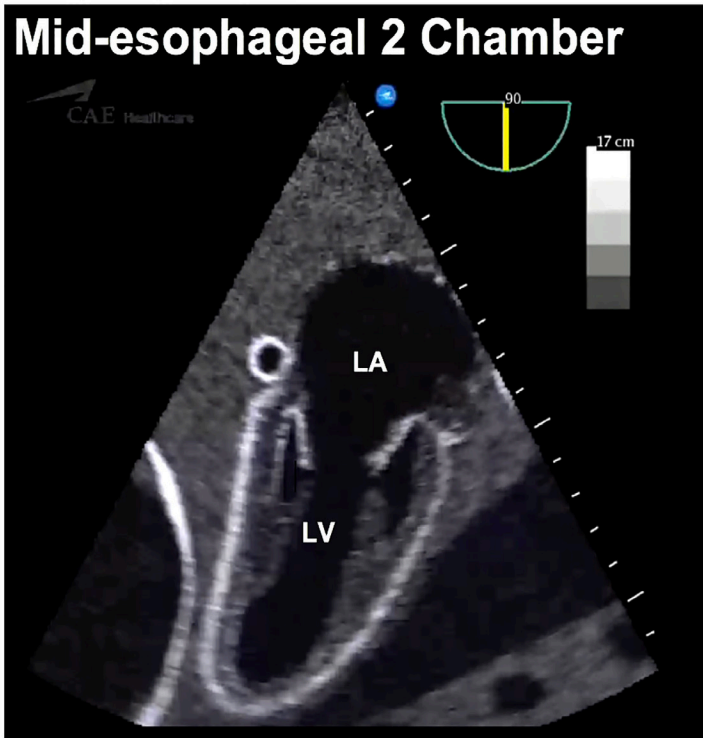


Figure ab. Simulator images of the quick look two-view protocol for transesophageal echocardiography
RA, right atrium; *LA*, left atrium; *RV*, right ventricle; *LV*, left ventricle.

pathology if any was present. Time started from the beginning of probe insertion and concluded after all the above criteria were met. Probe insertion time was a minimal component to the overall elapsed time of the procedure. No questions or clarification were allowed, and no help in obtaining the images was provided. Additionally, access to the simulator was restricted to the practice and testing sessions only, with no additional training provided.

We entered data directly into a study-specific spreadsheet. The spreadsheet recorded time to diagnosis, quality of images, and correct diagnosis. We summarized descriptive statistics using means and standard deviations (SD). Inter-rater reliability was estimated using a kappa (k) statistics, with k = 0.61–0.80 interpreted as "good agreement" and k > 0.80 interpreted as "very good agreement."

RESULTS

Forty EM residents from two different academic medical centers completed four consecutive weekly sessions, three for training and one for testing. They represented all three post-graduate years of EM training (Table 1).

After three consecutive weekly education sessions, testing was performed. During testing, six simulated cardiac arrest cases were presented in random order: asystole, cardiac tamponade, VF, acute MI, and two normal cases.

For each simulated cardiac arrest case, subjects were evaluated on the time to obtain both ME4C and ME2C views and the ability to correctly diagnose pathology. This resulted in 80 normal TEE studies and 160 pathologic TEE studies, for 240 total studies. In all cases, the subjects were able to insert the TEE probe into the simulator and successfully obtain both views, resulting in 100% success rate for both.

Our calculations for the ability to diagnose the cardiac pathology encountered in this simulation study by EM residents resulted in a cumulative sensitivity of 98% (95% confidence interval [CI] [95-99%]), specificity of 99% (96%-100%), positive likelihood ratio of 78.0 (11.1-547.1), and negative likelihood ratio 0.025 (0.009-0.067) (Table 2).

The sensitivity per pathology was as follows: asystole 100% (95% CI, [100-100%]), tamponade 98% (93-100%), VF 98% (93-100%), acute MI 95% (88-100%). The average time to diagnose each objective structured clinical examination case was normal in 31 sec ± 15 (SD); asystole in 11 ± 5.5; tamponade in 14 sec ± 8; acute MI in 21 sec ± 10; and VF in 12 sec ± 4.4**.** This included time for probe insertion, time to obtain both views, and time to make the interpretation. Inter-rater reliability between EPs was extremely high, resulting in a k coefficient across all cases of 0.95.

DISCUSSION

TEE is a well-established diagnostic modality whose usefulness is now being explored by EPs in the care of critically ill patients and those in cardiac arrest. It has the potential to eliminate many of the barriers commonly associated with TTE in that setting, while providing higher quality diagnostic images and simultaneously allowing external interventions such as CPR. As such, there has been a push towards further dissemination of these skills to more EPs.[6,9] The use of TEE simulators has recently been demonstrated to be an effective method of training in multiple fields including EM, cardiology and cardiac anesthesia, all for users without prior exposure to TEE.[8-13] In

Table 1. Training year and institution distribution of emergency medicine residents who participated in a transesophageal echocardiography simulation study.

	Virginia Commonwealth University	Eastern Virginia Medical School
PGY1	6	6
PGY2	5	8
PGY3	7	8

PGY, post-graduate year.

contrast to prior studies that have focused on attending- and fellow-level learners, this study demonstrated that after a series of brief training sessions, EM residents can easily and routinely obtain two TEE views, the mid-esophageal four chamber and mid-esophageal two chamber. Furthermore, this study has shown that they can identify four pathologic conditions causing cardiac arrest in a simulated environment with a high degree of sensitivity and specificity.

All study participants were successful in obtaining both mid-esophageal four- and two-chamber views. These views were selected because they are easy to obtain and require little manipulation of the probe. They also provide images that are easily comparable to TTE images, thus allowing quick recognition of structures and pathology. The high success rate is likely because of the minimal probe manipulation required to obtain these views and is in keeping with a prior TEE simulation study.[9] In contrast to Arntfield et al., we did not ask participants to obtain more technically difficult gastric views, as these require more probe manipulation and time, and would be unlikely to provide any further discriminating information in the setting of real or simulated cardiac arrest. This is supported by an observational review, which noted that TEE had diagnostic influence in 78% of cases, during which a ME4 view was obtained 96% of the time, with all other views to a uniformly lesser degree.[6]

There were study participants from all three post-graduate years who completed the full study protocol, with varying levels of experience in echocardiography. Despite that, after just three brief training sessions, they were able to easily obtain two routine TEE views and identify common pathologic conditions in cardiac arrest with great success and high inter-rater reliability. This is the first study to evaluate the ability of EM residents to perform TEE, and shows that it can be easily taught and retained in the simulated setting. While this study should be repeated in the live patient, it may help to disprove one barrier to the more widespread practice of this modality, which is that limited two-view TEE is a difficult skill to learn.

LIMITATIONS

One of the limitations of this study is that it was a simulation-based training and testing protocol. Despite the use of a high-fidelity simulator, the study is subject to the limitations inherent within this paradigm. Specifically, in this study participants were asked to accurately diagnose pathologies during the testing phase that they had previously seen during training. On the simulator, this means the identical cases or images were used. While pattern recognition plays an important role in the practice of medicine, the simulator is not able to present the variability that would be seen in real-world cases, which may therefore result in an upward skew of the sensitivity and specificity.

Another limitation involves the translation of haptic skills between probe insertion and manipulation on a simulator model versus the live patient. It is inherently easier on the simulator, which may result in increased success rate with obtaining the required views of this protocol. Lastly, the EM residents who completed this voluntary study may be more experienced, motivated learners than those who did not complete all the study sessions. This may have resulted in increased sensitivity and specificity, and perhaps less generalizability to the general resident population.

CONCLUSION

After a series of brief teaching sessions, EM residents with varying levels of experience in echocardiography were able to uniformly obtain two standard TEE views and diagnose common pathologic conditions in simulated cardiac arrest with a high degree of sensitivity, specificity, and inter-rater reliability. This is the first study to evaluate the diagnostic abilities of physicians using TEE in a simulated cardiac arrest setting, and the first to evaluate the ability of EM residents to learn TEE skills. Further research efforts are needed to determine if the success of this study can be repeated in the in-vivo setting, and if the diagnostic benefits translate to improvements in survival.

Table 2. Cumulative sensitivity, specificity, positive and negative likelihood ratios for transesophageal echocardiography during simulated cardiac arrests, across all pathology.

	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR- (95% CI)
All cases	0.98 (0.95-0.99)	0.99 (0.96-1.00)	78.0 (11.1-547.1)	0.025 (0.009-0.067)

CI, confidence interval.

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Increased Computed Tomography Utilization in the Emergency Department and Its Association with Hospital Admission

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Introduction: Our goal was to investigate trends in computed tomography (CT) utilization in emergency departments (EDs) and its association with hospitalization.

Methods: We conducted an analysis of an administrative claims database of U.S. privately insured and Medicare Advantage enrollees. We identified ED visits from 2005 through 2013 and assessed for CT use, associated factors, and hospitalization after CT, along with patient demographics. We used both descriptive methods and regression models adjusted for year, age, sex, race, geographic region, and Hwang comorbidity score to explore associations among CT use, year, demographic characteristics, and hospitalization.

Results: We identified 33,144,233 ED visits; 5,901,603 (17.8%) involved CT. Over time, CT use during ED visits increased 59.9%. CT use increased in all age groups but decreased in children since 2010. In propensity-matching analysis, odds of hospitalization increased with age, comorbidities, male sex, and CT use (odds ratio, 2.38). Odds of hospitalization over time decreased more quickly for patients with CT.

Conclusion: CT utilization in the ED has increased significantly from 2005 through 2013. For children, CT use after 2010 decreased, indicating caution about CT use. Male sex, older age, and higher number of comorbidities were predictors of CT in the ED. Over time, odds of hospitalization decreased more quickly for patients with CT. [West J Emerg Med. 2017;18(5)835-845.]

INTRODUCTION

Computed tomography (CT) is both screening tool and diagnostic tool, with widespread application for evaluation of numerous conditions and diagnosis of complex medical problems.[1-3] CT utilization has increased in the emergency department (ED) in the United States and Canada[4] without a corresponding change in diagnostic yield[5] and with disproportion to growth in ED patient volume.[6] These findings may suggest that incremental CT use is of lower value.[7] The availability of CT scanners may have created a supply-induced demand, which may contribute to increased use and variability in practice without a corresponding increase in quality of care.[8,9]

A recent study reports that overall utilization rates were stable for all types of CT across a 10-year period;[10] however, CT use in the ED increased by more than 80% and decreased by nearly 10% in primary care. That CT use has increased in

the ED suggests that EDs are becoming diagnostic centers.[10] The increased use of ED-based imaging may be related to easy access to imaging and radiology services and to expedited care compared with a clinic setting. In the ambulatory setting, imaging use might be decreasing secondary to factors such as implementation of cost-saving strategies and scrutiny of the appropriateness of use.[11]

Several studies have shown variation among ordering patterns of emergency physicians regarding all CT types and a substantial increase in CT use in the pediatric population.[12] As the technical quality and speed have improved in medical imaging, clinical decisions have relied increasingly on CT and other imaging techniques.[7] However, the relationship between CT and hospital admission has not been well studied. We aimed to examine trends of CT use in the ED, investigate causes of varied CT utilization, and evaluate the association between CT use and hospital admission among ED patients.

Population Health Research Capsule

What do we already know about this issue?
Computed tomography utilization in the ED has increased without a corresponding change in diagnostic yield and with disproportion to growth in ED patient volume.

What was the research question?
Investigate trends in CT utilization in the EDs and its association with hospital admission using administrative claims.

What was the major finding of the study?
CT use increased in all age groups but decreased in children since 2010. Hospitalization was associated with increasing age, comorbidities, male sex, and CT use. Odds of hospitalization over time decreased more quickly for patients with CT.

How does this improve population health?
CT utilization in the ED has increased significantly from 2005 through 2013. For children, CT use after 2010 decreased, indicating caution about CT use. Over time, odds of hospitalization decreased more quickly for patients with CT, suggesting a diagnostic hub role for emergency departments.

METHODS

Study Design and Setting

We assessed administrative claims data from OptumLabs, a database including privately insured and Medicare Advantage enrollees throughout the U S.[13] The database has longitudinal health information of more than 100 million enrollees of the past 20 years from geographically diverse regions, with the South and Midwest represented the most.[14] A subset of enrollees has insurance plans that provide full coverage for professional (e.g., physician), facility (e.g., hospital), and outpatient prescription medication services. Medical claims for professional and facility services include *International Classification of Diseases*, *Ninth Revision, Clinical Modification* (*ICD-9-CM*), diagnosis codes; *ICD-9-CM* procedure codes; *Current Procedural Terminology, Fourth Edition*, (CPT-4) procedure codes; Healthcare Common Procedure Coding System procedure codes; site of service codes; and provider specialty codes. We accessed study data using techniques compliant with the Health Insurance Portability and Accountability Act of 1996. Because this study involved analysis of preexisting, de-identified data, it was exempt from institutional review board approval. This study adheres to the Reporting of Studies Conducted Using Observational Routinely Collected Health Data statement (RECORD).[15]

Selection of Participants

All patients who presented to an ED from 2005 through 2013 were identified. We assessed changes in CT use over time, associated factors, and disposition after CT use among patients of all ages. Patients were required to have six months of continuous enrollment before their index ED visit dates.

Data Collection

The demographic variables collected were birth year, sex, and race. We grouped age into six categories: <18, 18 to 34, 35 to 49, 50 to 64, 65 to 79, and >79 years. Race was grouped into White, Black, Hispanic, Asian, and "other." CT procedures were extracted using standardized CPT-4 codes.

We categorized CT into the body regions *head*, *chest*, *abdomen*, and *other*. Abdominal CT included imaging of the abdomen solely and of the abdomen and pelvis. Scans grouped as *other* included various, relatively uncommon CT evaluations of spine, extremities, neck, and sinuses. To decrease the risk of overestimating utilization of CT, we collapsed multiple procedures for the same body region performed on the same day into one CT event. CT performed for hospitalized patients was not included.

The primary diagnosis from each CT scan was taken using diagnosis codes from administrative claims data and with clinical classification software (CCS) created by the Agency for Healthcare Research and Quality (AHRQ) to organize these diagnoses into diagnostic categories. The outcomes of interest for the study were CT performed in the ED and its relationship with hospital admission. Patients admitted under observation status or placed in an observation unit did not count as in-patient stays.

Statistical Analysis

We calculated utilization rates per 1,000 ED visits across groups defined by baseline characteristics. Overall CT utilization trends were examined by patient age and sex, U.S. region, year, and CT body area. We reported rates of hospital admission of patients who received and did not receive a CT as risk ratios (RR) with 95% confidence intervals (CI).

We also estimated adjusted models by year, age, sex, race, U.S. region, and Hwang comorbidity score and explored associations among CT use, year, patient demographic characteristics, and hospitalization. Main outcomes were presented as adjusted odds ratio (OR) with 95% CI.

Patient Matching

To control for the effect of baseline differences among patients with and without CT, we used both propensity-score matching and exact matching to create two cohorts of similar people with and without the exposure (CT in the ED). The propensity score is the conditional probability of a patient receiving a particular exposure—in this case, initial CT exposure—given a set of potential confounders. To calculate propensity scores, we included the confounders in a logistic regression model to predict exposure without including outcome.[16,17] Patients with the same propensity score have the same adjusted probability of receiving CT, though some ultimately received a CT while others did not.

The propensity score was estimated using logistic regression. We matched by age, sex, race, number of comorbidities (baseline Hwang comorbidity score), U.S. region, race, year of ED visit, Berenson-Eggers Type of Service indicators and exact match on diagnosis group. To check the balancing properties of the propensity score, we compared standardized differences in patient characteristics before and after propensity-score matching[18] (Appendix Figure 1).

To ensure that matched patients were being seen in the ED for similar reasons, we determined the Hierarchical Condition Category [HCC] from AHRQ's CCS for the primary diagnosis for ED visit. This classification system categorizes all *International Classification of Diseases, 9th Revision, Clinical Modification* (I*CD-9-CM*) diagnosis into a limited number of categories or diagnosis groups. Finally, we further controlled for baseline differences by matching exactly on age, sex, primary diagnosis HCC, and baseline Hwang comorbidity score. As a result, each person who received a CT in the ED is matched to a person of the same age, sex, primary diagnosis HCC, and baseline Hwang score, and with a propensity score for CT use within nearest neighbor with a 1:1 ratio, which additionally accounts for patient race, visit year, types of services received in the ED, and region of the U.S.

We conducted analyses with SAS software version 9.3 (SAS Institute Inc), and Stata version 14 (StataCorp LP). Statistical significance was set at *P* less than 0.05 for modeling.

RESULTS

Trends in CT Use over Time

Of the identified 33,144,233 ED visits, 5,901,603 (17.8%) had a CT associated with the visit. Total ED visits increased over time from 3,079,601 in 2005 to 4,324,993 in 2013 (a 40.4% increase). CT use during ED visits increased 59.9%, from 153.0 CTs per 1,000 visits in 2005 to 245.1 per 1,000 in 2013.

Over time, female and male patients underwent CT at similar rates (151.7 and 154.6 per 1,000 ED visits in 2005 vs 245.3 and 244.9 in 2013, respectively) (Table 1). CT use increased in all age groups; the greatest growth occurred in the older population (45.2% increase in patients aged 65 to 79 years and 47.3% increase in those older than 79 years). In the pediatric population, CT exposure peaked in 2010 at 85.2 scans per 1,000 visits and decreased to 72.7 per 1,000 visits in 2013.

Patients with more comorbidities as measured with Hwang comorbidity score had greater increases in CT rates over time, with CT use increasing 36.9% for a 0 score and 45.7% for a score of 5 or higher. Those with Hwang score of 0 had a CT rate of 132.5 compared with 385.3 for those with a Hwang score of 5 or higher (Table 1 and Figure 1).

Trends in Hospital Admission

The rate of hospital admission increased 21.6% in the same period, going from 119.1 per 1,000 ED visits in 2005 to 144.8 per 1,000 ED visits in 2013. Overall, patients who received CT in the ED were more likely to be admitted to the hospital than those who did not receive it in 2005 (unadjusted RR [95% CI], 2.90 [2.88-2.91]) vs 2013 (unadjusted RR [95% CI], 2.29 [2.28-2.30]) (Table 1, Figure 2). Younger patients who had CT in the ED were less likely to be admitted to the hospital, with a 26.52% decrease in hospital admission for patients younger than 18 years and an 8.40% decrease for patients aged 18 to 34 years. CT in the ED was associated with increased admission rates in patients older than 50 years from 2005 to 2013. Male patients were more likely to be admitted to the hospital than female patients (from 123.3 to 154.7 vs 115.6 to 137.0 per 1,000 ED visits in 2005 and 2013, respectively). Patients with a Hwang comorbidity score of 0 or 1 were less likely to be admitted to the hospital after CT.

Matched Cohort Trends of CT Use

We performed propensity matching to evaluate the relationship between CT use and hospital admission. In total, 2,119,962 pairs were matched by age group, sex, race, U.S. census region, number of comorbidities, year of ED visit, baseline Hwang comorbidity score, and exact match on diagnosis group (Appendix Table 1). We used standardized differences to evaluate how effectively the propensity score balanced the matched cohorts. All variables were within the 10% threshold, showing that matching achieved balance across the groups (Appendix Figure 1).

Similarly to the trend analyses, the matched cohort

Table 1. Trends of CT use in the ED and relationship with hospital admission, 2005-2013.

Patient characteristic	Rate Per 1,000 ED visits by year									% Change over time
	2005 (Reference)	2006	2007	2008	2009	2010	2011	2012	2013	
Hwang comorbidity score, CT obtained										
0	96.79	104.01	111.35	116.88	125.00	131.72	130.80	130.59	132.54	36.93
1	148.37	158.36	168.83	175.38	184.97	194.27	194.62	194.10	198.27	33.63
2	178.91	192.85	205.39	211.80	224.52	235.54	235.67	235.24	242.57	35.58
3	207.20	217.90	234.23	244.53	257.66	268.35	270.41	273.26	281.90	36.06
4	226.71	240.93	260.42	267.92	285.87	296.86	302.36	304.50	317.36	39.98
≥5	264.45	282.87	303.34	317.76	338.74	349.88	358.74	368.35	385.26	45.68
Hwang comorbidity score, CT obtained and patients admitted										
0	14.74	15.49	15.55	15.44	15.28	15.95	15.01	13.95	13.86	−6.00
1	31.76	32.52	32.75	32.12	33.01	34.49	32.58	31.59	30.81	−2.98
2	49.41	51.51	51.92	51.66	52.49	55.34	53.40	50.92	51.88	5.00
3	69.58	70.99	73.02	73.43	74.94	78.99	76.52	73.93	74.79	7.49
4	89.12	92.44	96.12	94.32	99.20	102.91	100.20	98.80	100.58	12.85
≥5	136.86	143.53	148.18	153.59	161.77	167.18	167.23	171.55	174.64	27.60
Sex, CT obtained										
Female	151.65	164.95	180.33	190.61	209.50	225.75	229.39	234.29	245.30	61.75
Male	154.63	167.38	182.31	192.81	209.50	225.68	229.34	234.02	244.86	58.35
Sex, CT obtained and patients admitted										
Female	42.86	46.02	49.46	51.43	57.17	64.04	63.73	64.83	67.29	57.02
Male	47.74	51.60	55.02	57.85	64.10	71.89	71.55	73.39	77.02	61.31
Age, y, CT obtained										
<18	67.95	72.91	77.36	78.96	83.31	85.21	79.96	75.55	72.71	7.00
18-34	135.47	145.95	156.38	162.08	170.89	177.95	176.24	175.43	176.00	29.91
35-49	176.04	189.49	202.69	213.27	229.00	237.75	238.44	238.29	244.74	39.03
50-64	209.93	224.96	241.96	253.68	274.15	283.44	288.72	291.72	302.35	44.03
65-79	251.40	265.12	287.23	300.70	322.81	332.78	342.03	349.34	365.08	45.22
>79	305.43	321.80	351.03	373.29	399.95	409.62	420.07	433.25	450.00	47.33

CT, computed tomography; *ED*, emergency department.

Table1. Continued.

Patient characteristic	Rate Per 1,000 ED visits by year									% Change over time
	2005 (Reference)	2006	2007	2008	2009	2010	2011	2012	2013	
Age, y, CT obtained and patients admitted										
<18	12.30	12.52	12.38	12.38	11.35	11.90	10.73	9.50	9.04	−26.52
18-34	25.74	26.96	27.18	26.65	27.08	27.41	25.90	23.94	23.58	−8.40
35-49	43.89	46.21	47.24	47.72	49.29	50.60	47.06	44.88	44.08	0.45
50-64	76.06	80.23	83.18	84.40	89.94	92.64	90.79	87.65	88.43	16.27
65-79	124.50	130.88	135.39	141.08	149.25	151.30	150.73	154.09	155.57	24.96
>79	176.13	178.91	186.03	196.83	206.71	209.00	208.72	217.29	217.76	23.64

CT, computed tomography; *ED*, emergency department.

analysis found that overall, the rates of hospital admission increased with increasing age for patients older than 50 years (OR, 1.20 for age 50-64 years; 1.74 for 65-79 years; and 2.36 for >79 years), male sex (OR, 1.15), and increasing Hwang comorbidity score (OR, 3.34 for a score of 2; 5.15 for 4; and 7.25 for ≥5) Table 2. Among body areas, CT of the head and abdomen were the most common. CT for all types of body areas has increased over time (Appendix Figure 2).

Propensity-Matched Cohort Hospital Admission

Overall CT utilization in the ED increased over time, and the odds of being admitted to the hospital decreased. Among patients with CT, the odds of hospital admission decreased each year of the study (Figure 2), with a 42% decrease from 2005 through 2013. When evaluating the change in OR over time and determining the interaction between CT and year, we found that the rate of change over the years was significantly different for patients who received CT vs. those who did not ($P<0.001$). The odds of admission decreased faster among patients with CT than those without CT. The absolute decrease in the odds of hospital admission was greater among patients who had CT than those who did not.

DISCUSSION

In this study of CT use trends in the ED, healthcare delivery variation and its association with hospital admission rates, we found that CT during ED visits increased almost 60% from 2005 to 2013. Overall, CT use increased in all age groups and particularly in the oldest population (>79 years). However, a slight decline in CT use was found among the pediatric age group (<18 years) after 2010, perhaps secondary to the widespread adoption of pediatric clinical decision rules.[19]

Patients with CT performed in the ED were more likely to be admitted to the hospital. However, over the nine years, the ratio of admission among those with CT decreased faster than among those without CT during the ED visit, possibly indicating that CT is used both for diagnostic and risk stratification and guides admission decisions.

Patients with a major procedure, endoscopy or dialysis or who needed anesthesia on the date of the ED visit were more likely to have CT and be admitted to the hospital. This outcome probably suggests a strong relationship between disease complexity and CT utilization. This decrease in admission rates may be secondary to the increase in use of observation services and admission under observation status and not to a real decrease in the number of patients hospitalized.[20,21]

EDs increasingly support primary care providers through their complex diagnostic work-ups that cannot be performed in physician offices. EDs also augment primary care providers by managing case overflow, after-hours cases, and weekend demand for medical care.[22] In some cases, CT allows clinicians to avoid a hospital admission by providing the information necessary to make a definitive diagnosis.[23] By 2010, nearly one-half of ED visits included at least one

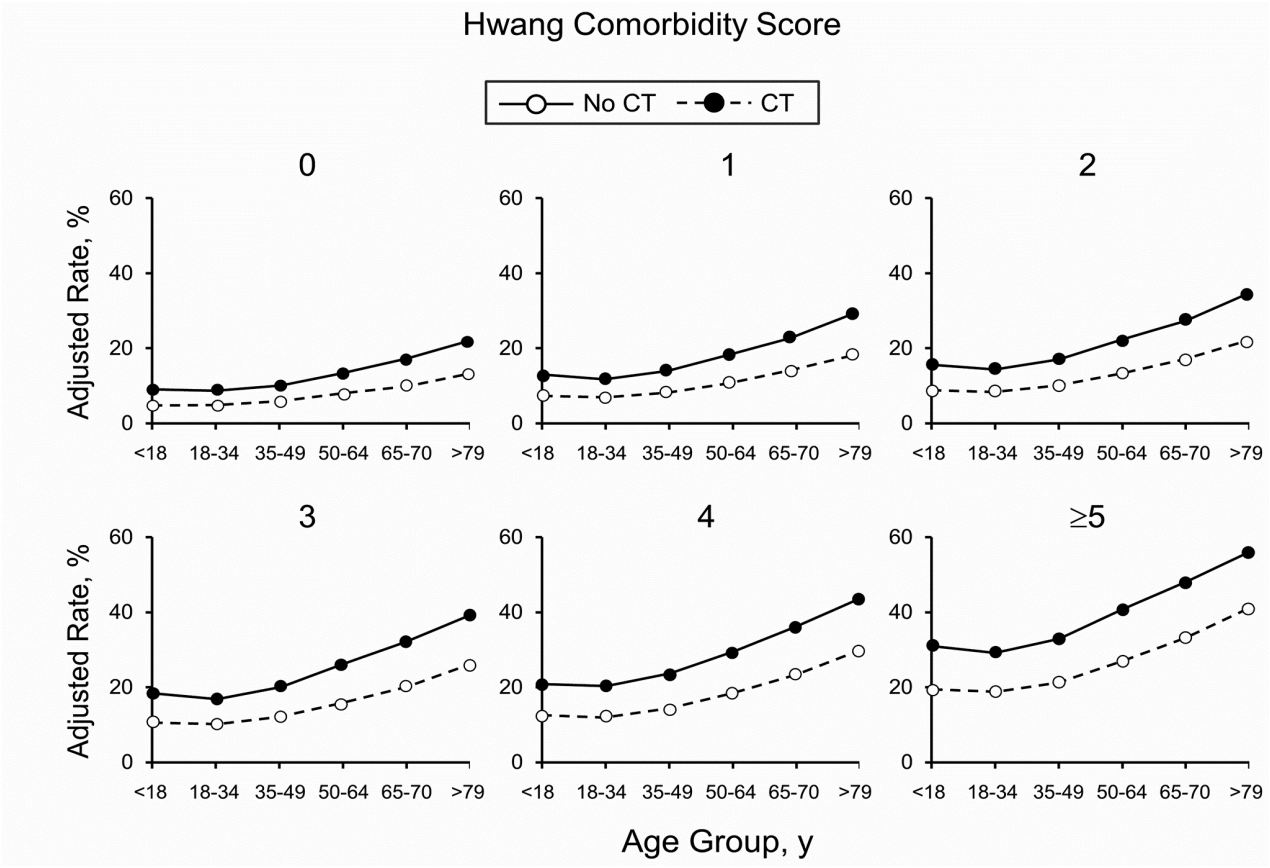

Figure 1. Rates of admission to the hospital by patient comorbidities (Hwang comorbidity score). Age and CT performed in the emergency department among the matched cohort.

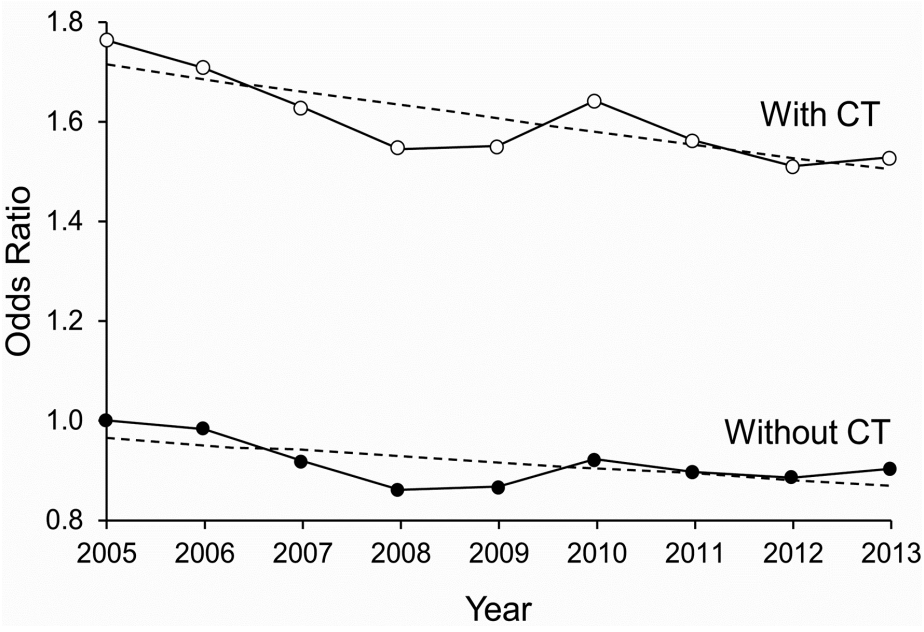

Figure 2. Odds of admission to the hospital associated with CT performed in the emergency department over time.

imaging test,[24-29] influenced by increased fear of malpractice litigation and patients' expectations.[29-35]

The news media, policymakers, patients, and healthcare providers have called CT utilization into question[23,36,37] because diagnostic imaging is considered one of the key drivers of increasing healthcare cost in the U.S.[38] One study reported that use of abdominal CT was associated with decreased revisits,[39] but other studies have suggested that outcomes are not necessarily improved with more imaging.[40-44] The prevalence of over-testing, over-diagnosing, and over-treating has been criticized in modern medicine. Emergency physicians on a survey reported use of unnecessary testing in EDs, and 97% reported that at least "some" advanced imaging that they personally order is medically unnecessary.[45]

Attempts to reduce the cost of diagnostic imaging procedures in the past decade have been either reducing payments per procedure[46] or imposing more thoughtful decisions about healthcare delivery, such as the Choosing Wisely initiative.[47] Analyzing trends in utilization helps healthcare systems understand whether these attempts were successful and identify gaps that should be addressed.

With the aging of the population and the increased use of EDs, the likelihood of CT performed in the ED is increasing. Variations on CT use have been associated with patient characteristics (i.e., age, race, insurance status, sex, and diagnoses)[48] and associated less with hospital characteristics (e.g., number of beds, hospital teaching status). Understanding variations in CT utilization can help identify underuse and overuse, both of which may be costly and negatively affect healthcare quality.[3,48,49]

A study by Horný, Burgess, and Cohen[50] from 2011 to 2013 showed that visits resulting in CT decreased over time, and diagnostic ultrasonography increased at a higher rate than the decrease in CT use. In our cohort of the present study, the pediatric population had a decrease in CT use since 2010. The awareness of providers and patients regarding radiation exposure-induced malignancies may have influenced the decreased CT use, as well as robust and validated decision rules.[19,51-53]

Imaging increases ED length of stay and poses a risk of misreading the imaging result and incidental findings.[54-57] The latter can lead to increased utilization from downstream testing that may be unnecessary. Morris et al[14] recently showed that CT coronary angiography in the ED was associated with increased downstream healthcare utilization, repeat testing, hospitalization, return ED visits, and later invasive procedures, such as coronary angiography and stent placement, compared with functional stress testing. This increase in downstream utilization could be due to suboptimal patient selection, unclear physiologic significance of coronary lesions identified on CT, or lack of standardization regarding how to best manage cases on the basis of the degree of coronary stenosis identified.

In the present cohort of privately insured and Medicare Advantage patients, CT utilization increased over the study period. Patients with CT in the ED had decreasing hospital admission rates over time at a higher rate than those without CT. This observation might indicate that CT is able to identify patients who can benefit from inpatient admission, and it appears to be a diagnostic tool to aid in determining appropriate disposition and risk assessment. This finding may be particularly relevant to patients who require major procedures and those with complex clinical presentations (e.g., elderly persons, patients with multiple chronic medical conditions).

LIMITATIONS

Administrative claims data are susceptible to coding errors, and problems like undercoding comorbidities or miscoding diagnoses are possible. Each individual claim may not include all of a patient's diagnoses, resulting in underreporting of comorbidities. To mitigate this limitation, we restricted the analysis to patients with at least six months of continuous enrollment before the ED visit, which increases the number of claims on which we base our comorbidity calculation. Second, despite use of propensity matching, there is potentially unmeasured confounding between the groups. In our propensity score, we included all available potential confounders and obtained propensity scores with a standardized difference of less than 0.1 for the covariates. Models that automatically select the variables to calculate the propensity score can reduce bias relative to models that use only a predefined group of variables.[58] Therefore, we supplemented a defined set of a priori confounders with additional covariates for all medical conditions and demographic characteristics.[59-61]

Third, we did not have access to data from uninsured or Medicaid patients. This is a potential source of bias, as it is possible that CT ordering patterns differ in these populations. Fourth, the need for CT and hospital admission might be markers of the severity of the underlying illness. To account for these differences, we adjusted data using the Hwang comorbidity score and matched for ED diagnosis. However, we acknowledge that comorbidities are only part of the severity of illness. We did not evaluate whether CT utilization translated into increased downstream healthcare utilization, including critical care unit use, surgery or procedures, and death.

Another limitation is the possibility that some patients were hospitalized for "observation stays" or placed in an observation unit, and despite occurring in the hospital, observation stays do not count as inpatient stays. This might result in increased rates of outpatient visits with CT use that did not result in hospitalization.

Future Directions

With the increase in the adoption of electronic health records, there has been an increase in the amount of data available for the study of ED imaging. Multicenter data sets are now available to investigators.[62] Overuse, underuse, and misuse of healthcare services affect the quality and cost of care. There are estimates that up to one-third of all U.S. healthcare spending produces

Table 2. Odds ratios of hospital admission among 2,119,962 patients with and without CT in the propensity-matched cohort

	CT	No CT
Characteristic	Odds ratio (95% CI)[a]	Odds ratio (95% CI)[a]
Age, y		
<18	Reference	Reference
18-34	0.94 (0.929-0.962)	0.87 (0.853-0.895)
35-49	1.11 (1.089-1.127)	1.11 (1.083-1.135)
50-64	1.50 (1.473-1.525)	1.52 (1.483-1.554)
65-79	2.30 (2.250-2.344)	2.29 (2.233-2.354)
>79	2.95 (2.890-3.016)	3.26 (3.171-3.345)
Sex		
Female	Reference	Reference
Male	1.19 (1.179-1.197)	1.19 (1.179-1.201)
Race		
White	Reference	Reference
Asian	1.08 (1.055-1.112)	1.10 (1.068-1.139)
Black	1.00 (0.981-1.009)	0.96 (0.942-0.973)
Hispanic	1.05 (1.033-1.063)	1.07 (1.049-1.087)
CCS Group No. on ED visit	1.02 (1.017-1.018)	1.02 (1.017-1.017)
Year of ED visit		
2005	Reference	Reference
2006	0.94 (0.921-0.953)	0.96 (0.939-0.978)
2007	0.85 (0.833-0.862)	0.85 (0.831-0.866)
2008	0.77 (0.759-0.786)	0.76 (0.742-0.774)
2009	0.75 (0.736-0.761)	0.73 (0.715-0.745)
2010	0.73 (0.714-0.739)	0.70 (0.687-0.715)
2011	0.67 (0.657-0.679)	0.65 (0.640-0.666)
2012	0.61 (0.602-0.622)	0.61 (0.603-0.627)
2013	0.58 (0.569-0.587)	0.58 (0.569-0.592)
Hwang comorbidity score		
0	Reference	Reference
1	1.52 (1.504-1.544)	1.58 (1.556-1.612)
2	2.05 (2.017-2.075)	2.25 (2.206-2.289)
3	2.54 (2.506-2.583)	2.89 (2.837-2.950)
4	2.98 (2.933-3.033)	3.48 (3.410-3.555)
³5	3.86 (3.801-3.921)	4.61 (4.519-4.701)
BETOS indicators during ED visit		
Anesthesia use	6.54 (6.358-6.732)	6.77 (6.547-6.991)
Major procedure	6.23 (6.036-6.440)	4.31 (4.175-4.455)
Ambulatory visit	1.92 (1.877-1.967)	0.03 (1.802-1.913)
Minor procedure	0.44 (0.433-0.446)	0.33 (0.325-0.338)
Oncology	1.14 (1.006-1.294)	1.12 (0.971-1.292)
Endoscopy	1.25 (1.203-1.305)	1.18 (1.132-1.240)

BETOS, Berenson-Eggers Type of Service; *CCS*, Agency for Healthcare Research and Quality's clinical classification software; *CT*, computed tomography; ED, emergency department.
[a] All P<.001.

Table 2. Continued.

Characteristic	CT	No CT
	Odds ratio (95% CI)[a]	Odds ratio (95% CI)[a]
Dialysis procedure	1.60 (1.367-1.879)	1.24 (1.059-1.452)
Laboratory test	0.69 (0.681-0.694)	0.76 (0.751-0.767)
Other test	1.56 (1.547-1.572)	2.04 (2.021-2.060)
Echocardiography	2.45 (2.426-2.484)	2.69 (2.655-2.725)

BETOS, Berenson-Eggers Type of Service; *CCS*, Agency for Healthcare Research and Quality's clinical classification software; *CT*, computed tomography; ED, emergency department.
[a] All P<.001.

no benefit to the patient and some results in harm,[63] with approximately $600 billion of avoidable cost to the healthcare system each year.[42,62]

Of paramount importance is assessment of patterns of healthcare utilization and effects on practice, with naturalistic understanding of the clinical behaviors of providers. It appears that CT utilization is driven in part not by a diagnostic goal but by a risk-stratification and disposition goal defined by EDs that function as diagnostic and imaging centers. Implementing evidence-based decision supports and aids to increase the understanding of providers' behavior (e.g., Pediatric Head CT rule)[19] are promising approaches for future interventions to decrease CT overuse and radiation exposure, increase practice efficiency, and decrease healthcare costs for patients being considered for CT.

CONCLUSION

CT utilization in the ED has significantly increased during 2005 through 2013, for which an increasing comorbidity number, male sex, and older age were predictors of CT use. Having CT in the ED increased the odds of hospital admission. Over time, patients who had CT in the ED decreased their admission rates at a faster pace than those without CT, particularly patients with high acuity and complex clinical presentations.

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Factors Influencing Participation in Clinical Trials: Emergency Medicine vs. Other Specialties

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Introduction: This study investigated factors that influence emergency medicine (EM) patients' decisions to participate in clinical trials and whether the impact of these factors differs from those of other medical specialties.

Methods: A survey was distributed in EM, family medicine (FM), infectious disease (ID), and obstetrics/gynecology (OB/GYN) outpatient waiting areas. Eligibility criteria included those who were 18 years of age or older, active patients on the day of the survey, and able to complete the survey without assistance. We used the Kruskal-Wallis test and ordinal logistic regression analyses to identify differences in participants' responses.

Results: A total of 2,893 eligible subjects were approached, and we included 1,841 surveys in the final analysis. Statistically significant differences ($p \leq 0.009$) were found for eight of the ten motivating factors between EM and one or more of the other specialties. Regardless of a patient's gender, race, and education, the relationship with their doctor was more motivating to patients seen in other specialties than to EM patients (FM [odds ratio {OR}:1.752, 95% confidence interval {CI}{1.285-2.389}], ID [OR:3.281, 95% CI{2.293-4.695}], and OB/GYN [OR:2.408, 95% CI{1.741-3.330}]). EM's rankings of "how well the research was explained" and whether "the knowledge learned would benefit others" as their top two motivating factors were similar across other specialties. All nine barriers showed statistically significant differences ($p \leq 0.008$) between EM and one or more other specialties. Participants from all specialties indicated "risk of unknown side effects" as their strongest barrier. Regardless of the patients' race, "time commitment" was considered to be more of a barrier to other specialties when compared to EM (FM [OR:1.613, 95% CI{1.218-2.136}], ID [OR:1.340, 95% CI{1.006-1.784}], or OB/GYN [OR:1.901, 95% CI{1.431-2.526}]). Among the six resources assessed that help patients decide whether to participate in a clinical trial, only one scored statistically significantly different for EM ($p<0.001$). EM patients ranked "having all material provided in my own language" as the most helpful resource.

Conclusion: There are significant differences between EM patients and those of other specialties in the factors that influence their participation in clinical trials. Providing material in the patient's own language, explaining the study well, and elucidating how their participation might benefit others in the future may help to improve enrollment in EM-based clinical trials. [West J Emerg Med. 2017;18(5)846-855.]

INTRODUCTION

There is strong evidence that clinical research efforts in emergency medicine (EM) are increasing as demonstrated by the recent establishment of the "Office of Emergency Clinical Research" within the National Institutes of Health. EM research results in special challenges as EM patients present without a pre-existing physician-patient relationship and with acute and often-undifferentiated diseases.[1,2]

Many studies have investigated the factors influencing patient participation in clinical trials from different areas of medicine.[3-23] Some of them have attributed decisions regarding participation in clinical research to patients' gender,[3-5] race,[5-8] linguistic capabilities,[8-10] and socioeconomic status.[11-12] In addition to these personal characteristics, multiple extrinsic factors associated with the research process itself, the clinical staff with whom they interact, the quality of clinical care, and the communication from the research staff are known to play a role.[7-10,13-23] Some of the reported motivating factors include how well the study was explained to them,[7,13] a strong patient-physician relationship,[7,14-16] the knowledge that their participation was going to benefit someone in the future,[7,9,17,18] and compensation for participating.[19] Other factors reported to function as barriers to participation include distrust in the doctors,[7,20-23] risk of unknown side effects,[7,20-23] and language differences.[9,10]

Despite this plethora of studies, there are virtually no data investigating whether these factors vary by type of clinical specialty. We hypothesized that, based on specialty, these factors' influence would indeed vary: e.g., factors influential for oncology patients would not necessarily be similar for obstetric patients. Likewise, EM patients, being under a complex array of physical and psychological stressors, might perceive each motivator and barrier differently when considering participation in a clinical trial.

Since it would be beneficial for EM researchers to know what matters to their patients and how to use this knowledge to customize and optimize their recruitment approach, we sought to determine the factors that influence EM patients' decision to participate in clinical trials and whether their impact varies from other selected medical specialties.

Population Health Capsule

What do we already know about this issue?
Enrollment in clinical trials is particularly challenging in EM as patients often present with acute, undifferentiated diseases, and have no preexisting relationship with providers.

What was the research question?
What factors influence EM patients to participate in clinical ttrials, and does their impact vary from other specialties?

What was the major finding of the study?
Impact of several factors that influence EM patients' participation in research significantly varies from other specialties.

How does this improve population health?
Enrollment in EM research may improve by providing material in patient's own language, explaining the study well, and elucidating how their participation might benefit others in the future.

METHODS

This was an institutional review board-approved prospective, cross-sectional, self-administered survey study using a convenience sample of patients attending different medical specialties' outpatient practices at three hospital sites affiliated with a single health network. In preparation, the principal investigator (PI) contacted various specialties for collaboration. Three agreed to participate: obstetrics and gynecology (OB/GYN), family medicine (FM), and infectious disease (ID). The survey subsequently was conducted in the network's two OB/GYN clinics, four FM clinics, two ID clinics, and three separate emergency departments (EDs). Surveys were offered only to those patients who were in the waiting rooms of these specialties. Thus, patients who came to the ED via ambulance and/or bypassed the waiting room were not surveyed.

The survey was anonymous, voluntary, and administered over a nine-month period (June, 2014 through March, 2015). Potential subjects were approached by multilingual research team members who, in addition to English, were fluent in either Spanish, simplified Chinese, or traditional Chinese. Inclusion criteria required participants to be a minimum of 18 years of age, active patients on the day of the survey, and have the ability to complete the survey without assistance.

The survey was developed by the EM investigators and reviewed by researchers from the other departments involved, a statistician, and the EM research review committee. Based on their feedback, the survey was revised and piloted among 15 randomly selected non-clinical and non-research hospital staff. A brief questionnaire was given to these pilot participants asking whether they could tell us what the purpose of our survey was, how long it took them to complete it, if any questions were too long or confusing, and to provide their general feedback. The respondents accurately determined

the purpose of the survey and felt it was appropriate in length. We redistributed the survey to these pilot participants after a two-week interval and compared their second responses to their first to ensure a rate of 95% consistency in interpretation. Revisions were made as needed.

Patients were approached in the "check-in" area of each specialty office by a study team member, were asked their age and, if 18 years of age or older, were offered the survey. Although a cover page explained the purpose of the survey, research staff also provided a brief oral introduction about the survey's goal, which was to ascertain patients' opinions about clinical research trials in which doctors test new medications or devices. Confirmation that the patient had not taken the survey on any previous visit to our network's facilities was obtained. The research staff asked if patients were able to self-administer the survey and, based on their preference, were given a copy of the survey in English or one of the three translated languages. We included in the data analysis only those surveys that indicated the respondent was an active clinic patient.

Regarding potential influential factors for research participation, subjects were asked to rate each factor on a five-point Likert scale as having no (0), very little (1), some (2), moderate (3), or greatest (4) significance. Following the administration of the survey, two trained research associates entered the data into Excel spreadsheets. The PI audited every 20th survey to ensure entry accuracy, consistency of the data entry, and to confirm the integrity of the database.

We compared demographic variables among specialties using a chi-square test. If a significant association ($p<0.05$) was found, pairwise comparisons were performed to determine which specialties' results were significantly different from each other. We applied the Bonferroni correction to account for the multiple pairwise comparisons for each demographic variable; with this correction applied, the p-value required for statistical significance was 0.008 (0.05/6).

We used the Kruskal-Wallis test to compare responses for each factor affecting participation in research by specialty. This test is appropriate when comparing two or more groups on an ordinal independent variable.[24] The Kruskal-Wallis test first ranks the data and then compares the mean of the ranks between groups. If any factor was found to be associated with a specialty, multiple pairwise comparisons were performed to determine which specialties differed. We performed the pairwise comparisons using Dunn's procedure[25] with a Bonferroni correction. This method of adjustment is used when dealing with ordinal or non-parametric data with unequal group sizes, if interested in all pairwise comparisons.[26] The data analysis for this study was generated using SAS version 9.3 (SAS Institute, Cary, NC) and SPSS version 22 (IBM SPSS Statistics for Windows, Armonk, NY, USA).

To further explore the association between the specialty in which the patient took the survey and their responses to specific motivational factors and barriers, we performed an ordinal logistic regression. One motivational factor was chosen, "my relationship with my doctor," on the premise that responses differed significantly between EM and all other specialties. Similarly, the responses for the two barriers that were chosen, "time commitment" and "religious beliefs," differed significantly between EM and at least two other specialties. The predictors included in the models were gender, race, education, and specialty. We chose gender, race, and education in an attempt to control for confounding of the relationship between specialty, motivator, barriers to participation in clinical research.

We collapsed the categories for the responses from five to three levels to ensure large enough cell counts for each predictor by each response variable. The collapsed response categories for the motivational factors were "high or very high," "moderate," and "slightly or not motivating at all." Similarly for the barriers, the collapsed categories were "significant or very significant," "moderate," and "slight or not a barrier at all." After collapsing the response variables, we assessed and met the proportional odds assumption.

RESULTS

We screened 2,917 subjects (Figure), of whom 24 were ineligible due to their age; 2,893 subjects were offered the survey, and 2,025 (70%) agreed to participate. The response rate for EM was 73.3%, for FM 67.2%, for ID 62.8%, and for OB/GYN 76.4% (Table 1). We further excluded 184 surveys because these respondents did not confirm they were active patients. We analyzed the remaining 1,841 surveys.

Demographic characteristics were significantly associated with specialty ($p<0.05$). Table 2 identifies specific specialties between which an association was observed. Participants from EM (66.4%) and ID (66.3%) were less likely to report better overall health than the participants from FM (71.3%) and OB/GYN (86.1%). Participants from EM and OB/GYN were younger than those in FM or ID. In each specialty, the majority of participants were female (EM, 64.7%; FM, 70.7%; OB/GYN, 99%), except for ID (42.4%). Compared to the other three specialties, participants from EM had a lower education level, a higher percentage reporting Hispanic/Latino ethnicity (EM, 53.2%; FM, 27.8%; ID 29.9%; and OB/GYN,

Table 1. Response rate of emergency medicine (EM), family medicine (FM), infectious disease (ID), and obstetrics/gynecology (OB/GYN) patients to a survey regarding participation in clinical trials.

	EM	FM	ID	OB/GYN
Offered	726	734	693	740
Agreed	532	493	435	565
Response rate %	73.3	67.2	62.8	76.4

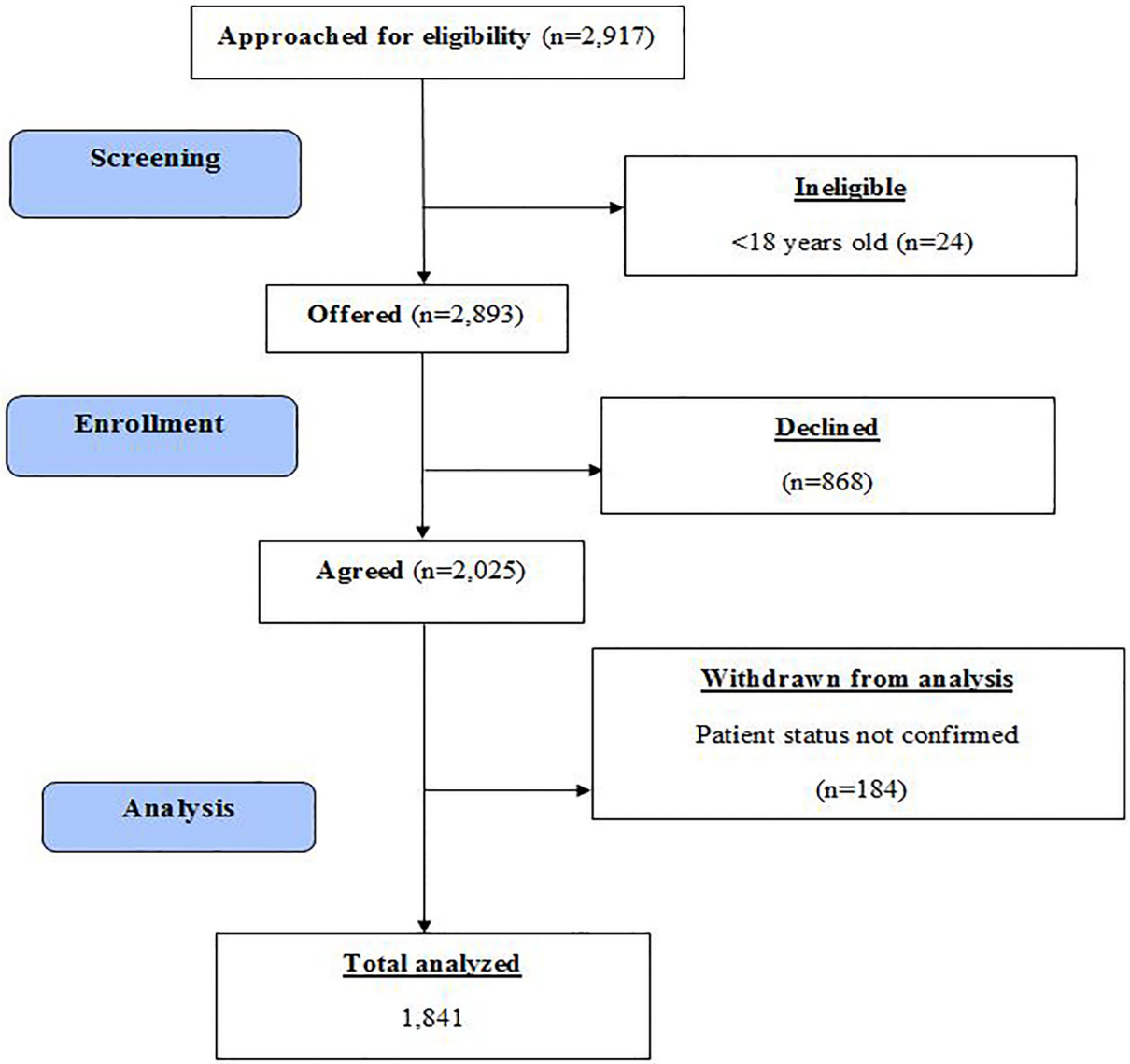

Figure. CONSORT flow diagram.

42.4%), and a higher percentage who said they understood English but had a hard time speaking it (9.1%), along with those who could not speak English (7.3%). While only slightly less than half from EM were White (48.5%), the majority of participants from FM (68.1%), ID (59.2%), and OB/GYN (55.5%) were White.

Analysis of potential motivating factors

EM patients ranked the majority of motivational factors lower than other specialties. Statistically significant differences were found for eight of the ten motivating factors between EM and one or more specialties. Two factors that did not show statistically significant differences between EM and any other specialty were "my desire to please the doctor" and "the doctor conducting the research is the same race/ethnicity as me." The top two motivating factors for EM patients appeared to be "how well the research is explained to me" and "knowledge learned from my participation will benefit someone in the future" (Table 3).

Analysis of potential barriers

All nine barriers showed statistically significant differences between EM and one or more specialties. While all patients, including EM, ranked "risk of unknown side effects" as the strongest barrier, one particular barrier, "my family's concern," scored slightly higher for EM patients than other specialties (Table 3).

Table 2. Demographics of emergency medicine (EM), family medicine (FM), infectious disease (ID) and obstetrics/gynecology (OB/GYN) respondents.

Variables (total respondents)	EM n(%) 457 (24.8)	FM n (%) 451 (24.5)	ID n (%) 408 (22.2)	OB/GYN n (%) 525 (28.5)	*p* value‡
Self-reported health status (1,835)					<0.001
Poor/fair	153 (33.6)[a*]	129 (28.7)[a]	137 (33.7)[a]	73 (13.9)[b]	
Good/very good/excellent	302 (66.4)	320 (71.3)	269 (66.3)	452 (86.1)	
Age (1,774)					<0.001
Under 35	207 (46.6)[a]	96 (22.2)[b]	60 (15.2)[c]	381 (75.8)[d]	
35-65	206 (46.4)	268 (62.0)	285 (72.2)	120 (23.9)	
>65	31 (7.0)	68 (15.7)	50 (12.7)	2 (0.40)	
Gender (1,779)					<0.001
Male	158 (35.4)[a]	127 (29.3)[a]	228 (57.6)[b]	5 (1.0)[c]	
Female	289 (64.7)	307 (70.7)	168 (42.4)	497 (99.0)	
Highest education level (1,756)					<0.001
Less than high school diploma	86 (19.7)[a]	40 (9.4)[b]	80 (20.5)[c]	66 (13.2)[b,c]	
High school graduate or GED	187 (42.8)	137 (32.0)	121(31.0)	164 (32.8)	
Some college or 2-year degree	113 (25.9)	129 (30.1)	116 (29.7)	170 (34.0)	
College graduate or more	51 (11.7)	122 (28.5)	74 (18.9)	100 (20.0)	
Latino or Hispanic origin? (1,757)					<0.001
Yes	235 (53.2)[a]	119 (27.8)[b]	117 (29.9)[b]	210 (42.4)[c]	
No	207 (46.8)	309 (72.2)	275 (70.2)	285 (57.6)	
Race (1,643)					<0.001
White or Caucasian	197 (48.5)[a]	280 (68.1)[b]	218 (59.2)[c]	254 (55.5)[a,c]	
Black or African-American	52 (12.8)	37 (9.0)	66 (17.9)	62 (13.5)	
Hispanic, Puerto Rican, Latino, Columbian, Spanish, Mexican-American, Dominican	114 (28.1)	59 (14.4)	56 (15.2)	88 (19.2)	
Multi-racial	19 (4.7)	13 (3.2)	7 (1.9)	23 (5.0)	
Other than above	24 (5.9)	22 (5.4)	21 (5.7)	31 (6.8)	
Speak and understand english? (1,753)					<0.001
Very well	335 (75.7)[a]	361 (83.4)[b,c]	305 (78.8)[a,c]	432 (87.6)[b]	
Pretty good	35 (8.0)	38 (8.8)	35 (9.0)	25 (5.1)	
Can understand, but have a hard time speaking it	40 (9.1)	26 (6.0)	26 (6.7)	20 (4.1)	
Cannot speak English	32 (7.3)	8 (1.9)	21 (5.4)	16 (3.3)	
Employment (1,735)					<0.001
Full-time	147 (34.0)[a]	174 (40.6)[b]	113 (29.4)[c]	187 (38.3)[d]	
Part-time	61 (14.1)	55 (12.8)	41 (10.7)	100 (20.5)	
Unemployed and looking for work	80 (18.5)	37 (8.6)	41 (10.7)	72 (14.8)	
Unemployed, but not looking for work	36 (8.3)	28 (6.5)	39 (10.1)	67 (13.7)	
Student	12 (2.8)	11 (2.6)	8 (2.1)	20 (4.1)	
Retired	48 (11.1)	82 (19.1)	73 (19.0)	8 (1.6)	
Other	18 (4.1)	8 (1.9)	19 (4.9)	21 (4.3)	
Disabled	31 (7.2)	34 (7.9)	51 (13.7)	13 (2.7)	

GED, General Education Development.

*Superscript letters highlight results of pairwise comparisons by specialty. For each demographic variable, cells with at least one letter the same indicate specialties for which there was no statistically significant association.

‡ P-values are the results of the omnibus chi-square test for each demographic variable by specialty and are not adjusted in any way.

Table 2. Continued.

Variables (total respondents)	EM N (%) 457 (24.8)	FM N (%) 451 (24.5)	ID N (%) 408 (22.2)	OB/GYN N (%) 525 (28.5)	*p* value‡
Income in 2013 (1,680)					<0.001
Less than $30,000	237 (56.4)[a]	186 (44.5)[b]	191 (51.9)[b, c]	250 (52.7)[a, c]	
$30,001-$50,000	52 (12.4)	78 (18.7)	46 (12.5)	80 (16.9)	
$50,001-$75,000	14 (3.3)	34 (8.1)	28 (7.6)	33 (7.0)	
More than $75,001	12 (2.9)	48 (11.5)	32 (8.7)	18 (3.8)	
I'd rather not answer	105 (25.0)	72 (17.2)	71 (19.3)	93 (19.6)	
Respondents using translated surveys	92 (20.1)	33 (7.3)	51 (12.5)	30 (5.7)	

* Superscript letters highlight results of pairwise comparisons by specialty. For each demographic variable, cells with at least one letter the same indicate specialties for which there was no statistically significant association.
‡ P-values are the results of the omnibus chi-square test for each demographic variable by specialty and are not adjusted in any way.

Analysis of potential helpful resources

Among six resources assessed that help patients decide whether to participate in a clinical trial, EM patients ranked "having all material provided in my own language" as the most helpful. EM was not statistically different from any other specialty in their rankings of these factors with the exception of whether or not they would be given the opportunity to speak to a patient who has participated in a clinical research study; OB/GYN patients ranked this factor higher ($p<0.001$) than all other specialties (Table 3).

Ordinal Logistic Regression Analyses for Selected Factors

Regardless of their gender, race and level of education, patients seen in other specialties had higher odds of being motivated by their relationship with their doctor compared to those seen in EM: FM (OR:1.752, 95% CI[1.285-2.389]), ID (OR:3.281, 95%CI[2.293-4.695]), and OB/GYN (OR:2.408, 95% CI[1.741-3.330]).

Regardless of race, patients seen in FM (OR:1.613, 95% CI[1.218-2.136]), ID (OR:1.340, 95% CI[1.006-1.784]), or OB/GYN (OR:1.901, 95% CI[1.431-2.526]), females (OR:1.322, 95% CI[1.043-1.676]), and those who graduated college or had a higher degree (OR:1.573, 95% CI[1.096-2.256]), had higher odds of stating that time commitment was a barrier than those seen in EM, ID, or men, and those with less than a high school education.

Regardless of the specialty, women (OR:1.505, 95% CI[1.163-1.947]), African Americans (OR:1.903, 95% CI[1.400-2.587]), Hispanics (OR:1.724, 95% CI[1.306-2.276]), multiracial patients (OR:1.761, 95% CI[1.060-2.926]), and patients of other races (OR:2.362, 95% CI[1.547-3.607]) all had higher odds of stating that their religious beliefs were more of a barrier when compared to male Whites. Patients who were college graduates or had a higher degree (OR:0.569, 95% CI[0.393-0.823]), as well as those with some college or a two year degree (OR:0.644, 95% CI[0.463-0.897]), had lower odds of their religious beliefs being a barrier compared to those with less than a high school diploma.

DISCUSSION

Although EM treats a large and diverse population, including women, pediatric, geriatric, and patients of color, and has the potential to promote diversity in clinical trials, recruiting patients for participation in EM clinical trials appears to be very challenging.[1,2] To identify factors that influence EM patients' decision to participate in clinical trials and to assess whether the impact of these factors varies from other specialties, we conducted this study among patients visiting EDs and compared their responses with the responses of patients attending a broad range of other medical specialties. For example, FM provided patients to our sample that – in contrast to EM – present for primary care and typically have established relationships with their providers. Further, inclusion of patients from ID (the AIDS Activity Office/Hepatitis Care Center and the Travel ID Clinic) added those who were suffering from contagious illnesses, and patients from OB/GYN represented a vulnerable population in our sample. Despite the heterogeneity of the populations compared from these four specialties, acceptance rates for all specialties were satisfactory except for ID. Since the reason(s) for non-participation were not collected and also because IRB restrictions do not permit collecting demographics on non-participants, a non-response bias analysis was not possible.

Compared to OB/GYN and ID patients, EM and FM patients did not indicate strong motivation to participate in clinical trials by the factors listed in our survey. It is noteworthy that since the survey was offered to all patients in the waiting rooms of each specialty, the survey was consequently not offered to those EM patients who arrived by ambulance. Other patients who were not surveyed might have included those whose condition was so severe that they were taken directly to a bed without any wait. However, had we included these patients, it is possible that the motivational factor scores for EM may have been even lower because of the physical and psychological stressors associated with these patients' severe health conditions.

Table 3. Mean response to each motivational factor, barrier, and helpful resource for emergency medicine (EM), family medicine (FM), infectious disease (ID), and obstetrics and gynecology (OB/GYN) respondents to a survey regarding participation in clinical trials.

Variables	EM	FM	ID	OB/GYN
Motivational factors				
My relationship with my doctor	2.54[*a]	2.99[b]	3.35[c]	3.16[b,c]
Doctor's reputation in the community	2.6[a]	3.01[b]	3.11[b]	3.37[c]
How well the research is explained to me	3.02[a,c]	3.21[c]	3.35[b,c]	3.44[b]
My desire to please the doctor	1.59[a,b]	1.36[a]	1.73[b]	1.57[a,b]
Money offered for my participation	1.84[a]	1.77[a]	1.89[a,b]	2.17[b]
A friend or family member participating in the same study	1.73[a,b]	1.6[b,c]	1.39[c]	1.89[a]
The doctor conducting the research is the same gender (sex) as me	1.15[a]	1.07[a]	1.02[a]	1.56[b]
The doctor conducting the research is the same race/ethnicity as me	0.86[a]	0.71[a]	0.73[a]	0.96[a]
The doctor conducting the research speaks the same language as I do	1.79[a]	1.81[a]	2.04[a,b]	2.23[b]
Knowledge learned from my participation will benefit someone in the future	2.94[a]	3.05[a]	3.32[b]	3.18[a,b]
Barriers				
My distrust in doctors	1.85[a]	1.79[a]	1.66[a]	2.36[b]
Time commitment	2.17[a]	2.56[b]	2.28[a]	2.74[b]
My family's concern	2.4[a]	2.26[a,b]	1.99[b]	2.32[a]
My religious beliefs	1.56[a]	1.21[b]	1.23[b]	1.58[a]
Clinical research studies are too hard to understand	1.42[a]	1.28[a]	1.26[a]	1.69[b]
Study related phone calls for follow-ups	1.7[a]	1.65[a]	1.53[a]	1.99[b]
Multiple follow-up visits related to the study	1.88[a]	2.11[a,b]	1.84[a]	2.35[b]
Risk of unknown side effects	2.78[a,c]	3.07[c,b]	2.59[a]	3.25[b]
Access to transportation	1.78[a]	1.46[b]	1.64[a,b]	1.8[a]
Helpful resources				
Written material explaining the research study	2.8[a]	3.0[a]	3.0[a]	3.02[a]
DVDs or electronic material explaining the research study	2.6[a]	2.74[a]	2.7[a]	2.82[a]
Having opportunity to speak to a patient who has participated in a clinical research study	2.66[a]	2.73[a]	2.63[a]	3.04[b]
Having access to a support group of patients who have participated in clinical research	2.52[a]	2.51[a]	2.44[a]	2.67[a]
Having all material provided in my own language	3.01[a]	3.0[a]	3.09[a]	3.24[a]
Having access to a medical interpreter throughout the study	2.38[a]	2.3[a]	2.23[a]	2.51[a]

* Values with at least one letter the same indicate specialties for which there was no statistically significant association as determined by pairwise comparisons of mean ranks.

Based on median scores, ID and OB/GYN patients ranked a total of four out of the 10 motivational factors as very highly motivating, while FM patients ranked three, and EM patients ranked only two factors as very highly motivating. For EM patients, scores for motivating factors were lower, and scores for most barriers were equal to other specialties. These findings help explain the challenges EM investigators and research staff experience and struggle with when trying to enroll patients in EM-based clinical trials.

It perhaps is not surprising that differences exist among the various specialties in their perceptions of factors that both motivate and deter patients from participating in clinical trials. In fact, EM patients are less likely to be influenced by the doctor's reputation or their relationship with their physician. This is in contrast to prior studies that have generally described an established relationship with the investigating physician as a strong motivator in making medical decisions, including clinical research participation.[14-16] EM patients being less influenced by these two factors may be due to the fact that they neither have an established relationship with their emergency care provider nor time to check on the provider's reviews.

The motivation for all patients, including EM, appeared to be the least affected by the investigator's race, their desire to please the doctor, financial compensation, and the investigator's gender (with the exception of OB/GYN patients). The factor "knowledge gained will benefit someone in the future" was ranked highly by all specialties. Altruism is widely reported to be a motivating factor for research participation,[9,17] and this finding supports a recent study conducted by Limkakeng, et al. that identified altruism as a motivating factor for research participation by the EM population.[18]

The primary barrier to participation for all specialties, including EM, is "fear of unknown side effects." This finding is in concordance with other reports.[20-23] It is unclear to what extent this barrier could be mitigated by emphasizing better and/or more complete communication with potential enrollees. "My family's concerns" was the second strongest barrier for EM patients. Involving families in decision-making in EDs has been reported to be challenging.[27] It is possible that family members are not present with the patient, or if they are present, they may be under as much psychological stress and anxiety as the patients themselves.

Factors that are easily modifiable by investigators, such as the provision of written or electronic material, were rated as moderately helpful in recruiting for clinical research. This was true even for the provision of material in the patient's own language. Compared to other specialties, EM had more respondents who belonged to a Latino or Hispanic origin, had less than a college-level education, and had fewer participants who were fluent in English. A prior study regarding enrollment challenges in EM research reported that a sizable proportion of eligible, non-English-speaking Latinos were not enrolled due to language barriers.[1] The availability of translated material has been noted as an effective measure in overcoming linguistic barriers.[8-10] In fact, the availability of translated surveys allowed a high percentage of EM respondents (20.1%) to participate in the current study. Further, the number of translated surveys used for each specialty corresponded with the number of those who were not proficient in the English language.

As the time frame to consent patients in the ED is usually shorter than for other specialties,[27] and the time taken for an explanation of research could delay the immediate clinical intervention,[28] the availability of translated material could help to improve EM study enrollment. Other potential solutions that may address the challenge of enrolling EM patients include conducting less complex, shorter intervention studies,[2] and either waiving or allowing deferred consent in EM clinical trials.[29, 30]

Since demographic variables, such as patient's gender,[3-5] race,[5-8] linguistic capabilities,[8-10] and socioeconomic status[11,12] are known to influence their decisions to participate, the heterogeneity of the study sample should not be undermined when interpreting these results. However, it is noteworthy that even though EM had a large female population, the results for EM were still significantly different from OB/GYN for six out of 10 motivating factors and for six out of nine barriers. While OB/GYN patients ranked a majority of motivating factors higher than the other specialties, their scores for barriers were higher as well. This, to some extent, explains the underlying reasons of gender disparity in clinical trials. ID (which had more male respondents than other specialties) appeared to be the second most motivated, after OB/GYN patients, to participate in research, but they were less deterred by barriers when compared to all other specialties. This may indicate that individuals with serious infections have better chances to participate, given the importance of research trials in these areas.

Our hypothesis that the impact of factors influencing a patient's decision to participate in clinical trials may vary among specialties was tested and confirmed by logistic regression analyses of a few of those factors that were significantly different for EM from either all, or a majority of other specialties in our sample. Regardless of their gender, race, and education status, "relationship with their doctor" was least motivating to EM patients than those from FM, ID, and OB/GYN. This finding as discussed above is logical. Patients and emergency physicians usually see each other only one time, and the chance of them seeing each other again in the future is slim to none. Additionally, EM patients have no choice of selecting their own doctor, whereas in other specialties, patients routinely make appointments with their preferred doctor for their follow-up care.

The results were similar for the barrier of "time commitment." Regardless of patient's race, "time commitment" was considered less of a barrier to EM patients, males, and those with less than a high school diploma. As the majority of EM patients present with acute and often-undifferentiated illnesses, it is logical that for them the diagnosis and resolution of emergency take priority over time commitment. Regression analysis of a second barrier, "my religious beliefs," which was scored significantly differently by EM patients than two other specialties (FM and ID), was found to be influenced by factors other than the specialty.

The results confirm our hypothesis and show that, regardless of demographic characteristics, the impact of some influential factors does vary from one specialty to the other. Therefore, we recommend that researchers customize their recruitment approach according to their specialty.

Strengths and Limitations

To our knowledge, this is the first large-scale prospective study that investigated factors that influence EM patients' decision to participate in clinical trials. This is also the first one indicating that the impact of the same factor may vary from one specialty to another. The strengths of this study include its large number of patients and an excellent response rate. Also, the availability of multilingual research staff and translated surveys in Spanish, simplified Chinese, and traditional Chinese maximized diversity.

Although surveying previous clinical trial participants and those who declined to participate in previous clinical trials may have been a better option for investigating influential motivators and barriers, human research participant protection and confidentiality-related policies did not allow us to identify and survey this population. The current study used a convenience sampling method based on when the research staff was available and on the patients who happened to visit the office that day, rather than a random-selection method. In addition, all participants were approached in the waiting room of these specialties. Since ambulance patients were excluded, our findings do not represent this subgroup of ED patients.

We acknowledge that although the overall response rate was satisfactory, a non-response bias may have potentially swayed the results. However, the reason(s) for non-participation were not collected, and IRB restrictions did not permit collecting demographics on non-participants. Therefore, a non-response bias analysis was not possible. Further, the decision to participate in a clinical trial depends on a variety of factors, and it is possible that a clinical trial has other motivators and barriers that were not assessed in this study. We acknowledge our survey responses may not mimic actual responses of potential subjects to a legitimate research trial invitation.

CONCLUSION

Even though a patient's decision to participate in clinical trials depends on multiple factors, we conclude that the impact of the same factor may vary from one specialty to another. Researchers should focus on factors that are more influential to their specialty populations and should customize study designs to make clinical trials more appealing to potential participants. When considering participation in clinical research, EM patients ranked their relationship with the doctor and the importance of their physician's reputation as significantly less important than patients in other specialties. The fear of unknown side effects was the most significant barrier for patients of all specialties. Although compared to other selected specialties, EM patients appeared to be less motivated on most factors assessed, providing material in a patient's own language, explaining the study well, and elucidating how their participation might benefit others in the future, may improve enrollment in EM-based clinical trials.

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Antimicrobial Therapy for Pneumonia in the Emergency Department: The Impact of Clinical Pharmacists on Appropriateness

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Introduction: Pneumonia impacts over four million people annually and is the leading cause of infectious disease-related hospitalization and mortality in the United States. Appropriate empiric antimicrobial therapy decreases hospital length of stay and improves mortality. The objective of our study was to test the hypothesis that the presence of an emergency medicine (EM) clinical pharmacist improves the timing and appropriateness of empiric antimicrobial therapy for community-acquired pneumonia (CAP) and healthcare-associated pneumonia (HCAP).

Methods: This was a retrospective observational cohort study of all emergency department (ED) patients presenting to a Midwest 60,000-visit academic ED from July 1, 2008, to March 1, 2016, who presented to the ED with pneumonia and received antimicrobial therapy. The treatment group consisted of patients who presented during the hours an EM pharmacist was present in the ED (Monday-Friday, 0900-1800). The control group included patients presenting during the hours when an EM clinical pharmacist was not physically present in the ED (Monday-Friday, 1800-0900, Saturday/Sunday 0000-2400 day). We defined appropriate empiric antimicrobial therapy using the Infectious Diseases Society of America consensus guidelines on the management of CAP, and management of HCAP.

Results: A total of 406 patients were included in the final analysis (103 treatment patients and 303 control patients). During the hours the EM pharmacist was present, patients were significantly more likely to receive appropriate empiric antimicrobial therapy (58.3% vs. 38.3%; p<0.001). Regardless of pneumonia type, patients seen while an EM pharmacist was present were significantly more likely to receive appropriate antimicrobial therapy (CAP, 77.7% vs. 52.9% p=0.008, HCAP, 47.7% vs. 28.8%, p=0.005). There were no significant differences in clinical outcomes.

Conclusion: The presence of an EM clinical pharmacist significantly increases the likelihood of appropriate empiric antimicrobial therapy for patients presenting to the ED with pneumonia. [West J Emerg Med. 2017;18(5)856-863.]

INTRODUCTION

Over four million Americans are diagnosed with pneumonia annually, and it is the leading cause of infectious disease-related hospitalization and mortality in the United States.[1-3] Empiric antimicrobial therapy is often initiated in the emergency department (ED) and pneumonia remains one of the most common infections requiring antimicrobial therapy.[4,5] Further, the treatment of pneumonia is complex, with changing antimicrobial susceptibilities, changing definitions, and changing time-to-treatment targets making uniform appropriate treatment challenging.[6,7] Appropriate antimicrobial therapy for community-acquired pneumonia (CAP) and healthcare-associated pneumonia (HCAP) has been shown to decrease hospital length of stay and mortality.[8,9] Infectious Diseases Society of America (IDSA) guidelines provide guidance for the treatment of CAP and HCAP and recommend identifying patients with risk factors for multi-drug resistant (MDR) pathogens to select empiric therapy.[6,7] Unfortunately, in a busy ED setting, emergency medicine (EM) providers are left with the difficult task of differentiating patients at risk for MDR pathogens to select appropriate antimicrobial therapy. EM clinical pharmacists play an important role on the healthcare team and have been shown to impact antimicrobial prescribing for various infectious conditions.[10-14] A clinical pharmacist in the ED has a unique focus on pharmacotherapy prescribing, allowing them to assess the patient for multi-drug resistant (MDR) pathogen risk factors and guide empiric antimicrobial therapy.

The primary objective of our study was to test the hypothesis that the presence of an EM clinical pharmacist improves the appropriateness of empiric antimicrobial therapy for CAP and HCAP. Secondary objectives were to assess whether the presence of an EM clinical pharmacist improves timing antimicrobial therapy and if appropriate antimicrobial therapy shortened hospital length of stay (LOS), decreased repeat hospital visits for pneumonia, and reduced in-hospital mortality.

Population Health Research Capsule

What do we already know about this issue?
Appropriate antimicrobial therapy for pneumonia decreases hospital length of stay and mortality. Emergency medicine (EM) pharmacists have been shown to impact antimicrobial prescribing.

What was the research question?
Does the presence of an EM pharmacist improve appropriateness of empiric antimicrobial therapy for pneumonia?

What was the major finding of the study?
EM pharmacist presence increases the likelihood of appropriate empiric antimicrobial therapy for patients with pneumonia.

How does this improve population health?
EM pharmacists play an important role in the healthcare team and can have a positive impact on medication appropriateness for patients presenting to the emergency department.

METHODS

Design

This study was a retrospective observational cohort study conducted in the ED of an academic medical center with an annual ED census of 60,000 patient visits between July 1, 2008, and March 1, 2016.

Participants and setting

We included all patients 18 years and older diagnosed with pneumonia who received antimicrobial therapy in the ED and were admitted to the hospital. Patients were identified by *International Classification of Diseases, Ninth Revision (ICD-9)* discharge diagnosis codes for pneumonia. During the data abstraction process, the diagnosis of pneumonia was confirmed by the ED provider's documentation in the electronic medical record (EMR). Patients were excluded if they had a diagnosis of cystic fibrosis, did not receive antimicrobial therapy in the ED, or had incomplete documentation in their medical records.

The treatment group consisted of patients who received antimicrobial therapy during the hours an EM clinical pharmacist was present in the ED (before October 2015: Monday-Friday, 0900-1800; starting October 2015: Monday-Saturday, 0900-1900). The control group included patients who received antimicrobial therapy during the hours when an EM clinical pharmacist was not physically present in the ED.

All variables were defined *a priori* and recorded in an EMR as part of clinical care. Variables collected from the patient's EMR included age, height, weight, gender, date and time of presentation, past medical history, serum creatinine, white blood cell count, lactate, risk factors for MDR-resistant pathogens, initial antimicrobial therapy administered in the ED, time to antimicrobial therapy, mechanical ventilation in the ED, admitting service (general ward vs. intensive care unit), hospital LOS, in-hospital mortality and 30-day repeat hospital visits for pneumonia. Clinical variables were abstracted from the EMR by a trained data abstractor (LM) blinded to the study hypothesis. After data abstraction, 10% of charts were randomly selected for review by a second independent pharmacist (JD) to validate data accuracy and abstraction techniques.

Definitions

We defined appropriate empiric antimicrobial therapy using the IDSA consensus guidelines on the management of CAP and management of HCAP.[6,7] Appropriate vancomycin dosing was defined as 15-20 mg/kg in accordance with guideline recommendations.[15] An independent clinical pharmacist unaware of patient group allocation (treatment vs. control group) determined appropriateness of antimicrobial therapy based on IDSA guidelines. Patients were defined as receiving guideline-concordant therapy if they met all criteria in the guidelines (e.g. ceftriaxone plus azithromycin = appropriate for CAP, ceftriaxone monotherapy = inappropriate for CAP). We defined risk factors for MDR pathogens as hospitalization for two days or more in the preceding 90 days, residence in a long-term care facility or nursing home, chronic hemodialysis, home infusion therapy (including antibiotics), chronic home wound care, and immunosuppressive disease/therapy.[7] The definition of immunosuppressive disease/therapy included the following: patients taking corticosteroids (at least 5 mg per day of prednisone or an equivalent drug) or immunomodulating agent (e.g infliximab, adalimumab, etanercept, etc.), documentation of human immunodeficiency virus, received either a solid organ transplant or bone marrow transplant, or were receiving treatment with chemotherapy or radiation.

Outcomes

The primary outcome was the proportion of patients who received appropriate empiric antimicrobial therapy for CAP and HCAP. Secondary outcomes included time to antimicrobial therapy, appropriate vancomycin dosing, hospital LOS, 30-day repeat visits for pneumonia and in-hospital mortality. We also measured the effect of antimicrobial selection in the ED and whether the same empiric antimicrobial therapy was continued upon admission to the hospital.

Analysis

We calculated that a sample size of 90 patients per group would have 80% power ($\alpha = 0.05$) to detect an absolute difference of 20% in patients who receive appropriate antimicrobial therapy, assuming that antimicrobial appropriateness was 26% in the control group based on previous reports in the literature.[8,10] To examine differences in patient characteristics and outcomes by the absence/presence of the EM pharmacists, we reported Pearson chi-square and percent differences (95% confidence interval [CI]) for categorical variables. Differences in continuous variables (e.g., age), were examined using mean differences and 95% CIs (parametric variables) or Wilcoxon sum test (non-parametric variables). We used multivariable logistic regression analysis to estimate the effect of clinical pharmacist presence on 30-day repeat visits among survivors, controlling for potentially confounding covariates (age, antimicrobial appropriateness, CAP, HCAP). We prespecified variables included in the model based on *a priori* knowledge and defined a statistical threshold for inclusion of $p<0.20$. All tests were two-tailed and a p-value <0.05 was considered statistically significant. We conducted all analyses using SAS® software (version 9.3, SAS system for Microsoft, SAS institute Inc., Cary, NC, USA). The institutional review board approved the study protocol. The design and results reporting were completed in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[16]

RESULTS

We included 406 patients in the final analysis (103 treatment group and 303 control group). There were no statistically significant differences in demographic variables (Table 1). Hospitalization for two or more days in the prior 90 days (n=131, 52%) and immunosuppressive disease/therapy (n=112, 45%) were the most prevalent risk factors for HCAP (Table 2).

Patients who received antimicrobial therapy and were seen in the ED when an EM pharmacist was present were significantly more likely to receive appropriate antimicrobial therapy (58.3% vs. 38.3%; $p<0.001$). Significance remained regardless of pneumonia subtype (CAP vs. HCAP) (Figure 1). The main reason for inappropriate antimicrobial therapy was misidentification of pneumonia subtype (e.g., treating using HCAP antibiotics for CAP, or vice versa) (Figure 2 and 3). There were no statistical differences in time to first antibiotic or in secondary clinical outcomes (Table 3). Using univariate analysis among survivors, 30-day repeat visits were not associated with the presence of an EM pharmacist. Using multivariable logistic regression adjusting for appropriate antimicrobial therapy and HCAP, 30-day repeat visits were more likely in patients diagnosed with HCAP (aOR 3.08 [1.49-6.35], p=0.002), but was not associated with the presence of an ED pharmacist (aOR 1.718 [0.915-3.23], p=0.09). Patients who received appropriate empiric antimicrobial therapy in the ED were significantly more likely to have the same therapy continued after admission to the hospital (65% vs. 35%, $p<0.001$).

DISCUSSION

Appropriate antimicrobial therapy for pneumonia decreases hospital LOS and mortality.[9,17,18] The ED is the primary source of admission for the majority of pneumonia patients, making it an optimal place to improve empiric antimicrobial selection.[3,19] Our study differs from previous research as it evaluated the effects of the presence of an EM clinical pharmacist on appropriate antimicrobial therapy for all patients presenting with pneumonia (CAP and HCAP). The results shed light on the ability of a clinical pharmacist to impact appropriate empiric antimicrobial therapy for pneumonia in the ED.

Because appropriate antimicrobial therapy improves clinical outcomes, it is important that patients receive therapy covering presumed pathogens without exposing them to

Table 1. Baseline demographics in study examining whether the presence of a clinical pharmacist in the emergency department affects the appropriateness of antimicrobial therapy in patients presenting with pneumonia.

	Emergency medicine clinical pharmacist present	
	Yes (n=103)	No (n=303)
Age, years (mean SD)	60 (18.4)	62.4 (17.4)
Weight, kg (mean SD)	85.3 (23.5)	85.7 (27.1)
Temperature, C^{o} (mean SD)	37.3 (1)	37.6 (1.2)
White blood cell, k/mm^3 (mean SD)	13.2 (7)	12.7 (7.3)
Lactate, mEq/L (mean SD)	1.7 (1.1)	1.9 (1.4)
Mechanical ventilation (%)	7 (7)	14 (5)
ICU admission (%)	21 (20)	54 (18)
Community-acquired pneumonia (%)	36 (35)	119 (39)
Healthcare-associated pneumonia (%)	67 (66)	184 (61)

ICU, intensive care unit; *SD*, standard deviation.

Table 2. Healthcare-associated pneumonia risk factors.[#]

Risk factors	n (%)
Hospitalization for 2 days or more in the preceding 90 days	131 (52)
Residence in long term facility or nursing home	70 (28)
Chronic hemodialysis	19 (8)
Home infusion therapy	1 (<1)
Chronic home wound care	40 (16)
Immunocompromised	112 (45)

[#]Multiple risk factors may have been recorded for each patient.

Table 3. Comparison of secondary outcomes and clinical outcomes in pneumonia patients based on whether an emergency medicine clinical pharmacist was on duty.

	Clinical pharmacist coverage (n=103)	No clinical pharmacist coverage (n=303)	p value
Time to first antibiotic, hrs (median, IQR)	2.01 (1.25,2.83)	2.12 (1.35,3.48)	0.15
Average vancomycin dose, mg/kg (mean, SD)	16.7 (2.8)	17.3 (4.4)	0.32
Correct vancomycin dose, n (%)[1]	31 (81.6)	62 (71.3)	0.22
Hospital LOS (days, IQR)	4.1 (2.2,7.8)	3.9 (2.6,6.8)	0.57
In-hospital mortality, n (%)	2 (2)	11 (4)	0.40
30-day repeat hospital visits, n (%)[2]	20 (19.8)	33 (11.3)	0.03

LOS, length of stay; *IQR*, interquartile range; *SD,* standard deviation.
[1]Analysis only among those receiving vancomycin (N=125), of which 38 were seen when the pharmacist was present and 87 when there was no pharmacist).
[2] Among those who survived initial visit (N=393).

unnecessarily broad therapy resulting in increased resistance and adverse effects.[20,21]

Our findings are important for several reasons. First, even though guidelines exist to provide recommendations for empiric treatment of CAP and HCAP, adherence improved when a clinical pharmacist was present in the ED. In our study, over half of the patients treated when the EM clinical pharmacist was present received appropriate therapy. In contrast to previous studies evaluating pneumonia, our findings showed improvement in a higher percentage of patients receiving guideline-concordant therapy for CAP and HCAP when an EM pharmacist was present.[8,10]

Second, our study showed that guideline adherence was low for both CAP and HCAP when the clinical pharmacist was not present. A previous study by DeFrates et al. evaluated the presence of an EM clinical pharmacist on appropriate antimicrobial therapy in patients presenting to the ED with HCAP.[10] They were able to show that the presence of an EM clinical pharmacist improves appropriate therapy for HCAP (49.4% vs. 25.7%, p=0.005).[10] Our HCAP population findings were similar to DeFrates et al., as our treatment and control group received guideline-concordant therapy approximately 50% and 25% of the time respectively.[10] However, they did not evaluate antimicrobial therapy for patients admitted with CAP.

Third, patients who received appropriate antimicrobial therapy were significantly more likely to have that therapy continued upon admission. Previous reports have shown that care received in the ED can positively or negatively influence care after the patient is admitted to the hospital.[22-24] Our findings support a positive impact; however, interventions to improve antimicrobial selection should continue to focus on improving the percentage of patients receiving appropriate antimicrobial therapy in the ED.

Survival of pneumonia patients has been shown to be directly related with early appropriate antimicrobial therapy.[17,18,25] Although a definitive time point has not been established to provide timely therapy, the median time to antimicrobial therapy in both groups was approximately two hours after being admitted to the ED. This time frame was significantly shorter compared to previous reports and within an acceptable time period to decrease mortality based on previous evidence.[10,17] However, we were unable to show a significant difference in mortality even though a significantly higher proportion of control patients received inappropriate antimicrobial therapy. While our study was not powered to evaluate the effects of appropriate antimicrobial therapy on mortality or other clinical outcomes, this remains an important finding as exposure to inappropriate antimicrobial therapy can lead to serious adverse drug reactions and development of MDR pathogens.[20,21,26]

Our results show that patients often receive inappropriate antimicrobial therapy regardless of pneumonia type (CAP vs. HCAP). It is evident that an EM clinical pharmacist can play an important role in intervening on antimicrobial orders in the ED to promote guideline-concordant antimicrobial selection for patients presenting with pneumonia. Additionally, EM clinical pharmacists should continue to enhance their role in improving the identification of patients at risk for MDR pathogens, appropriate dosing based on patient-specific characteristics and timely administration of antimicrobial therapy for patients with pneumonia.

LIMITATIONS

This study has several important limitations. First, because it was retrospective our study introduced the possibility of unmeasured confounders potentially influencing the outcome. However, both groups had similar baseline demographics and a similar proportion of pneumonia type (CAP and HCAP), so it is likely that internal validity of our study was maintained. Second, some of our data could be incompletely recorded, especially risk factors for HCAP. The majority of the risk factors for HCAP should be accurately recorded (e.g. dialysis dependent, residence in a long-term care facility or nursing home, immunosuppression); however, we cannot be sure that all relevant factors were consistently captured. Additionally, because we are not a closed healthcare system, repeat visits at 30 days could have been underreported if the patient presented to a different ED.

Third, patient group assignment was based on antimicrobial therapy administration times in the EMR. By assigning patients in this manner, patients could have been placed in the control group even though antimicrobial recommendations were made before the end of the clinical pharmacist's shift. On the other hand, patients could have been assigned the treatment group even if the patient was admitted to the ED before the arrival of the clinical pharmacist. Antimicrobial therapy could have been ordered before clinical pharmacist arrival but administered shortly after the shift started, not allowing time for the clinical pharmacist to intervene on the orders. Because both the treatment and control groups would

have patients fall into these categories, we do not believe there were any major between group differences.

Fourth, the latest iteration of the IDSA guidelines for the treatment of hospital-acquired and ventilator-associated pneumonia was recently updated and the designation of HCAP has been removed.[27] The main rationale for removing this designation is the lack of evidence showing the risk factors used to define the HCAP population are associated with a higher risk of MDR pathogens.[28-30] Additional evidence suggests HCAP-designated patients receiving broad-spectrum therapy show no improvement in clinical cure rates or outcomes.[31] As evidence continues to evolve and the prevalence of resistant pathogens increases, it is imperative yet remains complex to identify patients who require broad-spectrum antimicrobial therapy.

Fifth, we elected to use *ICD-9* codes to identify pneumonia patients. Using *ICD-9* codes has been shown to be an effective approach to identify patients in our cohort; however, we

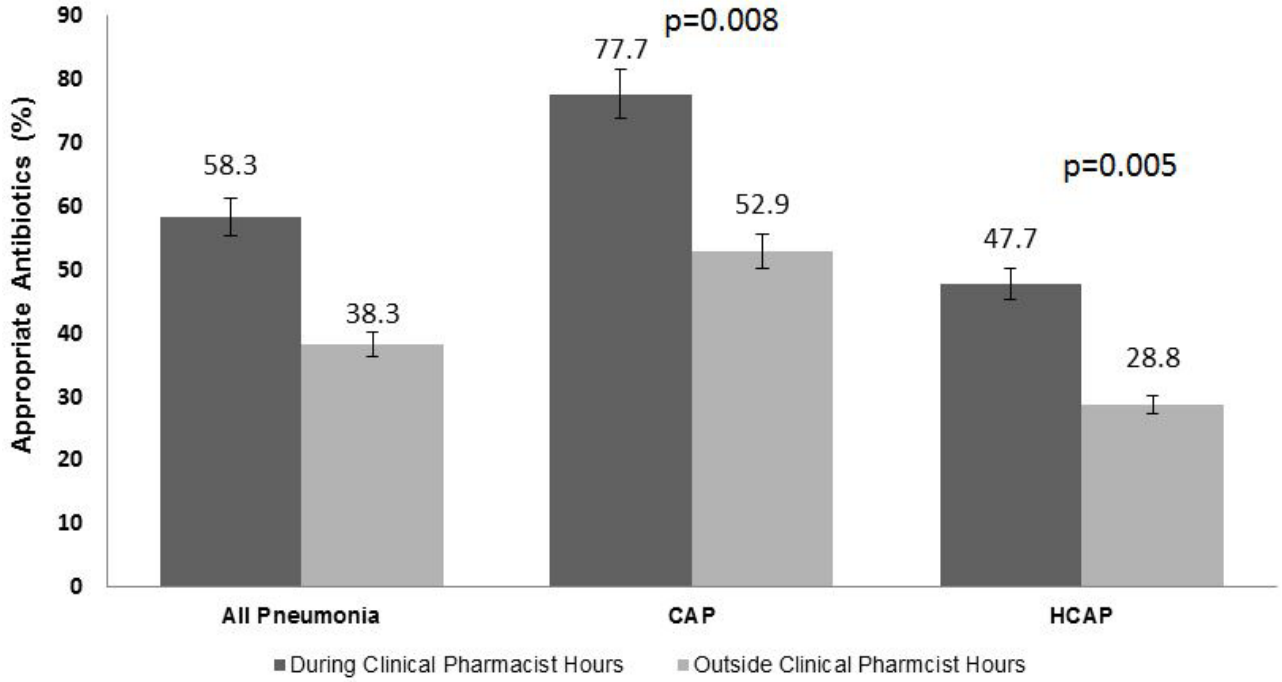

Figure 1. Appropriate empiric antimicrobial therapy.
CAP, community-acquired pneumonia; *HCAP*, healthcare-associated pneumonia.

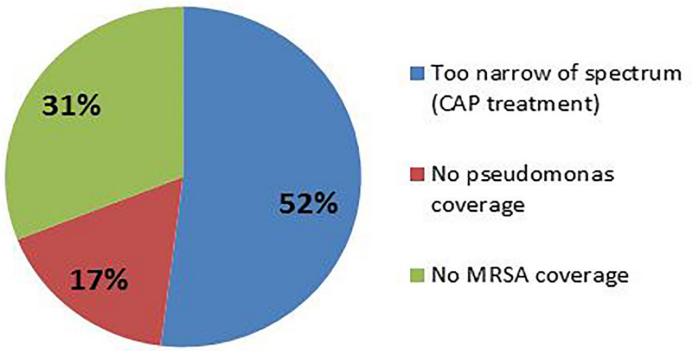

Figure 2. Categorization of inappropriate antimicrobial therapy description for patients presenting with HCAP (Healthcare-associated pneumonia).
CAP, Community-acquired pneumonia.

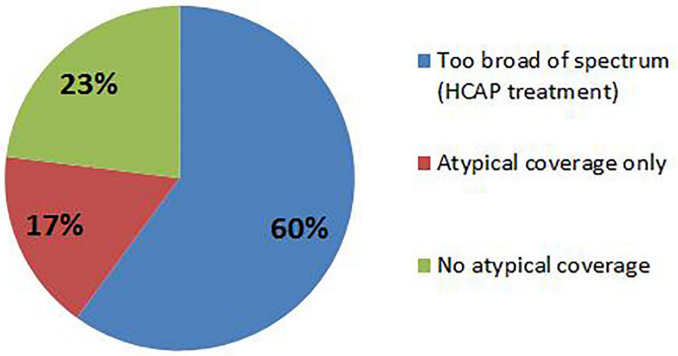

Figure 3. Categorization of inappropriate antimicrobial therapy description for patients presenting with CAP(community-acquired pneumonia).
HCAP, healthcare-associated pneumonia.

could not rule out that some patients might have been missed because of improper coding.[10] Sixth, based on ED workflow and on competing priorities (e.g. other critically ill patients, trauma/cardiac arrest resuscitation), it was not feasible for the EM clinical pharmacist to review all antimicrobial therapy before administration by nursing staff. This could reflect why appropriateness was not higher in the intervention group.

Finally, we did not define appropriate antimicrobial therapy based on culture and susceptibility reports. The majority of patients diagnosed with pneumonia do not have positive blood cultures, and most sputum cultures are low yield with variable results influenced by the quality of the collection process.[6] Conducting a study using only culture-positive patients would not have been feasible. Additionally, it would have decreased the external validity of our study as antimicrobial therapy initiated in the ED is not typically based on culture data.[6]

CONCLUSION

The presence of an EM clinical pharmacist significantly increases the likelihood of appropriate empiric antimicrobial therapy for patients presenting to the ED with pneumonia. Future studies should focus on the impact of EM clinical pharmacist interventions on clinical outcomes for patients presenting to the ED with pneumonia. The studies should be consistent and reproducible with their findings of specific interventions to demonstrate the benefit of an EM clinical pharmacist to impact patients' medication-related outcomes.

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Availability and Accuracy of EMS Information about Chronic Health and Medications in Cardiac Arrest

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Introduction: Field information available to emergency medical services (EMS) about a patient's chronic health conditions or medication therapies could help direct patient care or be used to investigate outcome disparities. However, little is known about the field availability or accuracy of information of chronic health conditions or chronic medication treatments in emergent circumstances, especially when the patient cannot serve as an information resource. We evaluated the prehospital availability and accuracy of specific chronic health conditions and medication treatments among out-of-hospital cardiac arrest (OHCA) patients.

Methods: The investigation was a retrospective cohort study of adult persons suffering ventricular fibrillation OHCA treated by EMS in a large metropolitan county from January 1, 2007, to December 31, 2013. The study was designed to determine the availability and accuracy of EMS ascertainment of selected chronic health conditions and medication treatments. We evaluated chronic health conditions of "any heart disease," congestive heart failure (CHF), and diabetes and medication treatments of beta blockers and loop diuretics using two distinct sources: 1) EMS report, and 2) hospital record specific to the OHCA event. Because hospital information was considered the gold standard, we restricted the primary analysis to those who were admitted to hospital.

Results: Of the 1,496 initially eligible patients, 387 could not be resuscitated and were pronounced dead in the field, one patient was left alive at scene due to Physician's Orders for Life-sustaining Treatment (POLST) orders, 125 expired in the emergency department (n=125), and 983 were admitted to hospital. A total of 832 of 1,496 (55.6%) had both sources of data for comparison and comprised the primary analytic group. Using the hospital record as the gold standard, EMS ascertainment had a sensitivity of 0.79 (304/384) and a specificity of 0.88 (218/248) for any prior heart disease; sensitivity 0.45 (47/105) and specificity 0.87 (477/516) for CHF; sensitivity 0.71 (143/201) and specificity 0.98 (416/424) for diabetes; sensitivity 0.70 (118/169) and specificity 0.94 (273/290) for beta blockers; sensitivity 0.70 (62/89) and specificity 0.97 (358/370) for loop diuretics.

Conclusion: In this cohort of OHCA, information about selected chronic health conditions and medication treatments based on EMS ascertainment was available for many patients, generally revealing moderate sensitivity and greater specificity. [West J Emerg Med. 2017;18(5)864-869.]

INTRODUCTION

Chronic health conditions and medications can provide important clinical insight when triaging, diagnosing, and treating patients with critical, emergent illness. In life-threatening emergencies however, the patient is often not able to provide information, and clinicians must use other sources of information. Medical records are often available in the hospital setting. However emergency medical services (EMS) providers must gather information from the family, other bystanders, and/or medications containers in an effort to construct a chronic health profile. Cardiac arrest represents an extreme instance where the patient will uniformly be unable to provide clinical history or medication treatments. Thus, the out-of-hospital cardiac arrest (OHCA) circumstance provides an instructive condition to evaluate the availability and accuracy of this information in the pre-hospital setting.

Moreover, resuscitation from OHCA generally follows a singular algorithm that often ignores the heterogeneous acute pathophysiology.[1] Although there is no clinical evidence that a patient-specific approach can affect outcome, there is increasing experimental evidence that targeting an individual's specific pathophysiology may result in greater likelihood of successful resuscitation.[2,3] To this end, chronic comorbidity and medication treatment can affect arrest pathophysiology, response to care, and the likelihood of survival.[4-8]

Investigation regarding whether and how chronic comorbidity may influence pathophysiology and response to treatment depends in part on the field availability and accuracy of such information. To date, there are no published investigations on the availability or accuracy of field information related to chronic comorbidities and medication treatments in cases of OHCA. The purpose of the present study is to evaluate the availability and accuracy of field information about selected underlying chronic health conditions and medication treatments in patients suffering ventricular fibrillation OHCA.

Population Health Research Capsule:

What do we already know about this issue?
Little is known about the availability and accuracy of information collected by EMS in the prehospital setting regarding chronic health conditions or chronic medication treatments.

What was the research question?
The study compared prehospital information with the hospital record to determine agreement for patients suffering out-of-hospital cardiac arrest.

What was the major finding of the study?
EMS information was available for many patients and had moderate sensitivity and greater specificity.

How does this improve population health?
The findings suggest that EMS information about chronic health conditions and medication treatments has ample accuracy to be considered for research or help inform clinical decisions.

METHODS

Study design, population, and setting

This was a retrospective cohort study of persons 18 years or older who suffered a non-traumatic cardiac arrest and presented to EMS with an initial rhythm of ventricular fibrillation in a large metropolitan EMS system between January 1, 2007, to December 31, 2013 (n=1496). We a priori chose out-of-hospital ventricular fibrillation cardiac arrest because this group provides a well-defined benchmark group that would uniformly be unable to provide a first-person account of chronic health issues or medication treatments.[9] Because we used the hospital record as the gold standard to determine the presence of chronic health conditions and medication treatments, the primary analyses excluded those who could not be resuscitated and were pronounced dead in the field (n=387), one patient who was left alive at scene due to Physician's Orders for Life-sustaining Treatment (POLST) orders, and those transported to hospital who died in the emergency department (ED) (n=125). The remaining 983 were admitted to hospital and served as the eligible analysis cohort.

The study EMS system is a two-tiered system that serves 1.2 million people in urban, suburban, and rural settings. The first tier of EMS response is firefighter emergency medical technicians equipped with automated external defibrillators. The second tier is paramedics who practice advanced care life support. This study was approved by the appropriate institutional review board.

Data collection

The EMS maintains a registry of every treated OHCA organized according to the Utstein template.[9] Information is collected from dispatch, EMS, hospital, and death certificate records. The study was designed in keeping with chart-review research guidelines.[10] We used a uniform data collection form to ascertain information about chronic health conditions and chronic medication treatment (preceding the OHCA). Information was collected from the EMS record and the hospital records independently. Specifically, we collected information about chronic health conditions and particular

classes of medications using a uniform abstraction form (Appendix 1). Abstraction was aided by a written guideline (Appendix 2) that provided generic, trade name, and medication class as well as rules for coding particular chronic health conditions. Abstractors were not aware of the specific hypotheses, which data elements were of primary interest, or how the data elements would be formally tested.

We coded comorbidities as present if noted to be present in the narrative of the prehospital medical incident report form completed by paramedics, or by the notation of a medication used for that specific condition if medication information was available in the absence of any other information. Conditions were deemed absent if they were stated to be absent or if they were not mentioned in the context of a documented medical history. We classified clinical condition or medication as unknown if stated to be "unknown" or if there was no information about medication treatment or chronic health conditions from the record. For hospital data collection, we used the entire hospital record for the OHCA hospitalization to assess comorbidities and medication treatments prior to the OHCA event.

Data Definitions

We defined heart disease as any prior cardiac comorbidity or cardiac procedure. A history of hypertension or hyperlipidemia was not considered to be heart disease. Further, the determination of any heart disease from the prehospital records included the notation of any cardiac medication such as nitroglycerin or digoxin in the absence of other information about a patient history. As part of the process there was an evaluation of inter-reviewer reliability to assure consistency in the abstraction. At the outset, each abstractor independently reviewed a common set of 20 cases. There was 90% agreement with regard to the diagnosis of any heart disease from the EMS report between the two reviewers. We a priori chose to evaluate chronic health conditions associated with cardiac arrest to include any heart disease, congestive heart failure (CHF), diabetes, beta blocker use, and diuretic use specific to loop diuretics (furosemide – trade name Lasix; bumetanide – trade name Bumex; and torsemide – trade names Demadex, Diuver, and Examide).

Data analysis

We used the hospital record as the gold standard when identifying medical conditions and medications. We compared independent proportions of categorical variables with the chi-square statistic or Fisher's exact test, paired categorical comparisons with the McNemar's test, comparisons of independent continuous variables with the Mann-Whitney nonparametic statistic, and paired comparisons of continuous variables with the paired t-test. We also compared characteristics between patients who died prior to hospitalization and thus lacked hospital information and those with hospital information. We report the characteristics of the 513 who died prior to admission and were excluded from the primary analysis to highlight the differences between those in the primary comparison group and those excluded from the study.

In the primary analyses, we generated 2 x 2 tables to determine sensitivity and specificity of the specific chronic health conditions and medication treatments comparing the EMS information to the hospital information. In generating sensitivity and specificity, we excluded those for whom the information was coded as "missing" or "unknown" in the EMS record. All analyses were conducted with SPSS Version 21.[11]

RESULTS

Of the 1,496 adult non-traumatic arrests that presented to EMS with an initial shockable rhythm during the study period, 1,360 (91%) had an EMS report available for abstraction. Of these 1,360, 1,129 (83%) had at least some information about chronic health conditions and 885 (78%) had at least some information about medication therapies. Of the 1,496 patients, 1,108 were transported to hospital for continued treatment, and 983 were admitted. Among the eligible 983 admitted patients, 910 (92.6%) had a comorbidity form, and 903 (91.9%) had a hospital record abstraction form; 832 (84.6%) had both sources of data for comparison and comprised the primary analytic group.

Compared to those who survived to hospital admission, those pronounced dead in the field or the ED (so excluded from the primary analyses) were older, more likely to suffer the arrest in a residential setting, less likely to be witnessed or receive bystander cardiopulmonary resuscitation (CPR), and more likely to have comorbidity information reported on their EMS reports. The group who died prior to admission also was more likely to be treated with beta blockers or loop diuretics (Table 1).

For the comparison of clinical comorbidity, approximately 75% (638/832) had known status regarding the three comorbidity conditions from the EMS and hospital information The large majority of missing information was from the EMS record (98%, 191/194). Missing or unknown information for any of the three comorbidity variables from the EMS record was greater among OHCA occurring in public locations (43%, 138/320) compared to residential locations (10%, 53/510). Agreement between EMS and hospital records among the selected comorbid conditions was significant. EMS ascertainment of any prior heart disease had a sensitivity of 0.79 (304/384) and a specificity of 0.88 (218/248) using the hospital record as the gold standard ($p<0.001$). For CHF, sensitivity was 0.45 (47/105) and a specificity was 0.87 (477/516) ($p=0.01$); and for diabetes, sensitivity was 0.71 (143/201) and specificity was 0.98 (416/424) ($p<0.001$).

For the comparison of selected medications, 56% of patients (467/832) had known medication status, with the

Table 1. Case characteristics by status of patients admitted with non-traumatic cardiac arrest , n = 1,496.

	Admitted		Died prior to hospital		
	n	%	n	%	p-value
Number of cases	983		513		
Male	748	76.1%	406	79.1%	
Patient age, mean years (SD)	61.1(14.7)		65.5 (15.7)		< 0.001
Circulatory arrest prior to EMS arrival	873	88.8%	468	91.2%	
Witnessed collapse (for arrest on EMS arrival)	690	79.0%	287	61.3%	< 0.001
Bystander CPR (for arrest prior to EMS arrival)	669	76.6%	328	70.1%	< 0.001
Response location					< 0.001
private residence	577	58.7%	322	62.8%	
public location	373	37.9%	140	27.3%	
Care setting: NH, AFH, GH, AL*	33	3.4%	51	9.9%	
Case has a Comorbidity Form (n=1,360)	910	92.6%	450	87.7%	< 0.001
Comorbidity information reported (n=1,360)					< 0.001
any information reported	747	82.1%	382	84.9%	
none reported, or stated unknown	163	17.9%	68	15.1%	
Any heart disease reported (n=1,059 known)	372	53.5%	209	57.4%	0.014
CHF reported (n=1,051 known)	94	13.6%	73	20.3%	< 0.001
Diabetes reported (n=1,052 known)	169	24.5%	99	27.4%	0.01
Number of medications (n=885 known), mean (SD)	3.5(3.3)		3.9(3.0)		< 0.02
Beta blocker listed (n=885 known)	166	29.0%	100	32.1%	< 0.03
Loop diuretic listed (n=885 known)	92	16.1%	73	23.4%	0.025

NH, nursing home; *AFH*, adult family home; *GH*, group home; *AL*, assisted living, *SD*, standard deviation; *CHE*, congestive heart failure.

number and types of medications reported on both the EMS and hospital forms. The average number of medications was 3.4 (SD 3.1) by EMS report compared to 5.0 (SD 4.0) for the hospital form, for a mean difference of 1.6 more medications reported on the hospital form (95% CI 1.3 – 1.9, p < 0.001, paired t-test). As with chronic conditions, there was moderate sensitivity and high specificity with regard to beta blocker and diuretic use (Table 2).

DISCUSSION

In this cohort of persons suffering ventricular fibrillation arrest, we observed variable amounts of information available and recorded by EMS providers. EMS ascertainment of selected chronic health conditions and medications had modest sensitivity and greater specificity when compared to the hospital record.

The field availability of information about chronic health conditions and medication treatments is not well described. In the current investigation, EMS was able to ascertain some information about chronic health conditions for approximately 83% of patients and information about medications in approximately two thirds of patients, though the availability for a specific condition or medication was less. Thus, there is some opportunity for EMS to glean clinical history in the majority of patients, even when the patient cannot be a resource.

Beyond availability, the accuracy of the information about chronic health conditions and medication therapies is also

Table 2. Sensitivity and specificity of emergency medical services (EMS) report for medication use.

	Hospital	
	Positive	Negative
Beta blocker (n=459)*		
EMS		
Positive	118	17
Negative	51	273
Diuretic (n=459)†		
EMS		
Positive	62	12
Negative	27	358

*sensitivity = 0.70, specificity = 0.94, p < 0.001.
† sensitivity = 0.70, specificity = 0.97, p < 0.03.

uncertain. In this current study, with the exception of CHF, we found that the selected medical conditions and medications therapies had a sensitivity of approximately 70% and specificity of 90% or greater. Thus EMS correctly identified about 70% who truly possessed a given characteristic. Conversely, about 5-15% of the time EMS incorrectly identified a given characteristic when it was not present (false positive).

Whether more (accurate) information might be available if this questioning was prioritized as part of training is uncertain. The precise timing of the information was not available based on this review. Information that is available late in the field process may have less relevance for field care though it could direct hospital treatment decisions. Moreover, the study community's EMS system typically has five or more EMS rescuers on scene of a cardiac arrest so that there is potentially more opportunity for this type of information gathering. These qualifications aside, the results suggest that at least some information about chronic health conditions and medications is available during many field resuscitations.

What are the implications of these results? The approach provides an opportunity to understand whether chronic conditions or medication treatments might help explain the OHCA outcome disparity across systems and among patients.[12]. For example, there was a five-fold variation in survival among ventricular fibrillation cardiac arrest cases across the sites participating in the Resuscitation Outcomes Consortium and a 10-fold variation in overall survival among communities participating in the Cardiac Arrest Registry to Enhance Survival.[13,14] The current Utstein data elements explain less than 25% of system differences in survival for ventricular fibrillation.[15] Whether some of this disparity might be explained by patient substrate as characterized by chronic conditions or medication treatment requires further investigation. Certainly there are individual and community differences in chronic health conditions and access to medical care that might provide the circumstance for important differences that not only influence the risk of incident OHCA but also influence prognosis.[16,17]

Moreover, the findings inform the potential to incorporate chronic health conditions into treatment approaches. Although there is currently no strong evidence that selected conditions or medications are amenable to a specific alteration in resuscitation treatment, the concepts are derived from experimental models and modest evidence from observational human investigations.[2,5] The current results suggest that treatment alterations could be implemented in a manner such that a subset with a particular chronic health condition or medication treatment could be correctly identified, but that a sizable subset with the specific condition or medication treatment would be missed based on a substantial false-negative rate. However, there is no clear consensus about what conditions or treatments should be prioritized and how such information collection could be standardized across systems.[18] Presumably the choice would depend upon the presentation and circumstances.

LIMITATIONS

This study has several limitations. The gold standard of hospital ascertainment was only available for those who survived to hospital admission. Those who died prior to hospitalization were different based on Utstein measures such as older age, less bystander CPR, and more residential location. Our finding that this group of older, in-residence arrests had a greater prevalence of chronic conditions and medications suggests that EMS ascertainment for those who died prior to admission is at least consistent with the expectation that comorbidity increases with age.

We also a priori selected chronic health conditions and medications that we believed may be relevant to resuscitation pathophysiology and prognosis. Other conditions or medications may produce different results. Outside of the initial inter-reviewer reliability testing and informal group discussions, there was not a repeat formal evaluation of abstraction performance. Additional effort to evaluate and refine inter-reviewer agreement may have improved precision though the initial inter-reviewer reliability was good.

As noted, the investigation involved a large metropolitan EMS system and the results may not be generalizable to other systems. These limitations should be considered in the context of the study's strengths. The investigation involved a large sample of well-characterized OHCA events, was motivated by an evolving understanding of the pathophysiology and treatment of OHCA, and presented results for a number of conditions and medication treatments.

CONCLUSION

In this cohort of adult patients with non-traumatic OHCA presenting with ventricular fibrillation, information about selected chronic health conditions and medication treatments based on EMS ascertainment was available for many patients, generally revealing moderate sensitivity and greater specificity. The findings suggest that information about chronic health conditions or medication treatments could be relevant when investigating outcome disparity and potentially help guide therapy for a subset if a directed and individualized approach ultimately has therapeutic rationale. Future efforts may evaluate approaches to increase both the availability and accuracy of field information involving chronic health conditions and medication treatments.

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Rapid Primary Care Follow-up from the ED to Reduce Avoidable Hospital Admissions

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Introduction: Hospital admissions from the emergency department (ED) now account for approximately 50% of all admissions. Some patients admitted from the ED may not require inpatient care if outpatient care could be optimized. However, access to primary care especially immediately after ED discharge is challenging. Studies have not addressed the extent to which hospital admissions from the ED may be averted with access to rapid (next business day) primary care follow-up. We evaluated the impact of an ED-to-rapid-primary-care protocol on avoidance of hospitalizations in a large, urban medical center.

Methods: We conducted a retrospective review of patients referred from the ED to primary care (Weill Cornell Internal Medicine Associates – WCIMA) through a rapid-access-to-primary-care program developed at New York-Presbyterian / Weill Cornell Medical Center. Referrals were classified as either an avoided admission or not, and classifications were performed by both emergency physician (EP) and internal medicine physician reviewers. We also collected outcome data on rapid visit completion, ED revisits, hospitalizations and primary care engagement.

Results: EPs classified 26 (16%) of referrals for rapid primary care follow-up as avoided admissions. Of the 162 patients referred for rapid follow-up, 118 (73%) arrived for their rapid appointment. There were no differences in rates of ED revisits or subsequent hospitalizations between those who attended the rapid follow-up and those who did not attend. Patients who attended the rapid appointment were significantly more likely to attend at least one subsequent appointment at WCIMA during the six months after the index ED visit [N=55 (47%) vs. N=8 (18%), P=0.001].

Conclusion: A rapid-ED-to-primary-care-access program may allow EPs to avoid admitting patients to the hospital without risking ED revisits or subsequent hospitalizations. This protocol has the potential to save costs over time. A program such as this can also provide a safe and reliable ED discharge option that is also an effective mechanism for engaging patients in primary care. [West J Emerg Med. 2017;18(5)870-877.]

INTRODUCTION

Hospital admissions from the emergency department (ED) now account for approximately 50% of all admissions.[1] At the same time the Centers for Medicare & Medicaid Services restructured federal policies in 2013, specifically the Two-Midnight Rule and the revised 30-day readmission penalties, to encourage hospital systems to reduce short-stay admissions.[2] The majority of ED visits leading to hospital admissions are classified as intermediate severity.[3] Intermediate severity cases include exacerbations of chronic diseases (e.g. congestive heart failure) and acute presentations of complex medical illnesses (e.g. hyperglycemia in diabetics).[3] Some ED admissions may not benefit from inpatient care if outpatient care can be optimized. Further, discontinuity between ED care and outpatient care can lead to over-testing and conflicting care plans, as well as less-effective preventive care and chronic disease management.[4-6] Thus, ensuring rapid access to outpatient care presents a potentially high-yield intervention with the goal of reducing admissions, repeated ED visits and improving chronic disease management.

The decision to admit a patient from the ED is complex. The disposition of ED patients takes into account not only the clinical scenario but also the presence or absence of immediate and reliable outpatient follow-up. Evidence suggests that access to primary care after ED discharge is critical and challenging.[2-5,8-11] Further, patients' perceptions of their inability to access timely follow-up is a primary motivator for return ED visits and readmissions.[12-15] This may be of particular significance in the publicly insured; as many as two thirds of Medicaid patients with urgent conditions may be unable to procure timely appointments after an ED visit.[16]

Research on successful programs to facilitate care transitions between the ED and primary care is limited.[17] Case management and patient navigation are the only interventions found to consistently reduce ED visits and increase primary care follow-up.[9,18-20] However, to our knowledge there are no studies that directly evaluate the extent to which hospital admissions from the ED may be averted with access to rapid (next business day) primary care follow-up. In this study we evaluate the impact of an ED-to-rapid-primary-care follow-up protocol on avoidance of hospitalizations in a large, urban medical center. As secondary objectives we also determined the rates of rapid follow-up appointment completion, ED revisits, hospitalizations, and subsequent primary care engagement among patients referred through this protocol.

Population Health Research Capsule

What do we already know about this issue?
Access to primary care after emergency department (ED) discharge is critical and challenging. Research on programs to facilitate care transitions between the ED and primary care is limited.

What was the research question?
To what extent can hospital admissions from the ED be averted with access to rapid (next business day) primary care follow-up?

What was the major finding of the study?
Rapid access to primary care is a safe alternative to low-acuity admissions and engages patients into primary care.

How does this improve population health?
Efforts to reduce low-acuity hospitalizations can include, for select patients, rapid access to primary care. Rapid access may also offer an opportunity to engage such patients in primary care.

METHODS

In May 2014, an ED-to-rapid-primary-care protocol was designed and initiated through the collaboration of the New York-Presbyterian Hospital (NYP), Weill Cornell Emergency Department and Weill Cornell Internal Medicine Associates (WCIMA), a large academic faculty and resident practice at the NYP / Weill Cornell campus. This protocol uses a "transitions team" (a registrar and a nurse care manager at WCIMA), as well as a secure Intranet-based electronic and telephone scheduling system to facilitate the rapid scheduling of ED patients with a primary care provider at WCIMA. The system was created for emergency physicians (EP) to use for patients who could avoid an admission to the hospital if given rapid primary care follow-up (within 24 hours on weekdays or a Monday appointment for those seen over the weekend). Since the beginning of this program, each patient referred through this process has been tracked for quality and safety purposes via a secure registry kept by the WCIMA transitions team. Although the protocol was created primarily to serve those patients for whom an admission could be averted, our registry demonstrated a diverse set of reasons for the ED referrals. For this reason, our chart reviewers were asked to isolate referrals that potentially represented an avoided admission.

We conducted a retrospective cohort study of all patients referred for rapid follow-up through this protocol from May 2014 to May 2015 – the first year of the program. Data collected from the electronic medical record (EMR) review included demographic information, primary ED discharge diagnosis, ED visit level of service, rapid-primary-care appointment completion,

outpatient visit level of service, 72-hour, 30-day, and six-month ED revisits, 30-day and six-month hospitalization, and mortality. Engagement in primary and/or specialty care was also assessed and was defined as completing at least one additional appointment in the six months following the rapid primary care appointment. The protocol was approved by the Weill Cornell Medical College Institutional Review Board.

We were interested in identifying and studying those patients for whom this protocol could most benefit (through the avoidance of a hospitalization) or potentially harm (through an ED discharge without completing a rapid appointment). To identify the first subset, physician reviewers were asked to review the patient charts and assess whether the referral represented an "avoided admission" by answering the following hypothetical question:

Without the option to refer this patient for rapid follow-up to WCIMA:

1. I definitely would have admitted this patient
2. I might have admitted this patient
3. I probably would not have admitted this patient
4. I definitely would not have admitted this patient.

Because internal medicine (IM) physicians and EPs may have disparate practices or thresholds for admitting patients, we had abstractors from both disciplines review the EMRs of each subject. This was done to enhance generalizability for institutions that have admitting internists instead of admitting EPs.

There were three IM physician reviewers. To establish agreement, the IM reviewers analyzed the same charts until at least 90% agreement was reached. Scores 1 and 2 were considered "would have admitted," and 3 and 4 were considered "would not have admitted." Once at least 90% agreement was reached, the remaining charts were divided evenly among the IM reviewers. Two EM reviewers used the same approach for reviewing charts. Both an IM and an emergency physician reviewed all charts. In recognition of potential hindsight bias, reviewers were instructed to only review EMR notes and data from the day of the ED visit or prior to the visit. Encounters or data that occurred after the ED discharge were not considered. The reviewers were blinded to the assessments of their colleagues.

We analyzed the characteristics and outcomes of patients in two ways. The first analysis included patients who were considered by the EM reviewers to represent an avoided admission. Although we compared categorizations between the IM and EM reviewers, we used the EM determination because in our institution, decisions to admit are made by EPs. Our second analysis compared characteristics and outcomes of patients who did and did not attend their rapid appointment.

Finally, we conducted a subgroup analysis among patients for whom this protocol could potentially have harmed – those patients discharged from the ED and who did not arrive for their rapid follow-up appointment. We described their characteristics and outcomes and performed a more in-depth, qualitative chart review of these patients.

Statistical Analysis

We performed all analyses using Stata 14.0 (Stata Corp., College Station, TX). Data are presented as proportions, means with standard deviations (SDs), and medians with interquartile ranges (IQRs). Analyses were done using chi-square, Fisher's exact test, Student's t-test, and Kruskal-Wallis test, as appropriate. All P values are two-tailed, with $P<0.05$ considered statistically significant.

RESULTS

We reviewed the charts of 162 subjects referred for rapid follow-up at WCIMA from the ED between May 22, 2014, and May 27, 2015. The subjects had a median age of 49 (IQR 33 – 63) years and 59% were female; 45% had commercial insurance, 14% were insured with Medicare, 32% with Medicaid, and 9% had no insurance. Most of the subjects were new to WCIMA, 114 (70%), and among these 20% had an outside PCP, 45% did not have an outside PCP, and 35% had no documentation about an outside PCP.

Nearly three-quarters of subjects had an ED level of service of 4 or 5. The top three categories for reasons for a referral for rapid WCIMA follow-up were gastroenterology, such as follow-up of abdominal pain (N=26, 16%), need to establish primary care (N=26, 16%), and cardiology, such as hypertension follow-up (N=23, 14%).

When the 4-point avoidability scale was collapsed into binary categories (referral represented an avoided admission or referral did not represent an avoided admission), agreement between the two physician groups was high at 75.93% (P<0.001). Isolating the referrals that were considered avoided admissions, EPs classified 26 (16%) of referrals compared with IM physicians who classified 43 (27%) as avoided admissions.

Of the 162 patients referred for rapid follow-up, 118 (73%) arrived for their rapid appointment, 31 (19%) did not arrive for their appointment, 9 (6%) cancelled, 2 (1%) declined, and 2 (1%) were unable to be contacted to make the appointment.

Characteristics of patients classified by EPs as having an avoided admission compared to those not considered to be among the avoided admissions are shown in Table 1. Patients with avoided admissions were older than those without avoided admissions. This group was also more likely to have a higher ED level of service. There were no statistically significant differences between the avoided admission and not-avoided admissions groups with respect to arrival to the rapid-primary-care appointment. Subsequent ED visits (at 72 hours, 30 days, and six months) and hospitalizations (at 30 days and six months) were similar between the groups. Primary care engagement following the index ED visit and referral for rapid primary care follow-up was also similar.

Table 1. Characteristics of patients with and without avoided admissions due to rapid primary care follow-up, as defined by emergency physicians.

	Overall (n=162)	Admission avoided (n=26)	No avoided admission (n=136)	p value
Demographic characteristics				
Age (years), median (IQR)	50 (33 – 63)	55 (42 – 74)	49 (31 – 60)	0.02
Female	95 (59%)	15 (58%)	80 (59%)	0.92
Insurance				0.20
Commercial	73 (45%)	10 (38%)	63 (46%)	
Medicare	23 (14%)	6 (23%)	17 (13%)	
Medicaid	52 (32%)	6 (23%)	46 (34%)	
None	14 (9%)	4 (15%)	10 (7%)	
ED level of service				0.04
2	4 (2%)	0 (0%)	4 (3%)	
3	41 (25%)	2 (8%)	39 (29%)	
4	94 (58%)	17 (65%)	77 (57%)	
5	23 (14%)	7 (27%)	16 (12%)	
Patient new to Weill Cornell Internal Medicine Associates (WCIMA)	114 (70%)	17 (65%)	97 (71%)	0.54
Patient has outside primary care physician (PCP) (n=114)				0.35
Yes	23 (20%)	5 (29%)	18 (19%)	
No	51 (45%)	5 (29%)	46 (47%)	
Unknown	40 (35%)	7 (41%)	33 (34%)	
Outcomes				
Arrived for rapid follow-up	118 (73%)	17 (65%)	101 (74%)	0.35
Return emergency department (ED) visit within 72 hours index ED visit	7 (4%)	1 (4%)	6 (4%)	1.00
ED visit within 30 days of index ED visit	16 (10%)	2 (8%)	14 (10%)	1.00
ED visit within 6 months of index ED visit	45 (28%)	7 (27%)	38 (28%)	0.92
Hospitalization within 30 days of index ED visit	7 (4%)	1 (4%)	6 (4%)	1.00
Hospitalization within 6 months of index ED visit	15 (9%)	2 (8%)	13 (10%)	1.00
Primary care engagement				
With WCIMA during 6 months after index ED visit	63 (39%)	10 (38%)	53 (39%)	1.00
With WCIMA during 6 months after initial rapid follow-up appointment (n=118)	55 (47%)	7 (41%)	48 (48%)	0.79
With another PCP during 6 months after index ED visit	4 (2%)	0 (0%)	4 (3%)	1.00
With WCIMA or another PCP during 6 months after index ED visit	66 (40%)	10 (38%)	56 (41%)	0.80

Characteristics of patients who attended their rapid primary care follow-up appointment compared to those who did not are shown in Table 2. Patients who attended their appointments and those who did not were similar with respect to most demographic characteristics. Those who attended were more likely to not have an outside primary care physician (PCP). Classification as an avoided admission, subsequent ED visits (at 72 hours, 30 days, and six months), and subsequent hospitalizations (at 30 days and six months) were similar between the groups. Primary care engagement differed significantly between the two groups with those attending their rapid follow-up appointment more likely to engage with primary care in the six months following the index ED visit.

Table 2. Characteristics of patients according to attending rapid primary care appointment after emergency department discharge.

	Attended rapid appointment (n=118)	Did not attend rapid appointment (n=44)	p value
Demographic characteristics			
Age (years), median (IQR)	50 (37 – 65)	46 (31 – 62)	0.79
Female	73 (62%)	22 (50%)	0.17
Insurance			0.71
Commercial	51 (43%)	22 (50%)	
Medicare	19 (16%)	4 (9%)	
Medicaid	38 (32%)	14 (32%)	
None	10 (8%)	4 (9%)	
ED level of service			0.28
2	2 (2%)	2 (5%)	
3	30 (25%)	11 (25%)	
4	72 (61%)	22 (50%)	
5	14 (12%)	9 (20%)	
Patient new to Weill Cornell Internal Medicine Associates (WCIMA)	84 (71%)	30 (68%)	0.71
Patient has outside primary care physician (PCP) (n=114)			0.03
Yes	17 (20%)	6 (20%)	
No	43 (51%)	8 (27%)	
Unknown	24 (29%)	16 (53%)	
Outcomes			
Emergency physician classification as avoided admission	17 (14%)	9 (20%)	0.35
Return emergency department (ED) visit within 72 hours index ED visit	4 (3%)	3 (7%)	0.39
ED visit within 30 days of index ED visit	10 (8%)	6 (14%)	0.33
ED visit within 6 months of index ED visit	30 (25%)	15 (34%)	0.27
Hospitalization within 30 days of index ED visit	6 (5%)	1 (2%)	0.68
Hospitalization within 6 months of index ED visit	10 (8%)	5 (11%)	0.57
Primary care engagement			
With WCIMA during 6 months after index ED visit	55 (47%)	8 (18%)	0.001
With another PCP during 6 months after index ED visit	4 (3%)	0 (0%)	0.58
With WCIMA or another PCP during 6 months after index ED visit	58 (49%)	8 (18%)	<0.001

None of the subjects who arrived for the rapid follow-up appointment were sent back to the ED from that appointment. Based on our chart review, there were no deaths among the entire patient cohort within the six months following the index ED discharge.

Patients who were new to WCIMA were less likely to be engaged in primary care during the six months after the index ED visit at WCIMA (31% vs. 58%; P=0.001). Patients without an outside PCP were more likely than those with an outside PCP, or those for whom it was not known whether they had an outside PCP, to engage in any primary care during the six months after the index ED visit (43% vs. 30% vs. 20%; P=0.06).

We considered nine (6%) patients to be at highest risk for adverse outcomes because they were considered an avoided admission and did not attend their rapid follow-up appointment (Figure). Most (78%) did complete an outpatient follow-up visit despite missing their rapid appointment; these visits occurred on average within 1-2 weeks of the ED index visit. None of the eight patients returned to our ED or had a subsequent admission to our hospital.

DISCUSSION

This retrospective review of the first year of an ED-to-rapid-primary-care follow-up protocol offers a number of

points for discussion related to quality, safety, and engagement of ED patients discharged to primary care. In this study we aimed to evaluate the extent to which the option to refer a patient for rapid follow-up would impact the EP's decision to admit a patient. While many previous studies have reported on defining "preventable" admissions and re-admissions, to our knowledge there is not a standard definition of admission avoidability.[9] To assess the extent to which the referrals represented an avoided admission, we developed an avoidability rating scale to isolate patients referred for this reason from the ED. Based on this avoidability assessment score and as determined by the EP reviewers, 16% of all subjects referred represented an avoided admission. While the overall number of patients in the first year of our program was small, over time this could represent a substantial cost savings. Furthermore, safely avoiding a hospitalization removes a significant burden on both patients and the hospital system.

An additional aim of our program was to provide the option for reliable and accessible rapid primary care follow-up for patients being discharged from ED. The majority of all subjects in the entire cohort as well as in the avoided admission group arrived for their rapid follow-up appointment. This rate is higher than the average appointment completion rate at our clinic and in other reports on completion of rapid follow-up after ED discharge.[5] We postulate this may reflect the timing of the appointment offering as well as communication from the ED providers around the importance of the follow-up. Thus, in most cases the opportunity to refer a patient for rapid primary care follow-up at WCIMA represented a safe and reliable discharge plan. None of the subjects were sent back to the ED from the rapid follow-up appointment, which suggests that at the time of follow-up there was no indication for emergency or inpatient care.

However, nine subjects in the avoided admissions group did not arrive for their rapid follow-up appointment. This group could be considered at the highest risk for an unsafe outcome since they likely would have been admitted without the existence of the rapid follow-up appointment. Fortunately, seven out of the nine subjects (78%) did complete outpatient follow-up with either primary or specialty care within 1-2 weeks of the ED discharge, suggesting that outpatient referral was successful and that more flexible timing of the rapid appointment should be considered. Two out of the nine were lost to follow-up: a 30-year-old female who was newly diagnosed with diabetes, and a 35-year-old female with congenital heart disease and atypical chest pain. None of the nine subjects returned to our ED or was admitted to our hospital within six months.

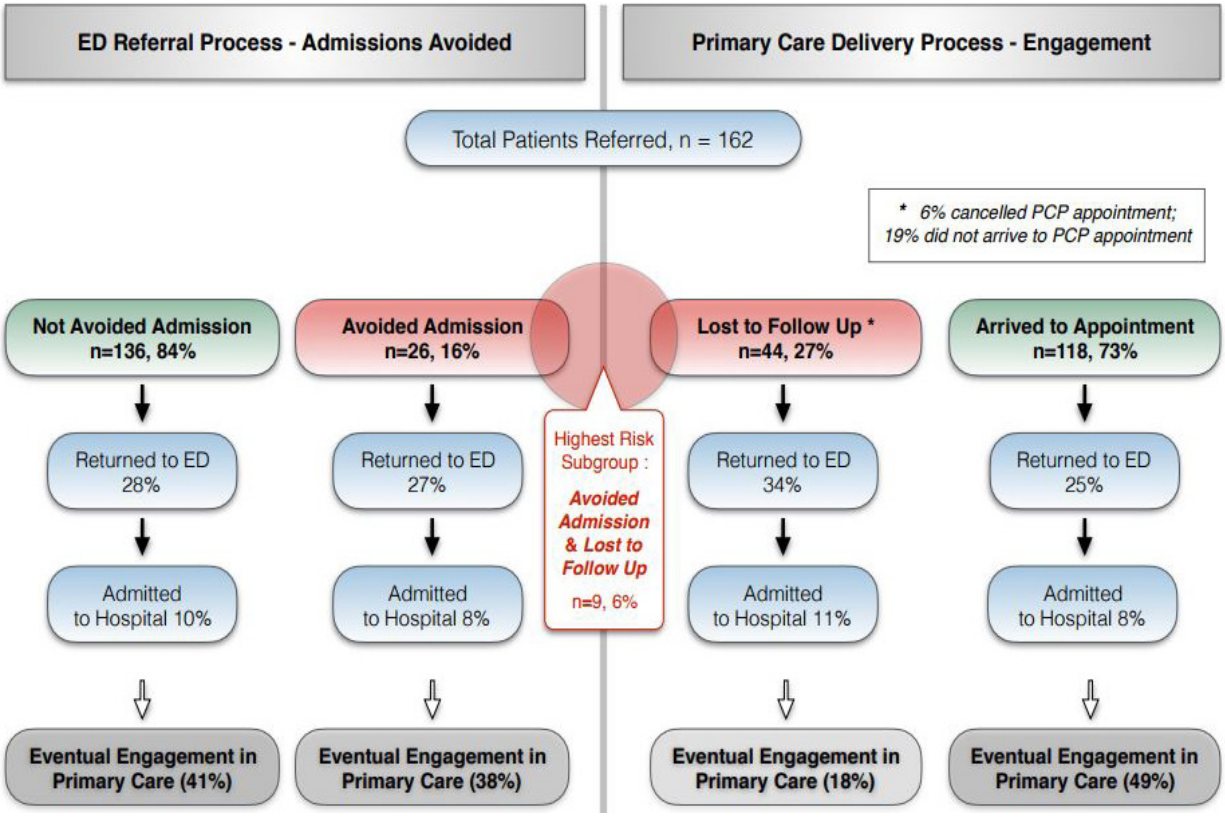

Figure. Patients referrals and outcomes.
ED, emergency department; *PCP*, primary care physician.

Ten percent of subjects in this cohort revisited the ED within 30 days of the index ED visit. This is lower than the national 30-day ED revisit rate of 19.9% reported by the Healthcare Cost and Utilization Project.[10] The rate in this cohort was comparable to historical ED revisit rates at our own institution (8%). These comparisons further indicate the safety and efficiency of the program.

Anecdotal evidence as well as some observational studies suggest that EPs may be more likely to admit patients to the hospital than their IM colleagues or admit patients who could be safely discharged from the ED.[9] However, in our retrospective review EPs rated fewer patients as those they would have admitted than the IM physicians.

The clinical reasons for referral for rapid follow-up in this cohort were diverse, which makes it challenging to identify particular diagnoses that might be especially appropriate for this program. However, the need to establish primary care was one of the most common reasons for referral. This reinforces the findings noted below that the ED encounter offers an opportunity to engage patients in primary care.

Receiving regular primary care is associated with a number of health benefits including increased receipt of preventative services and better chronic disease management.[11–15] A large percentage of subjects in our cohort engaged in primary care after the rapid primary care referral. Furthermore, subjects who attended the rapid follow-up appointment were significantly more likely to engage in primary care, suggesting that right after an ED visit may be an optimal time to capture patients into regular primary care.

LIMITATIONS

There are a number of limitations to this study. Our primary aim was to assess avoidability. Since no standard avoidability criteria exist, we were required to devise our own assessment. Therefore, we cannot ensure the validity or reproducibility of this assessment scale. Further, the retrospective nature of our evaluation cannot completely simulate the patient-care interaction where the actual admission decision was made, so it may be open to biases and is subjective. In addition, while we were able to collect data on follow-up, hospitalizations, and ED revisits at our own institution, as well as mortality data based on our EMR review, we were not able to include data on hospitalizations, ED visits, or outpatient follow-up at other institutions and could not verify mortality data in all cases. The average age of the patients in this sample was 50; thus, our findings may not be applicable to an older population. However, our results suggest that younger patients may be good candidates for a program such as this. Finally, this study was conducted at a single institution, which may limit generalizability. Further, since this is an analysis of the first year of the program only, we had a relatively small number of subjects.

CONCLUSION/FUTURE DIRECTIONS

Results from this analysis suggest that a protocol to ensure rapid primary care follow-up for ED patients can allow emergency physicians to avoid some patient admissions. Such a program has the potential for cost savings over time given that, in general, outpatient care often represents a cost savings when compared to an inpatient admission. In the future we intend to conduct a cost analysis to compare the inpatient costs saved by an avoided admission with those incurred from outpatient follow-up and from reserving appointment slots for the rapid discharge program. We also hope to conduct a prospective study. Our data suggest that a rapid-ED-to primary-care follow-up program can provide a safe and reliable ED discharge option that is also an effective mechanism for engaging patients in primary care. Such primary care engagement has the potential to lead to further containment in overall healthcare costs, as well as to improved patient care and health outcomes.

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Pediatric Patients Discharged from the Emergency Department with Abnormal Vital Signs

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Introduction: Children often present to the emergency department (ED) with minor conditions such as fever and have persistently abnormal vital signs. We hypothesized that a significant portion of children discharged from the ED would have abnormal vital signs and that those discharged with abnormal vital signs would experience very few adverse events.

Methods: We performed a retrospective chart review encompassing a 44-month period of all pediatric patients (aged two months to 17 years) who were discharged from the ED with an abnormal pulse rate, respiratory rate, temperature, or oxygen saturation. We used a local quality assurance database to identify pre-defined adverse events after discharge in this population. Our primary aim was to determine the proportion of children discharged with abnormal vital signs and the frequency and nature of adverse events. Additionally, we performed a sub-analysis comparing the rate of adverse events in children discharged with normal vs. abnormal vital signs, as well as a standardized review of the nature of each adverse event.

Results: Of 33,185 children discharged during the study period, 5,540 (17%) of these patients had at least one abnormal vital sign. There were 24/5,540 (0.43%) adverse events in the children with at least one abnormal vital sign vs. 47/27,645 (0.17%) adverse events in the children with normal vital signs [relative risk = 2.5 (95% confidence interval, 1.6 to 2.4)]. However, upon review of each adverse event we found only one case that was related to the index visit, was potentially preventable by a 23-hour hospital observation, and caused permanent disability.

Conclusion: In our study population, 17% of the children were discharged with at least one abnormal vital sign, and there were very few adverse (0.43%) events associated with this practice. Heart rate was the most common abnormal vital sign leading to an adverse event. Severe adverse events that were potentially related to the abnormal vital sign(s) were exceedingly rare. Additional research is needed in broader populations to better determine the rate of adverse events and possible methods of avoiding them. [West J Emerg Med. 2017;18(5)878-883.]

INTRODUCTION

Fever, tachycardia, and tachypnea are frequently seen in pediatric emergency department (ED) patients.[1,2] Experience suggests that children presumed to have a minor illness are often discharged from the ED despite having one or more abnormal vital signs and that they generally do not experience an adverse outcome.

Using vital signs for risk stratification has been postulated as one potential mechanism for identifying children at high risk for sepsis. Several studies have been published evaluating the diagnostic and predictive utility of vital sign abnormalities at the time of presentation and during an ED visit in pediatric patients.[2-5] Additionally, several pediatric clinical prediction rules have included vital signs in their analysis of the likelihood of sepsis in febrile children.[6-18] However, we are unaware of any literature examining the practice of discharging children from the ED who have abnormal vital signs at the time of discharge.

The aim of this study was to answer two questions: (1) What proportion of children discharged from the ED had at least one abnormal vital sign at the time of discharge during the study period; and (2) How often do these patients experience a significant adverse event that was likely related to the abnormal vital sign(s)?

METHODS

We conducted a retrospective chart review over a 44-month period (April 2010 to November 2013) of all children aged two months to 17 years discharged from a large academic medical center ED. Institutional review board approval was granted.

We obtained data from two sources. First, the ED electronic health record system was queried for all children aged two months to 17 years discharged from the ED during the study period. Discharge vital signs were extracted from the patient's medical record as their last set of vital signs taken on each patient. We defined abnormal vital signs as temperature greater than 100.4 F (38.0 C) and oxygen saturation less than 95%, while heart rate and respiratory rate were considered abnormal if outside standard published age-specific ranges.[19,20]

Second, our ED quality control database was reviewed for the same time period. This database has all 72-hour returns, patient complaints, internal and external referrals for morbidity and mortality review, and deaths. As the only pediatric referral center in northeastern New York State, we assumed that our quality assurance database estimates the total number of adverse events in children discharged from our ED.

Before collecting data, our research team – consisting of pediatric emergency medicine (PEM), dual-boarded emergency medicine (EM)/PEM, and EM-trained physicians – deliberated and reached a consensus on what constituted an adverse event: re-presentation to hospital and admission for ≥ five days, cardiopulmonary resuscitation, endotracheal intubation, and unexpected surgery. Patient death related to the initial visit was also included on a case-by-case basis, even if it did not take place within the 72 hours after ED discharge. Because there is no evidence-based consensus on what length of stay for a readmission constitutes an adverse event, our research team chose a longer length of stay for readmissions (five days as opposed to three days) in order to identify cases that would be very important for an emergency physician to avoid.

To further adjudicate each case, the records for all patients found to have an adverse event were independently reviewed by two study authors (one boarded in EM and another dual-boarded in EM/PEM) to determine whether (a) the adverse event could reasonably have been considered as potentially related to the initial visit; (b) the adverse event would likely have been prevented if the patient had been observed in the hospital rather than discharged; and/or (c) the adverse event resulted in death or likely permanent disability. On two occasions there was a discrepancy between the two reviewers, and a third investigator (board certified in EM) independently reviewed the case to break the tie. To minimize the rate of missed adverse events, the adjudicators were asked to categorize cases that were not clear as "having an adverse event."

We determined the proportion of pediatric patients discharged with abnormal vital signs and the rate of occurrence of adverse events. The relative risk was calculated by comparing the rate of adverse events in children with at least one abnormal vital sign at the time of discharge vs. children discharged with normal vital signs. For each individual vital sign, we created ROC curves and calculated the area under the curve. Data analysis was performed using STATA 14.0 (StataCorp LLC, College Station, Texas).

RESULTS

A total of 33,185 children aged two months to 17 years were discharged from the ED during the study period. Age distribution is shown in Figure 1, and additional demographics are shown in Table. Of these patients, 5,540 (17%) were discharged with at least one abnormal vital sign. A flow diagram of discharged patients with (1) normal vs. abnormal vital signs, (2) *a priori* defined adverse outcomes, and (3) preventable adverse outcomes leading to disability or death after review is presented in Figure 2.

Of the 5,540 children discharged with one or more abnormal vital signs, 24 (0.43%) met our *a priori* criteria for an adverse event (see below for categorization of outcome). Of the 27,645 patients discharged with normal vital signs, 47 (0.17%) met *a priori* criteria for an adverse event. The relative risk (RR) of *a priori* defined adverse events in patients discharged with one or more abnormal vital signs compared with those with normal vital signs was 2.5 (95%, CI [1.6 – 4.2]) and the number needed to harm (NNH) was 380 (95%, CI [252 – 767]).

Table. Demographic features of the study population.

	Percentage
Age	
2 months to 1 year	11.9%
1 year to 4 years	37.7%
5 years to 10 years	24.5%
11 years to 17 years	25.6%
Gender	
Female	46.2%
Male	53. 8%
Race/ethnicity	
White	56.2%
Black	28%
Other	15.8%
Identified as Hispanic	10.8%
Insurance status	
Insured	95.7%
Uninsured	4.3%

*Patients having Medicaid or Medicaid managed care were considered insured.

Among the 24 children discharged with one or more abnormal vital signs and who had an adverse event, seven (29%) were discharged with an elevated temperature ranging from 100.5 F to 103.2 F, seven (29%) were discharged with a low oxygen saturation ranging from 92% to 94%, 16 (67%) were discharged with an age-specific abnormal heart rate, and four (17%) were discharged with an age-specific abnormal respiratory rate. Among the 5,516 children discharged with abnormal vital signs and no adverse events, there were 2,498 (45.3%) children discharged with elevated temperatures ranging from 100.4 F to 105.6, 819 (14.9%) children discharged with low oxygen saturations ranging from 66% to 94%, 3,092 (56.1%) children discharged with an age-specific abnormal heart rate, and 483 (8.8%) children discharged with an age-specific abnormal respiratory rate. When creating ROC curves for each of the vital signs individually, we found that pulse, respiration, temperature, and oxygen saturation had poor discrimination for predicting adverse events (area under the curve 0.57, 0.54, 0.45, 0.59, respectively). See supplemental material for ROC curves.

When each adverse event was adjudicated, it was found in the abnormal vital signs group that five patients required surgery (none of which sustained permanent morbidity from a complication secondary to delayed presentation), 17 patients were admitted to the hospital for five days or longer (none with likely permanent morbidity/disability), and two patients died. On review of the deaths, one was judged to be unrelated to the index visit (unrelated accidental injury), and the other death was due to infection and not believed to be potentially preventable by hospital observation. Among the 17 patients admitted to the hospital for five days or longer, 12 were admitted primarily because of infectious related problem, three were admitted primarily because of gastroenterological or metabolic condition, and two were admitted primarily because of an exacerbation of a chronic condition.

In the normal vital signs group, 11 patients required surgery (one of whom sustained permanent morbidity from a complication secondary to delayed presentation), 36 patients

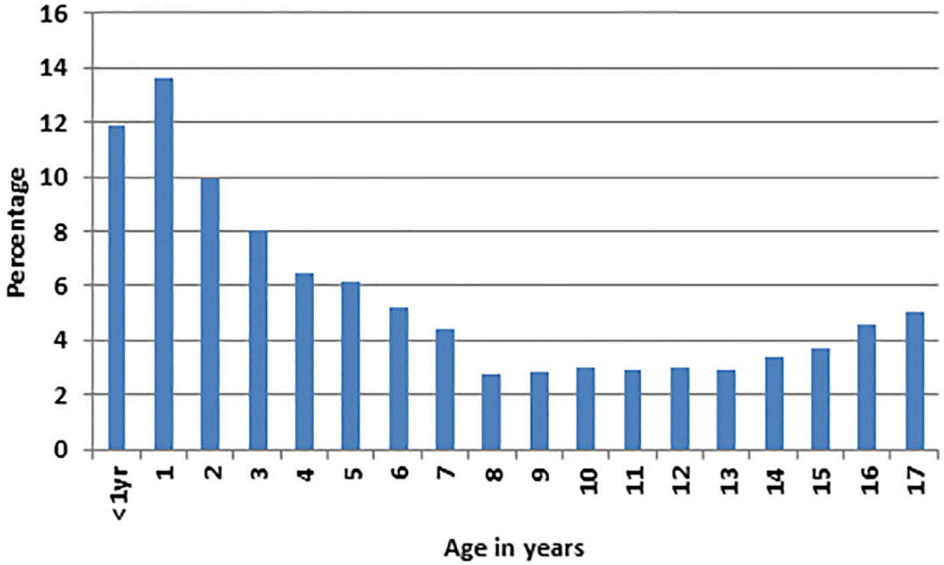

Figure 1. Age distribution of the 33,185 pediatric patients in a study examining the relationship between adverse outcomes and discharge from the emergency department with abnormal vital signs.

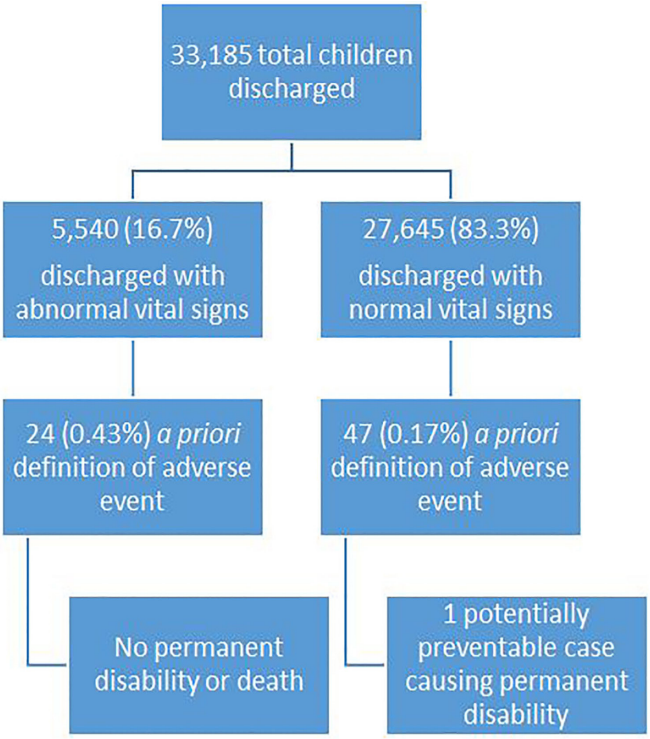

Figure 2. Flow diagram of discharged patients with (1) normal vs. abnormal vital signs, (2) a priori-defined adverse outcomes, and (3) preventable adverse outcomes leading to disability or death after review.

were admitted to the hospital for five days or longer, and no patients died. Among the 36 patients admitted to the hospital for five days or longer, 17 were admitted primarily because of infectious related problem, five were admitted primarily because of gastroenterological or metabolic condition, and 14 were admitted primarily because of rheumatologic, cardiac, otolaryngological, hematology/oncology, or other problem related to a chronic disease.

In summary, after further manual review of each adverse event, one case (in the normal vitals group) was deemed by the reviewers to have been related to the index visit, potentially preventable, and to have led to permanent disability. This patient was a pre-school aged child who presented during the index visit with intermittent abdominal pain and a normal testicular exam documented in the record, who subsequently represented with a testicular torsion requiring orchiectomy. The case was judged to be potentially preventable with a hospital admission and to have led to permanent disability by two out of the three adjudicators.

DISCUSSION

In our study population, it was relatively common for pediatric patients to be discharged from the ED with abnormal vital signs, and it was rare for these patients to experience adverse events.

The rate of adverse events was greater in children discharged with abnormal vitals than those discharged with normal vitals (RR = 2.5, 95%, CI [1.6 – 4.2]). This is not surprising since vital signs are usually considered to have at least some utility in predicting whether a child is sick. Nevertheless, it is important to contextualize the statistically significant relative risk as the rates of adverse events in both cohorts (children discharged with normal vitals and children discharged with abnormal vitals) were very low.

Furthermore, it was important to us to not only determine the rate of our *a priori* defined adverse events, but to also assess the nature and severity of each adverse event. For example, if a child with bronchiolitis is discharged from the ED and subsequently requires hospital admission for several days but suffers no permanent morbidity, this may be considered a typical progression of the illness rather than a severe adverse event. Conversely, a child who appeared well enough to discharge home but who returned with meningitis and permanent brain injury would be exactly the kind of disastrous case that we would most want to identify. When each case was reviewed for whether there was an event that was preventable and/or caused permanent disability or death, there were so few cases (one case of potentially preventable permanent disability and no potentially preventable deaths) that any type of comparison between the abnormal and normal vital signs groups would not be meaningful.

LIMITATIONS

Our study has several limitations. First, while our data represents 33,185 discharges, there were very few adverse events, deaths, and/or cases of permanent disability in our single-site retrospective study. Given the relatively small number of adverse events, we were only able to use a single "cutoff" value for each abnormal vital sign in our data analysis. Further studies, using larger datasets with greater numbers of serious adverse events, would be needed to determine vital sign thresholds or collections of abnormal vital signs that predict unsafe discharges.

Second, we assumed that our own morbidity/mortality review process collected all major adverse events in discharged patients. While we believe that this methodology was acceptable for this particular study, the study would have been strengthened if it had been linked with statewide registries and/or death records to ensure that there were no additional significant adverse events of which we were not aware. Third, categorizing adverse events is often subjective. Because we wished to identify more serious adverse events – cases in which it would be highly important for an emergency physician to take great pains to avoid – we defined a longer inpatient stay of five days (as opposed to three days) to be an adverse event. We also tried to mitigate this subjectivity as we best we could by basing our primary analysis on a set of predefined criteria, and then by adjudicating each case to see if it was preventable and/or caused permanent disability or death.

Fourth, we do not know the route by which temperature was taken since this information is often not recorded in our electronic heath record system. However, we believe that our study represents a real-life scenario, since the research data consists of the last set of vital signs that the emergency provider saw before discharging the patient. Finally, because we specifically looked at patients who were already discharged, we do not know how many patients may have been admitted to the hospital solely because they had one or more abnormal vital signs at the time of planned discharge on the index visit, and hence would not have been included in our analysis. We acknowledge that vital signs are only a piece of the clinical puzzle, and mature emergency providers must take into account the entire clinical picture, including clinical appearance, social situation, potential for follow-up, etc.

CONCLUSION

In this retrospective review at one institution, 17% of pediatric patients were discharged from the ED with one or more abnormal age-specific vital signs. Heart rate (66%) was the most common abnormal vital sign leading to adverse event. Adverse events were 2.5 times more common (95%, CI [1.6 – 4.2]) in patients discharged with abnormal vital signs compared to those discharged with normal vital signs, but the frequency of adverse events in both groups was low (0.43% in the abnormal vitals group and 0.17% in the normal vitals group). Furthermore, after reviewing each adverse event, there was only one case that led to permanent disability and may have been preventable if the patient had been observed or admitted rather than discharged. Further study in broader patient populations is needed to verify our results, and identify characteristics of ED discharge vital signs that may be useful to guide patient care.

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Predictors of Return Visits Among Insured Emergency Department Mental Health and Substance Abuse Patients, 2005-2013

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Introduction: Our goal was to describe the pattern and identify risk factors of early-return ED visits or inpatient admissions following an index mental health and substance abuse (MHSA)-related ED visit in the United States.

Methods: We performed a retrospective cohort study using Optum Labs Data Warehouse, a nationally representative database containing administrative claims data on privately insured and Medicare Advantage enrollees. Authors identified patients presenting to an ED with a primary diagnosis of MHSA between 2005 and 2013 who were discharged home. Study inclusion required continuous insurance enrollment for the 12 months preceding and the 31 days following the index ED visit. During the study period we included only the first ED visit for each patient.

Results: A total of 49,672 (14.2%) had a return visit to the ED or had a hospitalization within 30 days following discharge. Mean time to the next ED visit or inpatient admission was 11.7 days. An increased age (age 65+ vs. age <18 years; OR 1.65, 95% CI [1.57 to 1.74]), chronic medical comorbidities (Hwang comorbidity 5+ vs 0; OR 1.31, 95% CI [1.27 to 1.35]), prior ED and inpatient utilization (4+ visits vs 0 visits; OR 5.59, 95% CI [5.41 to 5.78]) were associated with return visits within 30 days following discharge.

Conclusion: In an analysis of nearly 350,000 ED visits for MHSA, 14.2 % of patients returned to the ED or hospital within 30 days. This study identified a number of factors associated with return visits for acute care. [West J Emerg Med. 2017;18(5)884-893.]

INTRODUCTION

It is estimated that one in five Americans suffer from a chronic mental health and substance abuse (MHSA) issue,[1] many of which require acute care. Reduction in the number of inpatient psychiatric beds since the 1960s has led to large increases in mental health-related emergency department (ED) visits in the United States.[2] MHSA-related ED visits increased from an estimated 4-6% in 1992 to an estimated 12% of ED visits in the U.S. in 2007.[3-5] EDs are frequently used for the initial evaluation of MHSA emergencies and many patients treated in the ED for MHSA return soon for acute care; a previous study of ED return visits related to pediatric

psychiatric illness from Canada indicated that as many as 15% of patients with mental illness returned to the ED within three days. [6] Thus, return visits for acute care following the initial ED visit may represent avoidable healthcare utilization.

Currently, little is known about the characteristics of patients who present to the ED for psychiatric care, and, more importantly, who among these patients are at high risk for early return for acute care whether mental health related or not. Elucidating the trend, timing of return beyond the three-day mark, and risk factors for return visits may enable clinicians to develop strategies for preventing early-return visits for acute care and assist policymakers with appropriate resource allocation for those at highest risk for early return.

We used a national insurance-claims database to describe the trend and identify risk factors of return visits to the ED or hospitalization occurring within 3, 7 and 30 days after index ED discharge for MHSA evaluation. The primary objective was to identify risk factors for early-return ED visits.

Population Health Research Capsule

What do we already know about this issue?
Emergency Departments are frequently used for the evaluation of mental health and substance abuse related emergencies. Many patients treated in the ED for MHSA return soon for acute care.

What was the research question?
To describe the trend and identify risk factors of return visits to the ED visit occurring after index ED discharge for MHSA evaluation.

What was the major finding of the study?
In an analysis of ED visits for mental health and substance abuse, 14.2 % of patients returned to the ED or hospital within 30 days with several risk factors for returns, including age, previous utilization and comorbidities.

How does this improve population health?
Our findings may help to elucidate the group that may benefit from intense outpatient referral to prevent unnecessary return visits.

METHODS

Data Source

We conducted an analysis using the Optum Labs Data Warehouse (OLDW), a database including administrative claims on privately insured and Medicare Advantage enrollees.[7] OLDW has been used previously in studies of the therapeutic patterns and outcomes of patient care.[7-9] The database includes all medical claims for over 100 million enrollees throughout the U.S.[7, 10] Medical claims and enrollment files include information on birth year, sex, dates of enrollment coverage, *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) diagnosis codes, ICD-9 procedure codes, *Current Procedural Terminology, Version 4* (CPT-4) procedure codes, *Healthcare Common Procedure Coding System* (HCPCS) procedure codes, place of service codes and provider specialty codes. We accessed study data in compliance with the Health Insurance Portability and Accountability Act of 1996. This study involved only the analysis of pre-existing, de-identified data and was therefore exempt from institutional review board approval.

Selection of Participants

We identified all ED visits of patients presenting to the ED with a primary diagnosis of a MHSA-related visit between January 1, 2005, and November 30, 2013. To be included in the cohort, patients were required to have had continuous medical coverage for at least 12 months prior to the index ED visit and 31 days after the visit. We defined 12 months of continuous coverage as the requirement to ensure the reliability of longitudinal data, which is similar to the previous study using OLDW.[10] ED visits related to MHSA conditions were determined by using the primary ICD-9-CM diagnosis codes. Agency for Healthcare Research and Quality (AHRQ) Clinical Classifications Software (CCS) for ICD-9-CM categorization scheme was applied to categorize the primary diagnosis for each index ED visit (Supplemental Table 1). [11] CCS is the software that collapses the ICD-9 code into a smaller number of clinically useful categories.[11]

We excluded ED visits if there was a hospital admission on the same or next day of ED discharge. ED visits were also excluded if they had a primary diagnosis that fell into the CCS categories for delirium, dementia, other amnestic disorders, and developmental disorder, as there are substantial overlaps with medical evaluation and admission associated with these diagnoses. We also excluded ED visits if there was a MHSA-related ED visit within the prior 12 months in order to set a wash-out period and accurately define the index visit. Without a visit-free period before the index visit, we would have needed to characterize not only factors on presentation, but also factors known from prior visits, as well as the trajectory of prior visits. By requiring a visit-free period, we were able to infer that the risk factors for return could be isolated to the index visit. If a patient had more than one qualifying ED visit over the study period, we considered the earliest ED visit as their index visit.

Independent Variables

Risk factors for ED return visits or hospitalization were chosen a priori based on expert opinion and literature review. [6, 12-14] Covariates included age group (< 18, 18-35, 36-64, and

65+ years), sex, number of chronic conditions classified using the Hwang index (0, 1, 2, 3, 4, 5+), [15] race/ethnicity (White, African-American, Hispanic, Asian) non-mental health related ED utilization within 12 months prior to the index ED visit (0, 1, 2, 3, 4+ encounters), and MHSA as primary diagnosis (Supplemental Table 1). The Hwang comorbidity method is a sum of chronic conditions, with a higher count being associated with increased comorbidity burden. [15] The comorbid conditions were identified by ICD-9-CM codes in the primary or secondary diagnosis on any claim during the 12-month baseline period. We used an additional Hwang index of 5+ to account for a high proportion of medical comorbidities.

Outcomes

Our main outcome of interest was a return ED visit or inpatient admission occurring within 30 days of discharge from an index ED visit. Follow-up began on the day following the index ED visit, and ended on the date of a return visit to the ED, the date of a psychiatric or non-psychiatric hospitalization, or 31 days following discharge from an index ED visit, whichever occurred first. We classified return ED visits or hospitalizations as being for MHSA purposes by the presence of a primary diagnosis included in CCS categories for MHSA as identified above; other return ED visits or hospitalizations were classified as being for non-mental conditions. We counted a return ED visit or hospitalization as study endpoints only if they occurred on days 2-30 following the date of discharge from an index ED visit; as noted above, admissions the next day resulted in exclusion of the ED visit from the cohort due to frequent extended ED stay, while next ED admissions were considered part of the same ED visit. We looked at three nested outcome events: those occurring within 2-3 days, within 2-7 days, and within 2-30 days.

Analysis

We summarized the demographic and clinical characteristics of the cohort using means and proportions, as appropriate. The frequencies of each risk factor were compared between the groups characterized by the study outcomes (return ED visit or hospitalization at 3, 7 and 30 days) using chi-squared tests. Then, to assess the independent association of each risk factor with return visits, we estimated a multiple logistic regression model for each outcome (3-day, 7-day, and 30-day return to acute care), incorporating all risk factors as predictor variables. For categorical variables we reported adjusted odds ratios (OR), and we reported C-statistics for all logistic regression models. Outcomes of the multiple logistic regression and time-to-event analyses were reported using OR with 95% confidence intervals (CI). We determined statistical significance by p-values < 0.05. All analyses were performed using SAS 9.3 (SAS Institute, Cary NC, USA, 2014) and Stata 14 (StataCorp, College Station TX, 2015).

RESULTS

Characteristics of Study Subjects

We identified a total of 350,406 qualifying index ED visits as the cohort (Figure 1). Demographic and descriptive characteristics of the cohort members are shown in Table 1. The cohort consisted primarily of non-geriatric adults, the majority of whom were White (52.0%) and female (54.4%). The majority of patients had at least one co-occurring chronic medical condition. Nearly 60% of cohort members had no evidence of ED utilization in the year preceding the index ED visit. The most common mental health conditions at the index ED visits were alcohol and other substance use disorders, anxiety disorders, and mood disorders (Table 1).

Main Results

Among the index ED visits during 2005-2013, 3.1% (n=10,860) of patients returned to the ED or were hospitalized within three days, 6.1% (n=21,348) within seven days, and 14.2% (n=49,672) within 30 days after the index ED visit cumulatively (Figure 1). The mean ± standard deviation (SD) time to early ED return visits or hospitalization was 11.7 (SD 8.6 days). Supplemental Figure 1 shows the distribution of the return visits. Among the 43,572 ED return visits, 17, 249 (39.6%) were due to MHSA conditions, and among the 6,100 hospitalizations, 4,542 (74.5%) were due to MHSA conditions.

Table 1 and Supplemental Table 1a, 1b show the comparative frequencies of early-return ED visits or hospitalization within 3, 7, and 30 days for each covariate, using those without early return to ED or hospitalization as a control group. The risk of early-return ED visits or hospitalization within 3 days, 7 days, and 30 days was associated with age, sex, race, Hwang index, and prior ED utilization and multiple CCS diagnostic categories. Because of the large number of patients with unknown race/ethnicity information, this variable was excluded from the models.

The results of the multiple logistic regression analyses are shown in Table 2, and supplemental tables 2a, 2b. Male sex was associated with an increased odds of early-return ED visit or hospitalization within three days (OR 1.09, 95% CI [1.05 to 1.13]), 7 days (OR 1.09, 95% CI [1.06 to 1.12]), and 30 days (30 days OR 1.08; 95% CI [1.06 to1.10]) (Table 2). Increasing age (age 65+ years vs. age <18 years; OR 1.65; 95% CI [1.57 to 1.74]), increasing medical comorbidity (Hwang comorbidity 5+ vs. 0; OR 1.31; 95% CI [1.27 to 1.35]), and prior ED utilization (4+ visits vs 0 visits; OR 5.59; 95% CI 5.[41 to 5.78]) were also associated with return visits within 30 days (Table 2). Similar results were found for early-return ED visits or hospitalization at three and seven days (Table 2, and supplemental tables 2a, 2b). The C-statistics ranged from 0.66-0.69 for the MHSA-related and all models, and 0.71-0.72 for the non-MHSA models.

Primary MHSA diagnosis of personality disorders (OR 1.59, 95% CI [1.35 to1.87]), schizophrenia and other psychotic disorders (OR 1.31, 95% CI [1.24 to 1.39]),

Table 1. Demographic data and rates of 3 day, 7 day, and 30 day return ED visit or hospital admission.

	Characteristics	All returns			MHSA returns		
		3 day	7 day	30 day	3 day	7 day	30 day
Variable	N* (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
N	35,0406(100.0)	10,860(100.0)	21,348(100.0)	49,672(100.0)	63,12(100.0)	11,326(100.0)	21,791(100.0)
Age mean (SD)	36(17.6)						
Age (category)							
<18	50,446(14.4)	989(9.1)	2072(9.7)	5,422(10.9)	718(11.4)	1,446(12.8)	3,293(15.1)
18-35	134,695(38.4)	3,470(32.0)	6,761(31.7)	16,049(32.3)	2,084(33.0)	3,661(32.3)	7,113(32.6)
36-64	142,586(40.7)	5,166(47.6)	10,082(47.2)	22,671(45.6)	2,911(46.1)	5,203(45.9)	9,628(44.2)
>65	22,679 (6.5)	1,235(11.4)	2,433(11.4)	5,530(11.1)	599(9.5)	1,016(9.0)	1,757(8.1)
Sex							
Female	190,461(54.4)	5,941(54.7)	11,773(55.1)	27,739(55.8)	3,295(52.2)	5,924(52.3)	11,335(52.0)
Male	159,945(45.6)	4,919(45.3)	9,575(44.9)	21,933(44.2)	3,017(47.8)	5,402(47.7)	10,456(48.0)
Race/ethnicity							
Caucasian	182,103(52.0)	5,897(54.3)	11,449(53.6)	26,641(53.6)	3,505(55.5)	6,204(54.8)	11,915(54.7)
Hispanic	27,754(7.9)	721(6.6)	1,412(6.6)	3,380(6.8)	369(5.8)	644(5.7)	1,280(5.9)
African American	24,818(7.1)	883(8.1)	1,800(8.4)	4,330(8.7)	466(7.4)	855(7.5)	1,616(7.4)
Asian	5,888(1.7)	140(1.3)	2,66(1.2)	596(1.2)	86(1.4)	143(1.3)	280(1.3)
Unknown	109,843(31.3)	3,219(29.6)	6,421(30.1)	14,725(29.6)	1,886(29.9)	3,480(30.7)	6,700(30.7)
Hwang group							
0	723,62(20.7)	2,201(20.3)	4,218(19.8)	10,160(20.5)	1,209(19.2)	2,059(18.2)	4,001(18.4)
1	703,61(20.1)	1,498(13.8)	2,861(13.4)	6,542(13.2)	920(14.6)	1,585(14.0)	3,107(14.3)
2	63,639(18.2)	1,591(14.7)	3,214(15.1)	7,496(15.1)	993(15.7)	1,907(16.8)	3,805(17.5)
3	47,990(13.7)	1,515(14.0)	2,919(13.7)	6,795(13.7)	959(15.2)	1,715(15.1)	3,396(15.6)
4	32,183(9.2)	1,114(10.3)	2,216(10.4)	5,025(10.1)	704(11.2)	1,285(11.3)	2,433(11.2)
5+	63,871(18.2)	2,941(27.1)	5,920(27.7)	13,654(27.5)	1,527(24.2)	2,775(24.5)	5,049(23.2)
Prior EDs							
0	203,657(58.1)	4,425 (40.7)	8,411(39.4)	18,881(38.0)	2,904(46.0)	5,163(45.6)	9,983(45.8)
1	78,194(22.3)	2,500(23.0)	4,874(22.8)	11,456(23.1)	1,512(24.0)	2,709(23.9)	5,272(24.2)
2	31,642(9.0)	1,328(12.2)	2,660(12.5)	6,349(12.8)	740(11.7)	1,329(11.7)	2,576(11.8)
3	14,764(4.2)	786(7.2)	1,612 (7.6)	3,878(7.8)	417(6.6)	763(6.7)	1,427(6.5)
4+	22,149(6.3)	18,21(16.8)	3,791(17.8)	9,108(18.3)	739(11.7)	1,362(12.0)	2,533(11.6)
Initial visit CCS category*							
Adjustment							
No		10,653(98.1)	20,936(98.1)	48,666(98.0)	6,175(97.8)	11,065(97.7)	21,295(97.7)
Yes	6,480(1.8)	207(1.9)	412 (1.9)	1006(2.0)	137(2.2)	261(2.3)	496(2.3)
Anxiety							
No		7,199(66.3)	13,773(64.5)	31,522(63.5)	4,579(72.5)	8,001(70.6)	15,294(70.2)
Yes	130,828(37.3)	3,661(33.7)	7,575(35.5)	18,150(36.5)	1,733(27.5)	3,325(29.4)	6,497(29.8)

CCS, clinical classifications software; *ED*, emergency department; *MHSA*, mental health and substance abuse; *SD*, standard deviation.
* Each visit may contain multiple primary diagnosis codes that fall in different CCS categories
*Suicide ideation and attempt
*N= Total

Table 1. Continued.

	Characteristics	All returns			MHSA returns		
		3 day	7 day	30 day	3 day	7 day	30 day
Variable	N* (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
ADHD							
No		10,572(97.3)	20,778(97.3)	48,362(97.4)	6,096(96.6)	10,911(96.3)	20,974(96.3)
Yes	9,452(2.7)	288(2.7)	570 (2.7)	1310(2.6)	216(3.4)	415(3.7)	817(3.7)
D/O childhood							
No		10,824 (99.7)	21,277(99.7)	49,479(99.6)	6,288(99.6)	11,276(99.6)	21,667(99.4)
Yes	1,390(0.4)	36(0.3)	71(0.3)	193(0.4)	24(0.4)	50(0.4)	124(0.6)
Impulse							
No		10,843(99.8)	21,317(99.9)	49,573(99.8)	6,299(99.8)	11,302(99.8)	21,722(99.7)
Yes	665(0.2)	17(0.2)	31(0.1)	99(0.2)	13(0.2)	24(0.2)	69(0.3)
Mood							
No		8,195(75.5)	16,187(75.8)	3,7901(76.3)	4,310(68.3)	7,737(68.3)	14,945(68.6)
Yes	64,657(18.5)	2,665 (24.5)	5,161(24.2)	11,771(23.7)	2,002(31.7)	3,589(31.7)	6,846(31.4)
Personality							
No		10,809(99.5)	21,252(99.6)	49,456(99.6)	6,277(99.4)	11,261(99.4)	21,660(99.4)
Yes	953(0.3)	51(0.5)	96(0.4)	216(0.4)	35(0.6)	65(0.6)	131(0.6)
Schizophrenia							
No		9,815(90.4)	19,463(91.2)	45,839(92.3)	5,664(89.7)	10,278(90.7)	20,047(92.0)
Yes	16,821(4.8)	1,045(9.6)	1,885(8.8)	3,833(7.7)	648(10.3)	1,048(9.3)	1,744(8.0)
Alcohol							
No		9,278(85.4)	18,356(86.0)	42,612(85.8)	5,332(84.5)	9,626(85.0)	18,360(84.3)
Yes	86,427(24.7)	1,582(14.6)	2,992 (14.0)	7,060(14.2)	980(15.5)	1,700(15.0)	3,431(15.7)
Substance							
No		9,364(86.2)	18,516(86.7)	43,366(87.3)	5,453(86.4)	9,891(87.3)	19,214(88.2)
Yes	35,308(10.1)	1,496(13.8)	2,832(13.3)	6,306(12.7)	859(13.6)	1,435(12.7)	2,577(11.8)
Suicide*							
No		10,702(98.5)	21,061(98.7)	48,904(98.5)	6,197(92.2)	11,135(98.3)	21,387(98.1)
Yes	5,749(1.6)	158(1.5)	287(1.3)	768(1.5)	115(1.8)	191(1.7)	404(1.9)
Screening							
No		10,655(98.1)	20,921(98.0)	48,648(97.9)	6,217(98.5)	11,147(98.4)	21,407(98.2)
Yes	6,239(1.8)	205(1.9)	427(2.0)	1024(2.1)	95(1.5)	179(1.6)	384(1.8)
Miscellaneous							
No		10,512(96.8)	20,618(96.6)	47,957(96.5)	6,209(98.4)	11,115(98.1)	21,382(98.1)
Yes	9,196(2.6)	348(3.2)	730(3.4)	1715(3.5)	103 (1.6)	211(1.9)	409(1.9)

ADHD, Attention-deficit, conduct, and disruptive behavior disorders; *D/O childhood*, disorders usually diagnosed in infancy, childhood, or adolescence.

* Each visit may contain multiple primary diagnosis codes that fall in different CCS categories.

*Suicide ideation and attempt.

*N= Total

Table 2. Logistic regression analysis showing rates of 3 day, 7 day, and 30 day return ED visit or hospital admission by patient characteristics.

	All returns			MHSA returns		
	3day	7day	30day	3day	7day	30day
Characteristic	OR	OR	OR	OR	OR	OR
Sex						
Female	ref	ref	Ref	Ref	ref	Ref
Male	1.09 [1.05,1.13]	1.09 [1.06,1.12]	1.08 [1.06,1.10]	1.14 [1.08,1.20]	1.16 [1.11,1.20]	1.18 [1.14,1.21]
Age (category)						
<18	ref	ref	Ref	Ref	ref	Ref
18-35	1.41 [1.30,1.52]	1.28 [1.22,1.35]	1.14 [1.10,1.18]	1.31 [1.19,1.43]	1.13 [1.06,1.21]	0.94 [0.90,0.99]
36-64	1.76 [1.63,1.90]	1.59 [1.51,1.68]	1.34 [1.30,1.39]	1.58 [1.45,1.74]	1.38 [1.29,1.47]	1.11 [1.06,1.16]
>65	2.02 [1.83,2.22]	1.85 [1.72,1.98]	1.65 [1.57,1.74]	1.64 [1.45,1.86]	1.37 [1.25,1.51]	1.06 [0.99,1.14]
Hwang						
0	Ref	Ref	Ref	Ref	ref	ref
1	0.95 [0.89,1.02]	0.96 [0.91,1.01]	0.89 [0.86,0.93]	0.99 [0.90,1.08]	0.98 [0.92,1.05]	0.96 [0.91,1.01]
2	0.99 [0.93,1.06]	1.06 [1.00,1.11]	1.02 [0.99,1.06]	1.03 [0.94,1.12]	1.15 [1.07,1.22]	1.16 [1.11,1.22]
3	1.15 [1.07,1.23]	1.17 [1.11,1.23]	1.15 [1.11,1.20]	1.22 [1.12,1.34]	1.28 [1.19,1.36]	1.31 [1.24,1.37]
4	1.16 [1.07,1.25]	1.22 [1.16,1.29]	1.19 [1.14,1.24]	1.27 [1.15,1.39]	1.36 [1.26,1.46]	1.36 [1.28,1.43]
5+	1.18 [1.11,1.25]	1.27 [1.21,1.33]	1.31 [1.27,1.35]	1.15 [1.06,1.25]	1.26 [1.18,1.34]	1.25 [1.20,1.31]
Prior EDs						
0	Ref	Ref	Ref	Ref	ref	ref
1	1.38 [1.31,1.45]	1.42 [1.37,1.48]	1.55 [1.51,1.59]	1.27 [1.20,1.36]	1.29 [1.23,1.36]	1.33 [1.29,1.38]
2	1.73 [1.62,1.84]	1.86 [1.78,1.95]	2.15 [2.08,2.22]	1.49 [1.37,1.62]	1.53 [1.44,1.63]	1.60 [1.53,1.68]
3	2.12 [1.96,2.30]	2.39 [2.26,2.53]	2.93 [2.82,3.06]	1.74 [1.57,1.94]	1.85 [1.71,2.00]	1.90 [1.79,2.02]
4+	3.24 [3.05,3.44]	3.89 [3.72,4.06]	5.59 [5.41,5.78]	2.03 [1.86,2.21]	2.21 [2.07,2.36]	2.32 [2.21,2.44]
Initial CCS category						
Adjustment						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.12 [0.96,1.30]	1.11 [1.00,1.24]	1.09 [1.01,1.18]	1.30 [1.09,1.56]	1.37 [1.20,1.57]	1.27 [1.15,1.40]
Anxiety						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	0.91 [0.84,0.99]	0.94 [0.89,1.00]	0.88 [0.84,0.92]	0.83 [0.75,0.92]	0.88 [0.82,0.95]	0.84 [0.79,0.89]
ADHD						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.38 [1.20,1.59]	1.32 [1.19,1.46]	1.14 [1.06,1.22]	1.75 [1.49,2.06]	1.74 [1.55,1.96]	1.50 [1.37,1.63]
D/O Childhood						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.22 [0.87,1.72]	1.16 [0.90,1.48]	1.19 [1.01,1.39]	1.32 [0.87,2.00]	1.40 [1.05,1.88]	1.53 [1.26,1.86]
Impulse						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.03 [0.63,1.68]	0.92 [0.63,1.32]	1.16 [0.93,1.45]	1.33 [0.76,2.31]	1.29 [0.86,1.95]	1.76 [1.36,2.27]
Mood						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.44 [1.33,1.56]	1.40 [1.32,1.48]	1.28 [1.23,1.34]	2.11 [1.93,2.32]	2.10 [1.96,2.25]	1.96 [1.86,2.06]

CCS, clinical classifications software; *ED*, emergency department; *MHSA*, mental health and substance abuse; *ADHD*, Attention-deficit, conduct, and disruptive behavior disorders; ***D/O childhood***, disorders usually diagnosed in infancy, childhood, or adolescence.

Table 2. Continued.

	All returns			MHSA returns		
	3day	7day	30day	3day	7day	30day
Characteristic	OR	OR	OR	OR	OR	OR
Personality						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.82 [1.35,2.44]	1.70 [1.36,2.12]	1.59 [1.35,1.87]	2.08 [1.47,2.96]	2.05 [1.58,2.67]	1.97 [1.62,2.39]
Schizophrenia						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.74 [1.57,1.91]	1.59 [1.47,1.71]	1.31 [1.24,1.39]	2.20 [1.95,2.47]	2.02 [1.84,2.21]	1.71 [1.59,1.83]
Alcohol						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	0.71 [0.64,0.77]	0.67 [0.63,0.72]	0.61 [0.58,0.64]	0.81 [0.73,0.91]	0.80 [0.73,0.87]	0.77 [0.72,0.82]
Substance						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.37 [1.25,1.50]	1.30 [1.22,1.39]	1.14 [1.09,1.20]	1.56 [1.39,1.74]	1.45 [1.33,1.58]	1.26 [1.18,1.34]
Suicide						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	0.95 [0.80,1.12]	0.85 [0.75,0.96]	0.91 [0.84,0.99]	1.15 [0.95,1.40]	1.03 [0.89,1.20]	1.06 [0.96,1.18]
Screening						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.05 [0.90,1.22]	1.10 [0.99,1.23]	1.06 [0.98,1.15]	0.91 [0.74,1.13]	0.97 [0.82,1.13]	1.02 [0.91,1.14]
Miscellaneous						
No	Ref	Ref	Ref	Ref	ref	Ref
Yes	1.16 [1.02,1.32]	1.21 [1.10,1.33]	1.11 [1.04,1.18]	0.70 [0.57,0.86]	0.79 [0.68,0.92]	0.73 [0.65,0.82]

mood disorders (OR 1.28, 95% CI [1.23 to1.34]), and substance abuse (OR1.14, 95%CI 1.09 to 1.20) were associated with increased odds of early-return ED visit or hospitalization within 30 days. Similar findings were observed for early-return ED visits or hospitalizations at three days and at seven days (Table 2). Alcohol-related disorders (OR 0.61, 95% CI [0.58 to 0.64]), anxiety disorders (OR 0.88, 95% CI [0.84 to 0.92]) and suicide and intentional self-inflicted injury (OR 0.91, 95% CI [0.84 to 0.99]) were associated with significantly decreased odds of early-return ED visit or hospitalization within 30 days. Similar findings were observed for the odds of early-return ED visit or hospitalization at three days and at seven days (Table 2, and supplemental tables 2a, 2b).

DISCUSSION

Principal Findings

This large, U.S.-based retrospective analysis of over 350,000 patients evaluated a population of individuals with continuous medical coverage for 12 months, presenting to the ED for a MHSA (excluding delirium, dementia, amnestic disorders, or developmental disorders) for the first time in at least 12 months and whose ED visit did not result in a hospitalization, to assess the rate of return to the ED within the next 30 days for either mental health or non-mental health reasons. The study showed a high rate (14.2%) of early-return ED visits or hospitalizations within 30 days of index discharge. For those who sought acute care within 30 days of index discharge, the median time to the next utilization was nearly nine days. Increased age, comorbidity burden, prior acute care utilization, diagnosed personality disorders, schizophrenia (and related psychoses), mood disorders and substance abuse were associated with an increased odds of return ED visits or hospitalization within 3, 7 and 30 days of index discharge.

Comparison with Prior Studies

The overall rates of return within 3 days, 7 days, and 30 days in our cohort were 3.1%, 6.1%, and 14.2%, respectively. This is consistent with the results of Pham et

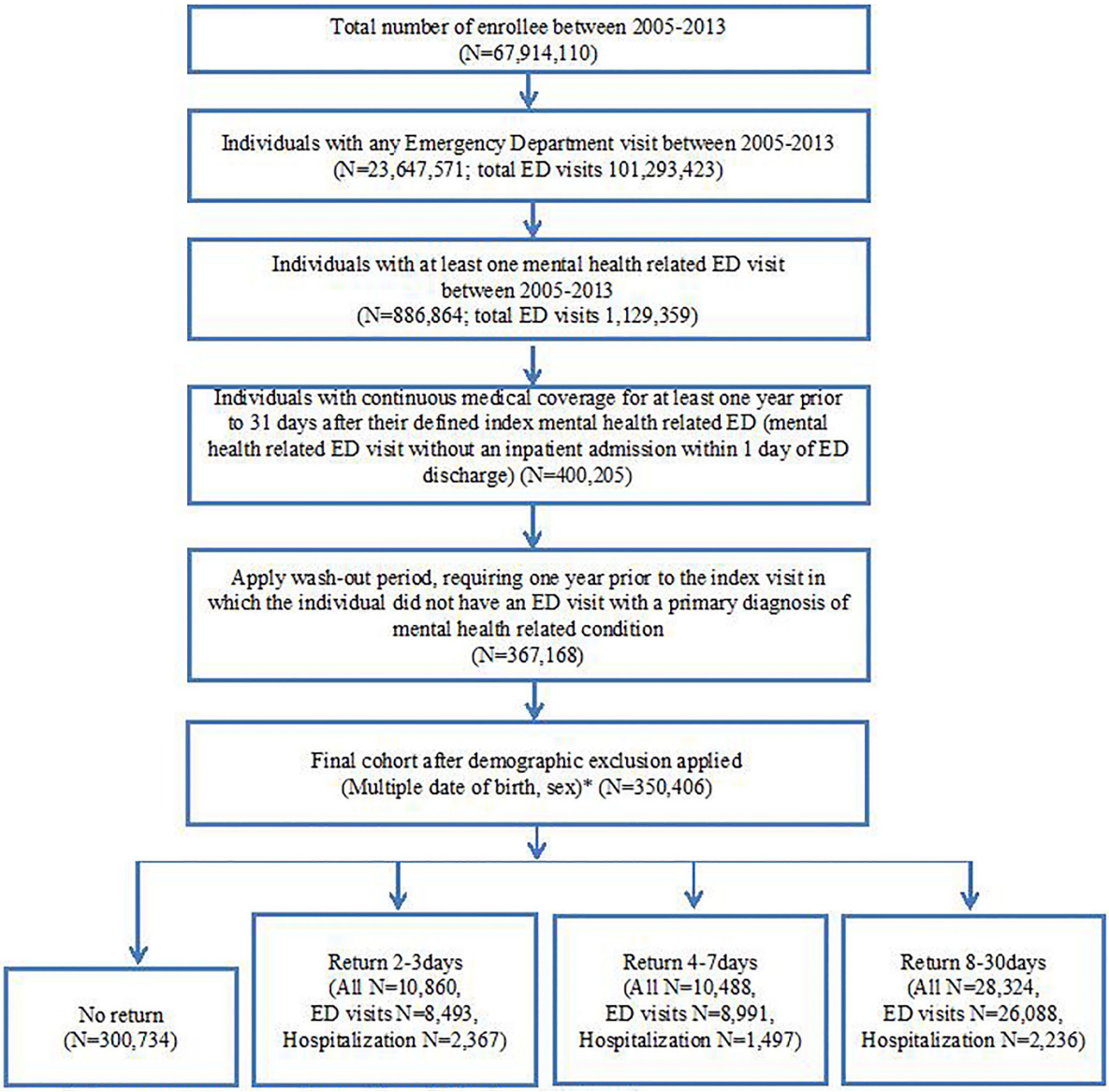

Figure. Flow chart of selection process.
ED, emergency department.
N=Total number of patients.

al., who used the National Hospital Ambulatory Medical Care Survey and reported a three-day general ED return rate of 3.2% for all ages and diagnoses.[13] In contrast, Rising et al. reported general ED return visits rates of 7.5% within three days and 22.4% within 30 days.[16] The increased rates reported by Rising et al. may be due to the fact that only adult patients were included.[16] Since the rate of return visits due to a MHSA condition seems to be increasing steadily, we propose that outpatient follow-up within one to two weeks might be a reasonable strategy for those who are at high risk for return ED visits after a MHSA-related evaluation.

We found that the median time to a return visit was nine days. Our results are consistent with those of Rising et al. who studied patterns of early ED return visits using data from the AHRQ Cost and Utilization Project and reported that the most frequent time interval to an early ED return visit was about nine days.[16] Although our study was limited to mental health-related visits and included both ED return visits and hospitalizations, the latter of which may or may not have a second associated ED visit, these results suggest that the commonly used metric of a three-day return rate is capturing only a small portion of potentially avoidable healthcare delivery among patients with MHSA-related conditions.

The highest rates of both MHSA-related and non-MHSA-related ED return visits at 3, 7, and 30 days in our cohort were in patients aged 65 years and older (Table 2). Increasing age and medical comorbidity burden were also identified as independent predictors of the risk for early return for acute care in our study. The absence of overlaps in the ORs and 95% CI suggested that the increased age and comorbidities were more associated with non-MHSA returns than MHSA returns. Martin-Gill et al. reported that both increased age and the presence of mental illness were associated with increased rates of 72-hour return visits among general ED patients.[17] Gabayan et al. used the California Office of Statewide Health Planning and Development files to examine the general geriatric population presenting to the ED and reported an increased hospitalization rate in those with a mental illness diagnosis (OR 2.17).[12]

Prior ED utilization was found to be one of the strongest risk factors for return visits in our study. A previous study of geriatric patients demonstrated that patients with prior utilization were more likely to return to the ED.[18] Our study showed that previous non mental health-related ED utilization independently predicted early return visits after an index mental health-related ED visit. Prior ED utilization may be related to patient functional status, limited primary care access or other factors.

With regard to specific MHSA disorders, diagnosed personality disorders, schizophrenia, mood disorders and substance abuse were identified as significant risk factors for return visits to acute care, consistent with prior literature.[6, 14, 19-21] Hesling et al. reported lower utilization of home healthcare after discharge for depression or schizophrenia compared to non-MHSA conditions.[22] These are some of the frequent MHSAs seen in the ED, and may benefit from specific interventions, such as expedited outpatient referral within 1-2 weeks and arrangement for home health visits for those who cannot.[22, 23]

Somewhat surprisingly, alcohol use disorders and suicide and intentional self-inflicted injury were inversely related with return visit in our study. One prior study showed lack of a significant relationship between the use of alcohol and negative health outcomes or treatment costs in inpatient settings.[24] Part of the reason for differences between our results and those of prior investigations may be our exclusion of patients who required inpatient admission at the time of the index ED visit. As such, our cohort may have been less ill than those of prior studies. This study's findings imply that the chance of an ED return visit could increase when there is any mental health condition, particularly depression, anxiety or substance abuse-related conditions, that requires some type of intervention. If clinicians or healthcare policymakers want to decrease the unnecessary utilization by allowing an easier access to outpatient resources, whether it be access to outpatient clinics or crisis units before the expected time to return, in our study, it would be within nine days.

LIMITATIONS

Our study has several limitations. First, it is observational, and as with any observational study any associations may be biased by unobserved confounders; at the same time, we can't make any causal inferences from the associations. Second, this cohort represents a commercially insured population that we assumed may experience different and fewer socioeconomic stressors than uninsured or underinsured populations. Because the data derived from a private insurance population and 12 months of enrollment status was required, the results likely under-represented the magnitude of ED utilization and return visits. This is particularly important for persons with severe or persistent mental disorders, such as schizophrenia or other psychotic disorders, and severe mood disorders, a substantial number of whom rely on publically-funded insurance programs, or are uninsured and frequently present to acute healthcare settings in need of urgent treatment for psychiatric and non-psychiatric problems.[22] Third, there was a substantial amount of unreported data for variables that are important factors in healthcare utilization, particularly race, income, availability of psychiatrists in the ED, access to primary care, size of healthcare system, psychiatric bed capacity, availability of assertive community treatment, family support and other intensive community-based MHSA treatment programs. Additional research with complementary or alternate datasets should be conducted to examine the influence of these factors.[25] Related to this, we did not have mortality data on our cohort; patients who expired outside the acute care setting during the 30 days post-ED visit could not be counted. Lastly, we did not include the index ED visit resulting in a hospitalization, as our primary interest was to evaluate the trend of ED return visits after discharge from the ED.

CONCLUSION

In summary, an analysis of over 350,000 ED visits for mental health treatment over eight years indicated that 14.2% of patients returned to acute care within 30 days of index ED discharge. Older age and prior ED utilization were the strongest risk factors for early return to acute care, both for MHSA and non-MHSA reasons. Additional risk factors for early return to acute care were also observed. Furthermore, the decline in inpatient psychiatry bed capacity might have contributed to the increase in mental health-related ED visits. It is time to explore creative solutions to improve care for MHSA conditions after ED evaluation. Our findings may help to elucidate the group that could benefit from intense outpatient referral to prevent unnecessary return visits.

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Effect Of A "No Superuser Opioid Prescription" Policy On ED Visits And Statewide Opioid Prescription

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Introduction: The U.S. opioid epidemic has highlighted the need to identify patients at risk of opioid abuse and overdose. We initiated a novel emergency department- (ED) based interventional protocol to transition our superuser patients from the ED to an outpatient chronic pain program. The objective was to evaluate the protocol's effect on superusers' annual ED visits. Secondary outcomes included a quantitative evaluation of statewide opioid prescriptions for these patients, unique prescribers of controlled substances, and ancillary testing.

Methods: Patients were referred to the program with the following inclusion criteria: ≥ 6 visits per year to the ED; at least one visit identified by the attending physician as primarily driven by opioid-seeking behavior; and a review by a committee comprising ED administration and case management. Patients were referred to a pain management clinic and informed that they would no longer receive opioid prescriptions from visits to the ED for chronic pain complaints. Electronic medical record (EMR) alerts notified ED providers of the patient's referral at subsequent visits. We analyzed one year of data pre- and post-referral.

Results: A total of 243 patients had one year of data post-referral for analysis. Median annual ED visits decreased from 14 to 4 (58% decrease, 95% CI [50 to 66]). We also found statistically significant decreases for these patients' state prescription drug monitoring program (PDMP) opioid prescriptions (21 to 13), total unique controlled-substance prescribers (11 to 7), computed tomography imaging (2 to 0), radiographs (5 to 1), electrocardiograms (12 to 4), and labs run (47 to 13).

Conclusion: This program and the EMR-based alerts were successful at decreasing local ED visits, annual opioid prescriptions, and hospital resource allocation for this population of patients. There is no evidence that these patients diverted their visits to neighboring EDs after being informed that they would not receive opioids at this hospital, as opioid prescriptions obtained by these patients decreased on a statewide level. This implies that individual ED protocols can have significant impact on the behavior of patients. [West J Emerg Med. 2017;18(5)894-902.]

INTRODUCTION

Background

In the early 1990s there was a concerted effort by the Veterans Health Administration (VHA) and The Joint Commission to target pain management with opioids.[1] Pain quickly became the "fifth vital sign," and opioid prescriptions escalated.[2] Between 1999 and 2010, the marketing of opioids to pharmacists, hospitals, and doctors' offices had quadrupled, and there was a 300% increase in the prescription of opioids in the U.S.[3,4] With this dramatic increase in opioid prescribing behavior, a number of serious unintended consequences were noted. In 2008, prescription opioids were estimated to be the direct cause for approximately 15,000 annual overdose deaths in the U.S., with that number almost doubling to 29,000 in 2014. [5,6]Each opioid abuser incurs $20,546 more in annual healthcare costs than demographically similar controls.[7] Direct healthcare costs of improper and non-medical opioid prescription use is estimated to be greater than $72 billion per year.[3]

Population Health Research Capsule

What do we already know about this issue?
Opioid prescriptions and overdoses have increased significantly in the past 30 years. Superuser patients may use the Emergency Department (ED) as a source for opioids.

What was the research question?
Does ED referral to a pain management group – with subsequent EMR-based reminders to ED practitioners - decrease annual visits from superuser patients?

What was the major finding of the study?
Superuser patients had fewer overall ED visits after the intervention, decreasing annual visits from 14 to 4.

How does this improve population health?
Enrollment in a chronic pain program with EMR-based provider reminders appeared to decrease overall visits to the ED post-intervention.

Importance

Emergency department (ED) visits related to prescription opioid abuse have risen dramatically from 173,000 in 2004 to 416,000 in 2009 and now are over 500,000 annually.[3,4,7] Many efforts have been made to identify patients with drug-seeking behaviors as well as providers with aberrant prescribing practices.[7-11] These include increased regulations on pain clinics, prescription threshold guidelines, controlled substance contracts, and the establishment of prescription drug monitoring programs (PDMP).

Goals of This Investigation

The purpose of this study was to examine and present the outcomes of a novel interventional chronic pain program established in a metropolitan ED. The protocol was designed to transition superuser opioid-seeking patients out of the ED and into a chronic taper-to-abstinence pain program. We primarily hypothesized that visits to the ED post-referral would decrease. We hypothesized that secondary outcomes would similarly decrease, such as statewide opioid prescriptions, number of opioid prescribers, number of electrocardiographs (ECG) , laboratory tests, radiographs, and computed tomography (CT) imaging.

METHODS

Study Design and Setting

This study is a retrospective analysis of a novel preexisting, administrative chronic pain management program at Methodist Hospital in Indianapolis, IN. This is an urban teaching hospital with an annual ED volume of approximately 102,000 patients per year. Patients were drawn from the existing administrative database of frequent opioid recidivists who had been prospectively identified for inclusion into the program as outlined below. The study is designed as a one-way crossover intervention, with patients serving as their own controls in the year prior to their referral in the program. The protocol was approved as an administrative policy four years prior to the collection of any research data. Research data gathering was separately approved and registered by the Indiana University (IU) Institutional Review Board (1409177708).

Selection of Participants

Inclusion criteria into the chronic pain program were as follows: 1) Frequent use of the ED, defined as ≥ 6 visits per year; 2) At least one visit identified by the treating attending physician as primarily driven by opioid-seeking behavior; and 3) Chart review by ED administration and case management for evidence of ED misuse. Patients meeting all three of these criteria were referred to the chronic pain program unless they met exclusion criteria below.

Exclusion criteria for the chronic pain program were preexisting chronic disease processes expected to cause frequent and uncontrollable visits to the ED, such as cancer or sickle cell disease. Pregnancy and age were not exclusion criteria.

We excluded patients from the retrospective data analysis if they had not been part of the chronic pain program for at least a year. These patients would not have a full year of data post-intervention to compare to the year prior. Demographic characteristics of the participants can be found in Table 1.

Table 1. Demographics with descriptive statistics.

Age (yrs)	
Mean (range)	41 (18-67)
Gender	
Female	151 (62%)
Race/ethnicity*	
American Indian	1 (0.4%)
Asian	1 (0.4%)
Hawaiian/Pacific Islander	0 (0%)
Black	71 (29%)
White	169 (70%)
Other	0 (0%)
Hispanic	3 (1%)
Charleson comorbidity score	
Median (IQR)	1 (0-1)

Interventions

After medical director approval, patients were referred to a free, outpatient taper-to-abstinence pain management clinic. A chronic pain management and addiction specialist runs the clinic. Patients were notified by an administrator either in person at their next visit or by telephone that they had been referred into a chronic pain program. They were also informed that they would no longer routinely receive opioids or opioid prescriptions for their chronic painful conditions from the ED. Additionally, they received written instructions and information either in person or by certified mail.

Exceptions were made for acute pain not related to a chronic condition, such as new fractures. Those patients non-compliant with follow-up with the pain management program were contacted on subsequent ED visits and referred again. Treatment with opioids, both parenteral and prescribed, remained at the discretion of the treating ED provider, with a reminder in place that the patient had already been given outpatient follow-up.

To reinforce the program to emergency physicians, an electronic medical record- (EMR) based notification was implemented, which was activated any time the patient arrived in the ED. This notification is three-fold. On the ED tracking screen, a flag is placed to alert providers to the patient's referral to the program. Upon opening the patient's chart, a pop-up alert indicates the patient's chronic pain management, with instructions to refer to the case management notes for specific details. If opioids are chosen as a treatment modality, a separate notification activates to ensure that the provider is aware that the patient has been referred to pain management.

Methods and Measurements

We collected and managed study data using REDCap electronic data capture tools hosted at IU.[12] REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing the following: 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.

Data regarding controlled substance prescriptions pre- and post-referral into the program was captured via the Indiana Board of Pharmacy Prescription Monitoring System or INspect. All pharmacies are mandated to report any controlled substance filled to this database. The few exceptions are entities and clinics governed by federal regulations (the VHA, as well as methadone and suboxone clinics). Data included in the database are the following: Patient demographics (name, date of birth, address), prescriber, prescriber demographics, date of prescription filled, pharmacy demographics, prescribed substance, strength, quantity, intended days, and date written. We obtained data regarding ED visits pre- and post-referral via Indiana University Health's (IUH) EMR (Cerner), which connects approximately 32 hospitals, rehabilitation facilities, and clinics across the greater Indianapolis area. Data were collected on a data abstraction form by blinded, trained abstractors. As this was a retrospective chart review, a random sample of 10% of the charts was reassessed by one of the investigators (reassessed by one of the investigators [ZPK]). We performed a kappa analysis for the primary outcome, which was found to be 0.91, indicating excellent inter-rater reliability.

Outcomes

The primary outcome of interest was the difference between annual ED visits to an annual ED visits to an IUH ED pre- and post-referral into the chronic pain program. Secondary outcomes included their statewide opioid prescriptions, number of unique prescribers of controlled substances, as well as ancillary testing: number of ECGs, laboratory tests, radiographs, and CTs.

Analysis

We performed statistical analysis using the R statistical software package with the Rstudio frontend (Foundation for Open Access Statistics, Boston MA). Descriptive analyses are reported where appropriate. Mean values are reported for normal data with standard deviations, with significance between results analyzed with Student's t-test for unpaired values and Student's

paired t-test for paired values. Non-normal data is reported in medians with interquartile ranges (IQR), with significance analyzed by Mann-Whitney U test for unpaired values and Wilcoxon signed-rank test for paired values. As most of the data is non-normal, the primary analysis method used was the Wilcoxon signed-rank test for paired medians. We calculated data to a significance of α=0.05 and β=0.20 where appropriate. There was no formal sample size calculated, as this was a retrospective study performed on all eligible existing patients in the program. A priori to capture and analysis of our data, we identified annual ED visits as our primary outcome, with secondary outcomes as described in outcomes and analysis.

RESULTS

Characteristics of Study Subjects

At the time of data gathering, 278 patients had been referred into the program. Of those patients, 243 had been in the program for one year or greater, and therefore had 12 months of data both pre- and post-intervention. Demographics of the participants are shown in Table 1. Mean age of the study group was 41, 62% of which were female. These were predominantly White patients (70%), while 29% were Black, and the remainder American Indian, Asian, and Hispanic. The cohort was healthy in general with a median Charleson Comorbidity score of 1. The most common comorbidities in this cohort were chronic pulmonary disease (asthma or COPD) n=23, and diabetes without end-organ dysfunction n=23.

The primary outcome was the number of ED visits pre- and post-intervention. This data is represented visually in Figure.

Given the skewness of the data, our data is primarily reported in median values, although mean values are also reported in Table 2.

Median ED visits to hospitals in our health system decreased from 14 to 4 (58% decrease, 95% CI [50 to 66]). We evaluated visits as paired data, with each patient serving as their own control. Mean visits decreased from 19 to 6, implying a rightward skewness of the data. When assessing the highest quartile, we found that median visits decreased from 25 to eight. The outlier patient decreased annual visits to our ED from 131 to 13.

Secondary outcomes were similarly significant. Total median number of opioid prescriptions filled statewide decreased from 21 to 13 (30% decrease, 95% CI [24 to 37]), as did median number of statewide prescribers 11 to seven (31% decrease, 95% CI [23 to 38]).

DISCUSSION

In this study, we present the outcomes of a novel, administratively instituted "no-opioid" policy for 243 patients at a large metropolitan hospital. These patients had been identified as over-using the ED, primarily to obtain opioids for chronic pain. It has been previously estimated that approximately 5% of patients account for 25% of all ED visits, and chronic pain and addiction is often a driving force behind this recidivism.[13] This population is at high risk for opioid overdose and subsequent hospitalization, and a major component of their access to opioids is a "revolving door" of prescribers.[14]

Our study demonstrated decreased visits to our facility from these patients by 58%, a decrease in the number of unique prescribers for their controlled substances by 31%, and a decrease in the number of prescriptions these patients received statewide by 30%. Of note, our intervention appears to have decreased overall opioid prescriptions and prescribers statewide for these enrolled patients, despite being implemented at only one facility. We believe that this implies that there is a significant degree of local bias in care for these patients – that is, patients preferentially seek care at the closest ED to their home. When access to opioids is fettered at that site, these patients did not appear to supplement by simply visiting neighboring EDs. This may be the understated strength of our administrative policy; our results imply that our ED was a major source of these patients' legal access to opioids. Further, when opioid prescriptions are restricted from the ED, this patient population decreases ED visit frequency.

To date, there is no standardized definition of frequent users of the ED. Various authors have proposed anywhere from 3-10 visits as "frequent."[15-18] Our protocol used $\geq$ 6 visits per year as the cutoff, although the median number of visits in our study population overall was 14 per year, with the highest 10% of our study group visiting 52 times per year. This population can be very difficult to manage; psychosocial factors, addiction, opioid hyperalgesia, and personality traits influence their presentation. Further, emergency physicians often treat acute flares of chronic pain with a "short course" of opioids, which may reinforce the patient's ED recidivism.

Several researchers have evaluated ED pain protocols prior to this study.[17-19] Our study is unique for three main reasons: the large number of patients included, the analysis of repeat ED visits, and the EMR-based reminders to providers. To date, no study has evaluated a policy such as ours on such a scale, nor have studies evaluated the granular effect on resource expenditure. We believe the success of this protocol was wholly dependent on strong administrative support for the policy and the repeated EMR-based alerts.

With regards to the first point, emergency providers often feel obligated to acquiesce to patient demands for fear of lowered patient satisfaction scores, or simply to avoid a complaint.[2,20] However, recent studies have called into question this assumption, with at least one study by Schwartz et al. finding no association between opioid administration and patient satisfaction. [2,21-24]Germaine to this point, recent evidence has demonstrated that increasing patient satisfaction scores are correlated with increased prescription drug expenses, increased healthcare expenditures and increased mortality.[25] It is of paramount importance to provide medically appropriate care for patients, which may contrast with the goals of ED superusers. This subset of patients often requests unnecessary treatments, inappropriate prescriptions, or may simply use the ED as a food

Table 2. Pre-post results for patients in the chronic pain program at one year.

	Median (IQR)	Mean	Min^ - Max	Percentage decrease (95% CI)
Number of ED visits				
Pre	14 (8 – 25)	19	0 – 131	58 (50 to 66)
Post	4 (2 – 8)	6	0 – 58	
Number of opioid prescriptions				
Pre	21 (12 – 30)	23	0 – 105	30 (24 to 37)
Post	13 (5 – 24)	16	0 – 103	
Number of prescribers				
Pre	11 (7 - 16)	13	0 – 45	31 (23 to 38)
Post	7 (3 – 12)	9	0 – 43	
Number of pharmacies used				
Pre	6 (3 – 9)	7	0 – 34	29 (14 to 36)
Post	5 (2 – 7)	5	0 – 17	
Number of lab draws				
Pre	47 (17 – 101)	59	0 – 175	46 (36 to 57)
Post	13 (4 – 40)	31	0 – 184	
Number of radiographs				
Pre	5 (2 – 10)	8	0 – 64	44 (38 to 56)
Post	1 (0 – 5)	3	0 – 28	
Number of CTs				
Pre	2 (1 – 5)	4	0 – 32	63 (50 to 75)
Post	0 (0 – 2)	1	0 – 16	
Number of ECGs				
Pre	4 (1 – 12)	12	0 – 158	50 (38 to 67)
Post	2 (0 – 4)	4	0 – 49	
Number of clinic visits				
Pre	1 (0 – 5)	4	0 – 30	13 (-13 to 38)
Post	1 (0 – 4)	3	0 – 37	
Number of hospitalizations				
Pre	0 (0 – 1)	1	0 – 16	*
Post	0 (0 – 1)	0	0 – 7	
Number of hospital days				
Pre	0 (0 – 5)	7	0 – 207	85 (57 to 129)
Post	0 (0 – 0)	2	0 – 75	

CT, computerized tomography; *ED*, emergency department; *ECG*, electrodiogram; *IQR*, interquartile range.
Rank test for median value.
^No minimum number of prescriptions required for referral. 8 patients unable to be found in EMR.
*Unable to compute secondary to divide by zero errors.

and bed source. Thus, we feel that strong administrative support for a policy such as ours is critical.

As only a handful of patients followed up with the pain management clinic, this component of the intervention is unlikely to have changed ED visit frequency or prescription volume. Instead, the authors believe that the EMR-based reminders to physicians were the key component. These reminders occurred at every visit for each provider who interacted with the patient. Thus, prior to the administration or prescription of an opioid, the EMR reinforced the behavior of physicians and therefore patients. Many hospitals use a provider-initiated system for opioid management; that is, a provider must go looking for a care

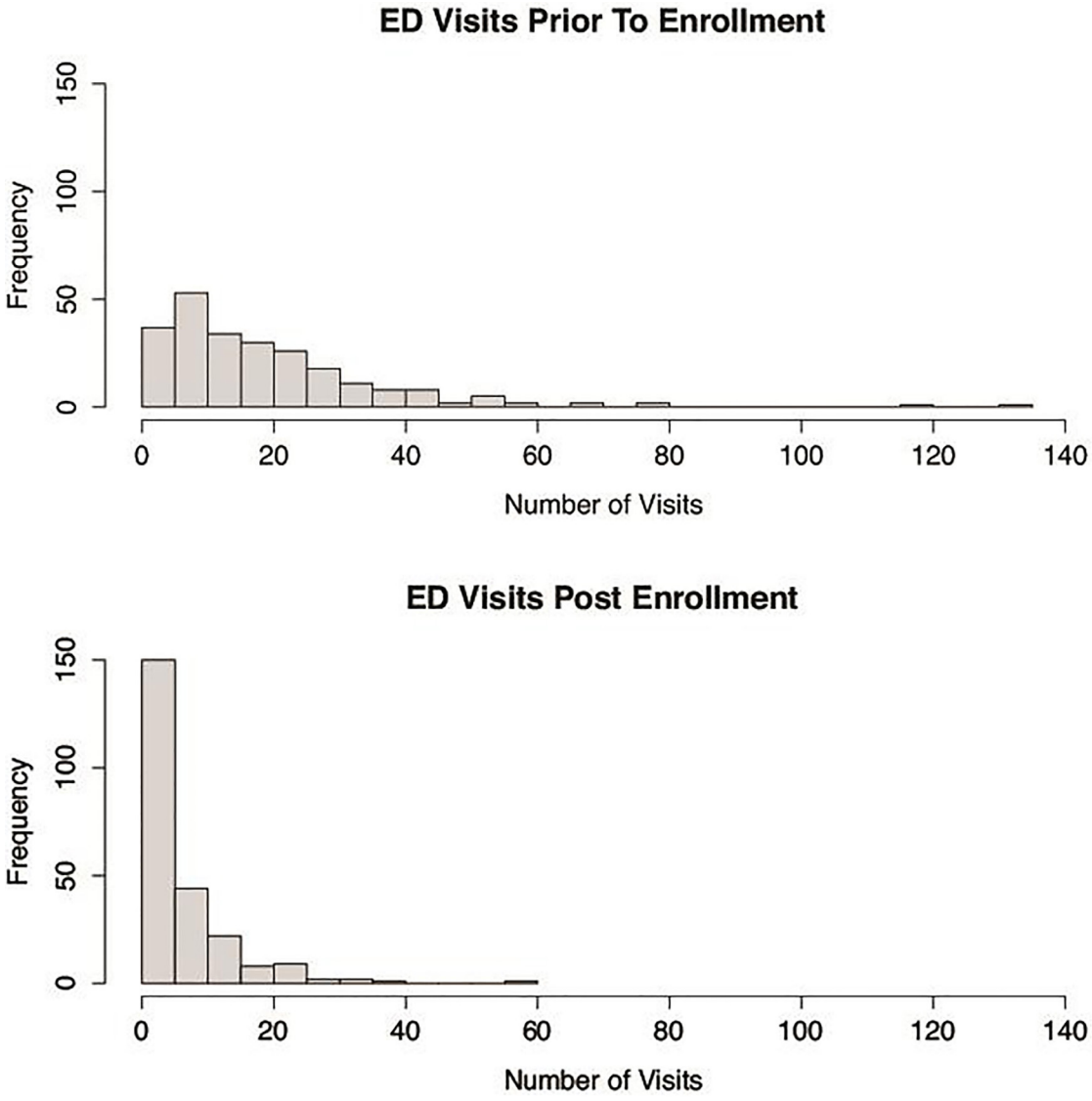

Figure. Pre- and post-intervention frequency (number of patients) of annual visits by patients identified as over-users of the emergency department (ED).

management note, chronic pain policy, or must do a chart review manually.[19] While accessing the state PDMP is encouraged before prescription of controlled substances, this typically requires a provider to leave the EMR and log into a separate system, which may hinder its use.

Our EMR-based alerts were active, informing the patient's ED provider of their chronic pain referral at every visit. When a patient's chart is initially accessed at each visit, a reminder screen is displayed prior to chart access and order entry. This ensured that every provider who interacted with the patient was aware of the referral to the clinic. A secondary alert was triggered if providers ordered opioids.

Ancillary testing decreased proportionally to the decrease in ED visits. If our intervention had biased physicians against these patients, causing physicians to assume that they were never "sick," one would expect a comparatively greater decrease in the quantity of ancillary services used. Instead, there was strong correlation between both the decrease in ED visits and most of the secondary outcome variables, implying that these patients received the same amount of testing at each visit. To a degree, this is surprising; if a patient routinely presents with opioid-seeking behavior, one would plausibly expect providers to decrease testing.

Of all 278 patients referred into the program, to date only seven have followed up with the referral outpatient clinic. Of these, only three have continued to follow up with the clinic, and the other four were discharged for noncompliance with controlled substance covenants. The remaining 271 patients either already had a primary care physician or missed all scheduled appointments with the clinic. We posit that this extremely poor

compliance is a direct function of the patient population included in our protocol; prior to referral in the protocol these patients had a 14:1 median ratio of ED visits to clinic visits. Our chronic pain clinic ensured that these patients had guaranteed follow-up for their chronic pain, and thus the ED was no longer an acceptable mechanism to fill this need.

There has been much research into maintenance therapy, adjunct therapy, and replacement therapy for opioid cessation.[26-33] Unfortunately these clinics and therapies are often expensive, and due to the nature of the patients enrolled in this study, many had no resources or had already violated a pain contract. Thus, we identified a provider who was willing to see all of these patients free of charge, provided they were willing to wean to abstinence. Recent research has identified success with ED-initiated buprenorphine treatment as compared to intervention or referral to community resources.[27] Our intervention was initiated without financial support; if possible, we would recommend that significant support in the form of social work, case management, and addiction specialists be provided to this vulnerable population.

One of our main concerns is that when cut off from a source of opioids, these patients may resort to illicit methods to supply their addiction. Recently there was an HIV outbreak in Southern Indiana among Opana (oxymorphone) users who were sharing needles to inject their prescriptions.[34] While the risk of illicitly obtaining opioids is a major public health concern, the authors do not feel that this is an appropriate rationale for the ED to provide unfettered access to these medicines. Instead, we believe that the revolving door of the ED contributes to the problem. Future work is planned to aggressively support these patients with addiction management, social work, case management, and replacement therapy.

LIMITATIONS

There are several limitations to this study. This was a retrospective observational analysis of a preexisting administrative database at a large metropolitan hospital, which is part of a wide-reaching health system. While the data itself were not prospectively collected, the administrative protocol was performed in a prospective fashion. Thus, this study was a retrospective analysis of a prospective protocol, which we feel improved the robustness of the data. However, fundamentally this study was a retrospective review of existing data, and limitations exist for this form of study protocol. There is a potential for sampling bias in any retrospective review, although our abstractors followed strict rules and were transcribing concrete data points. We do note that we were unable to blind abstractors, but given the cohort nature of the study, all patients were "case" and blinding would be impossible.

While the EMR connects most of the hospitals in our healthcare system, we were unable to assess visits at most urgent visit centers, or EDs within other health systems. However, the use of our state PDMP does act as a surrogate for whether subjects simply shifted their ED use to other health systems. We were unable to determine total morphine equivalents for our patients. Thus, the decrease in annual prescriptions may in fact represent consolidation of prescriptions to fewer providers, with increased pill quantities per prescription. As there was no interview component to this study, we cannot determine if these patients went on to use illicit drugs at an increased rate.

One potential confounder is the increased national attention on restriction of opioid prescription at the same time as the study period. However, the study authors feel that it is unlikely that national attention alone resulted in a 58% decrease in opioid prescriptions for these patients.

A second confounder may be a natural decrease in opioid usage as painful conditions improve. However, prior studies have demonstrated that patients on long-term opioid therapy are unlikely to discontinue usage.[35,36] Thus, we conclude that our intervention was the cause for the decreased overall prescription rate.

CONCLUSION

In summary, this study demonstrates the efficacy of an interventional protocol intended to decrease ED visits among ED superusers. These patients were selected as those who frequently presented for the primary purpose of obtaining opioids for chronic pain. While only a handful took advantage of the chronic pain clinic to which they were referred, our protocol resulted in a decrease in ED visits, fewer statewide opioid prescriptions for the cohort, and less ancillary testing such as ECGs, CTs and radiographs. Implementing this protocol is fairly straightforward, requiring only an EMR flag and a task force willing to steward the database. We believe that this protocol streamlines patient care, decreases unnecessary visits to the ED, improves patient safety and can be one tool to help EDs combat our current opioid epidemic.

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Loaded Questions: Internet Commenters' Opinions on Physician-Patient Firearm Safety Conversations

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Introduction: Medical and public health societies advocate that healthcare providers (HCPs) counsel at-risk patients to reduce firearm injury risk. Anonymous online media comments often contain extreme viewpoints and may therefore help in understanding challenges of firearm safety counseling. To help inform injury prevention efforts, we sought to examine commenters' stated opinions regarding firearm safety counseling HCPs.

Methods: Qualitative descriptive analysis of online comments posted following news items (in May-June, 2016) about a peer-reviewed publication addressing when and how HCPs should counsel patients regarding firearms.

Results: Among 871 comments posted by 522 individuals, most (57%) were generally negative toward firearm discussions, 17% were positive, and 26% were neutral/unclear. Two major categories and multiple themes emerged. "Areas of agreement" included that discussions may be valuable (1) when addressing risk of harm to self or others, (2) in pediatric injury prevention, and (3) as general safety education (without direct questioning), and that (4) HCPs lack gun safety and cultural knowledge. "Areas of tension" included whether (1) firearms are a public health issue, (2) counseling is effective prevention practice, (3) suicide could/should be prevented, and (4) firearm safety counseling is within HCPs' purview.

Conclusion: Among this set of commenters with likely extreme viewpoints, opinions were generally negative toward firearm safety conversations, but with some support in specific situations. Providing education, counseling, or materials without asking about firearm ownership was encouraged. Engaging firearm advocates when developing materials may enhance the acceptability of prevention activities. [West J Emerg Med. 2017;18(5)903-912.]

INTRODUCTION

More than 30,000 people die each year in the United States from firearm-related injuries,[1] leading organizations to call for increased attention to firearm injuries as a preventable public health problem.[2, 3] They recommend healthcare provider- (HCP) delivered discussions of firearm risks, based on evidence that such conversations may enhance home firearm safety behavior and reduce injuries.[4, 5] In addition, in June 2017 the American Medical Association House of Delegates passed a resolution calling for collaboration with stakeholders to develop "state-specific guidance for physicians on how to counsel patients to reduce their risk for firearm-related accidental injury or death by suicide…"[6] Several studies have demonstrated support for discussions about firearms in some circumstances, highlighting clinical situations in which firearm safety discussions may be effective prevention practice.[7-10] Despite efforts occurring in some states to prohibit HCPs from discussing firearm risks with patients,[11] recent court rulings have found such legislation an unconstitutional infringement on providers' First Amendment right to freedom of speech.[12]

Nevertheless, firearm safety discussions are not widely or routinely integrated into healthcare encounters, and public opinion may vary about when and where such conversations are appropriate.[7, 13, 14] Emergency department providers working with suicidal patients report discussing firearms and other lethal means in only a fraction of circumstances,[14] partially due to fear of offending patients.[15] "Cultural competence" of providers has been suggested as a means of increasing acceptability and implementation of firearm safety conversations.[16] Still unclear are the full meaning of competence in this context and how best to increase competence among HCPs. Framing firearm discussions as "means safety" instead of "means restriction" could increase the acceptability and effectiveness of physician-patient discussions of suicide risk.[17] Collaborations between firearm and public health groups also offer promise.[18-20] Otherwise, many gaps remain in our understanding of how to make firearm safety conversations as effective and acceptable as possible.

Using online media, including social media or Internet "comment" sections, for qualitative research permits the inclusion of extreme perspectives that would be difficult to reach otherwise. The anonymity of online comments may enhance the comfort and frankness of users.[21] Health communication specialists have used online media to examine attitudes about controversial medical topics.[22-25] To our knowledge, no prior work has examined online commentary to better understand the debate over HCP counseling about firearm safety.

In this study, we therefore sought to examine the content of reader-submitted online comments about firearm safety conversations in healthcare practice. We recognized a priori that the individuals engaging in online debates are not representative of the larger population. However, understanding the beliefs of strongly opinionated subpopulations provides context critical to helping improve the acceptability and effectiveness of firearm safety discussions for use in the wider population.

Population Health Research Capsule

What do we already know about this issue?
Professional societies advocate that doctors should counsel patients about firearm safety, but social and political opinions on such conversations vary.

What was the research question?
To characterize the opinions of Internet commenters regarding doctor-patient firearm safety counselling.

What was the major finding of the study?
Most comments (57%) were against firearm safety counseling, but it was supported in specific clinical circumstances.

How does this improve population health?
Understanding the extreme viewpoints of a vocal minority can highlight challenges and opportunities to improve implementation of safety-oriented care.

METHODS

Study Design & Data Source

We used a qualitative descriptive study[26] and followed recommended guidelines for reporting qualitative research.[27] For our sample, we restricted our search to comments made about a single journal publication in an attempt to standardize the topic of online debate. "Yes, You Can: Physicians, Patients and Firearms"[11] was a review publication by members of our team that described situations in which providers should consider asking and counseling patients about firearms. The article appeared online in Annals of Internal Medicine on May 17, 2016, with numerous online news reports following. We searched for eligible reports by reviewing both "news" and "blogs" results on the article's Altmetric page, supplementing this with a Google search using relevant keyword combinations (e.g., "physician," "firearm," "gun," "doctor") and a 10-day range (May 15-25, 2016). We also searched major news sources and purposefully sought websites representing a variety of perceived political viewpoints, following findings suggesting that online commenters are more honest when they feel that they will be supported.[21] To focus the content of the discussions to be analyzed, we excluded news items not directly reporting on the Annals article and those

that did not allow for public comments (Figure). Comments were analyzed using Dedoose (v 7.1.3: SocioCultural Research Consultants, Los Angeles, CA). We repeated our search in February 2017 and did not find any additional articles or comments that fit our search criteria, as the news stories and the debate they generated appeared immediately following the original article's publication.

The study team included diverse professional and research backgrounds and varying experiences related to firearms. These included prior firearm safety training, recreational target shooting and hunting, personal losses to suicide, and clinical care of patients at risk of suicide and/or with firearm injuries. The study team had no known prior relationships with any of the individuals whose comments were analyzed. All data came from publicly available sources, and no commenters were contacted. The project was deemed exempt by the Colorado Multiple Institutional Review Board.

Analysis

We used a team-based analytic approach and established techniques.[28-33] Analysis was completed in the fall of 2016. In the analysis of comments, each included independent coding by at least two team members of the team (A1, A2, A6). First, we categorized comments using a priori codes for apparent sentiments regarding doctor-patient firearm safety conversations (positive, negative, or neutral/unclear). Second, we used thematic analysis to describe codes emerging within and across categories. In both passes, team members maintained consistent contact, with regular meetings to adjudicate differences and review analytic memos. We synthesized the final codes into a core set of themes using our inductive and deductive toolkit[31, 32] in consultation with all investigators.

RESULTS

Our data included comments from items appearing on eight sites (*Bloomberg, Forbes, Fox News, Huffington Post, Medscape, MinnPost*, the *New York Times,* and the *Washington Post*; Figure) published May 16-19, 2016. There were 871 comments made by 522 unique user names/avatars; the number of commenters varied across sites (Figure). Most comments were posted close to the date of publication, with the latest posted on June 19, 2016. Among the user names, 242 (46%) were identifiable as male and 33 (6%) as female; 247 (47%) could not be classified. Most users (76%) posted one comment (range: 1-32; interquartile range: 1-1). Comments are quoted verbatim here, respecting the often informal or grammatically incorrect styles of writing used online.

Themes

Most online comments appeared to view patient-physician discussions of firearms negatively (57%; vs. 17% positive and 26% neutral/unclear). Emergent categories were "Areas of agreement" and "Areas of tension," with several themes identified within each.

Areas of Agreement

Whether commenters were "for" or "against" HCP-delivered discussions of firearm safety, there were areas of general agreement and consensus among commenters (Table 1).

1. Firearm safety conversations are appropriate when the patient presents risk of harm to self or others

This view was espoused even by commenters who otherwise opposed discussing firearms in clinical contexts. The pertinence of discussing firearms within the context of mental health problems was sometimes framed as an obvious, natural outgrowth of conversations related to depression, erratic behavior, or risk of committing violence against others.

"I feel they should only ask if they see signs of major aggression or depression in someone. They of course should look out for signs that there has been violence, or if they are signs of emotional or mental distress that may cause them to act out against theirselves or others."

There was disagreement, at times with racist or other inflammatory language, about how to identify at-risk individuals.

"if these doctors are speaking with young black males they probably should mention gun violence. Otherwise discussing this topic would be a waste of time. The rest of America is capable of controlling themselves and we don't typically act like animals."

2. Firearm safety conversations are acceptable as injury-prevention education for parents

Discussions surrounding secure storage of firearms in the home to prevent unintentional access and subsequent injuries to children were generally viewed as acceptable, particularly when framed in the context of other dangers.

"I routinely talk about safety with patients, not only gun storage, but also texting while driving and wearing helmets while skate boarding. Most patients appreciate the reminder."

3. Educate, don't ask: Informational materials are acceptable

General educational materials and approaches, especially those endorsed by gun-use advocacy groups, were viewed favorably. Safety promotion conversations and materials were favored if they provided information about firearm risks alongside efforts to address other common dangers.

"Doctors need to have a gun safety pamphlet on the wall. Just like pool safety, bathroom safety, chemical safety, car safety, ticks and dogs. Subjects that they are not experts on but can impact the safety of a kid/family."

These comments frequently noted that safety information could be universally provided to patients, irrespective of whether they own firearms. Some commenters expressed concern that entering information about firearm access into medical records could place patients at risk of privacy invasion.

"There's absolutely nothing stopping your Dr. from handing you a brochure on Gun Safety...The PROBLEM is that Doctors are entering your answer about Gun Ownership into your (now

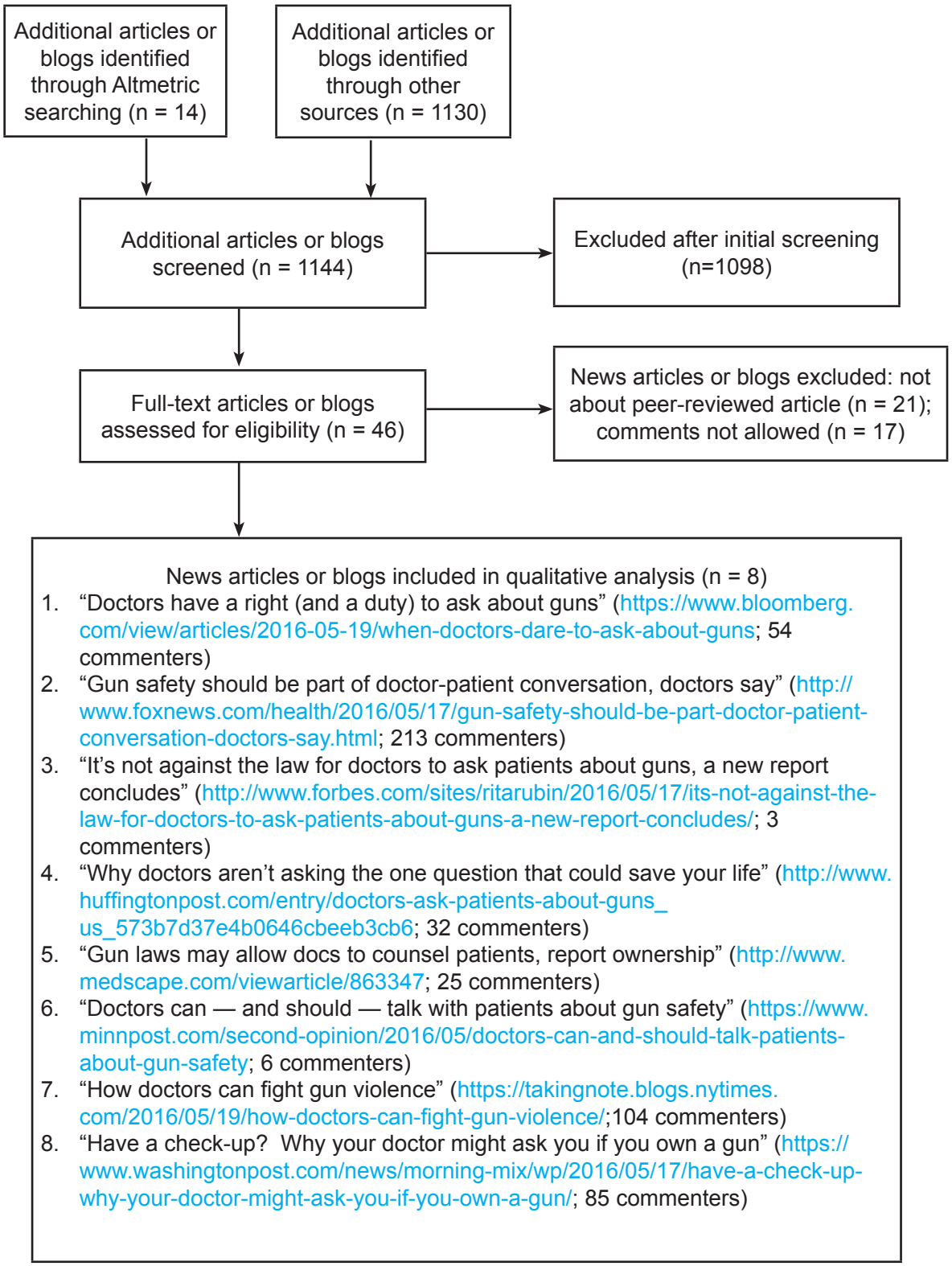

Figure. Flowchart of search strategy.

Table 1. Areas of agreement, with representative quotes.

Area	Quote
1. Firearm safety conversations are appropriate when the patient presents risk of harm to self or others	"Crisis/emergency intervention? Absolutely, yes. Ask and intervene. And don't limit it to just guns, but other aspects where the patient presents a frank danger to themselves and others." "If someone appears distraught or seems to be a threat to themselves, or someone else, then it makes sense to ask."
2. Firearm safety conversations are acceptable as injury prevention education for parents	"The American Academy of Pediatrics isn't recommending anything that the NRA isn't already recommending. . . . We actually don't care if you own a gun and do not share that information. We are only concerned if there are others in the house that could harm themselves or others if they have access to the weapon. . . . ." "It should go something like this…'Remember children are very inquisitive....store harmful liquids high and in a lockable cabinet, keep sharp objects, or hot pots and pans out of their reach, store firearms without ammunition and try to use a trigger lock or a safe while storing firearms. And remember to secure your child in a car safety seat while driving, use an approved seat and have it installed properly. Of you have a pool ensure that the pool is not accusable to your child unless you are present'."
3. Educate, don't ask: Informational materials are acceptable	"Okay, talk about them all you want. Discuss storage methods, explain how to keep them as safe as possible. Just don't ask if the patient owns any and we'll never have a problem." "Confidential questions about gun habits, like questions about driving, smoking and drinking, are legitimate medical inquiries." ASKING is not the problem, it is the SHARING with the Government/ THIRD PARTIES that becomes the issue!"
4. HCPs are not knowledgeable about firearms or the culture of gun ownership	"I have ONE doctor that I discuss firearms with and that is only because he is actually carrying during my visit. I hate to admit it, but he actually shoots better than I do too! The rest of my doctors have no business asking about my means of self defense or how many firearms I own. "

computerized) Medical Records....and the Government wants access to those records."

4. Doctors are not knowledgeable about firearms or the culture of gun ownership

Many commenters cited their own extensive experience with firearms as evidence that HCPs would provide little value to them when discussing firearm access and use.

"I am a certified rifle and pistol instructor, a certified Range Safety Officer, and was also trained my dear old Uncle Sam while vacationing at beautiful Parris Island, SC., where I learned to shoot....bigger guns. My doctor is welcome to ask me anything he needs to learn"

Conversely, individual anecdotes about doctors who are firearm owners, active participants in associated communities, or otherwise knowledgeable about firearms suggested a relationship between a HCP's perceived competence and a commenter's willingness to discuss firearm safety. Yet a few commenters suggested that basic firearm safety counseling need not require significant knowledge or training on the part of providers.

"Lord woman, does a doctor really need to be a gun safety expert to tell you that you need to lock up your gun because your kid has suicidal ideations?"

Areas of Tension

We identified four areas of conceptual disagreement between commenters with positive versus negative views of firearm safety conversations (Table 2).

1. Are firearms a public health concern?

Individuals who believed that firearm injuries and violence are not within the purview of healthcare tended to argue that guns and health were distinct. Commenters endorsing the public health importance of firearms often compared them to other dangers that are addressed in clinical conversations, such as domestic violence and household hazards.

*"If you own a gun, that's fine, be an adult about it and recognize that it *is* a health risk. I'm glad doctors are being persistent about this."*

2. Is physician counseling effective in preventing injuries/ deaths?

A positivistic view of research[34] surrounding prevention methods, in which a lack of evidence of efficacy is viewed as evidence of inefficacy, was common.

"FACT: Any doctor that ask their patients about guns are quacks."

Some commenters emphasized their own skepticism about approaches to firearm safety discussions without acknowledging existing studies supporting the effectiveness of firearm safety counseling.[4, 5] Others offered hypothetical situations in which such conversations might be a low-risk, but potentially high-reward, injury/violence prevention strategy.

3. Is suicide preventable? Should suicide be prevented?

Many commenters said that suicide was not preventable and that suicidal individuals without firearm access would substitute a

Table 2. Areas of tension, with representative quotes.

Question	No	Yes
1. Are firearms a medical/public health issue?	"It's none of your business. Simply put. It's not medicine, no matter how you try to stretch it." "What EXACTLY, has been the contribution to "patient health" from physicians learning about the ownership of firearms?"	"If doctors can tackle domestic violence, why not gun violence? Both have been public health emergency conditions for years. I am not anti-gun. My family are all gun-owners, we all learn to shoot safely and get our own .22 when we turn 12." "As the third-leading COD (second-leading in 2014), it is absolutely a medical issue, as are Cancers (first) and MVA's (second)."
2. Is counselling effective in preventing injuries/ deaths?	"I am a physician: I am trained to practice "evidence based medicine". There is no evidence that this policy would help, and it cannot be seen as the practice of medicine" "Did Goebbels spring from his grave and pen this? What, EXACTLY, are physicians to do if the patient says, 'Yes, I own a firearm.' What EXACTLY, has been the contribution to "patient health" from physicians learning about the ownership of firearms?" "I'm all for doctors asking whatever questions they deem fit, but realistically how many lives are going to be saved? My guess is 'very few' to 'none'. How many irresponsible gun owners are regularly visiting the doctor? How many of them would actually take on gun advice from said doctor? How many of those few who actually took the advice would then go home and follow through? If you want to curtail gun violence you only have one sure-fire method for doing so: start banning guns."	"If Mrs. Lanza's [mother of Adam Lanza the Newtown killer] physician had inquired about guns and said given your son's mental condition it would be wise not to have guns in your home perhaps the Newtown massacre would have been prevented" "It's not the gun safety issue, it's the mental state of the owners issue the doctor should be watching for. My dad had a stroke and the doctor revoked his drivers license until he was well enough again and got it reinstated. Same if a doctor sees a patient is getting into a depressive state from a divorce or job loss etc, revoke the firearms license until they are better."
3. Is suicide preventable? Should It be prevented?	"If someone is going to take their life then they will do it by any means necessary. They do not need a gun." "The great majority of annual gun deaths are suicides in the middle-aged to elderly. Why do we think we need to prevent this? Who can say that this is not a rational decision for many of these people? Often it is a blessing for their families that they no longer have to deal with the intractable problems associated with living with or around these broken people."	"if you were depressed and killed yourself with a gun and your family came after me to sue, I'm sure my malpractice insurer would be quite interested in whether or not I'd asked about guns" "What doctor doesn't talk to suicidal patients about removing firearms from the home? I've done it countless times."
4. Is firearm safety within HCPs' professional role?	"Please. Like some 'doctor' knows what is and isn't good for me." "Safety is a lie told to stupid people to keep them in line... Doctors are not working for our benefit." "If I want to see a doctor, it's because I need medical attention, not because I need to get into a debate with a gun control advocate."	"A lot of people who take gun freedom to gun nuttery seem to think that they need to get the government to pass a nanny-state law telling your doctor how to treat you because they don't want to face an uncomfortable question." "The point being is that doctors should be able to ask questions whenever they feel the need, and honestly? They shouldn't have to spend most of the visit justifying the questions."

different fatal method. Some specified that suicide is a reasoned action, and that reducing firearm access therefore infringed on individuals' liberty to end their own lives.

"Why do the meddling do-gooders want to prevent suicides, if a person wants to end his life? The reason why older White males have a high suicide rate is because they are determined and decisive. (This is also the reason why most good executives are White males - they make decisions and get things done)."

Most arguments supporting suicide's preventability were made by commenters who endorsed a positive view of firearm safety discussions. Many of these comments were written by individuals self-identifying as HCPs.

4. Is firearm safety within HCP's professional role?

Some commenters indicated that conversations with providers who lack requisite knowledge and cultural competence would be unhelpful and unnecessarily contentious. Others highlighted the intimate nature of other clinical conversations, situating firearms among myriad sensitive topics discussed within healthcare encounters.

"Doctors routinely advise patients not to drive because their age, vision, neurological problems, etc. make it a risk to

Table 3. Other themes, with representative quotes

Theme	Quote
1. Belief that firearm discussions are part of a hidden agenda for gun control	"Doctors asking patients about owning guns during a simple check up is nothing but a new tactic by a segment of the gun-control crowd (anti-gun doctors) used in an attempt to stigmatize guns. Period" "Doctors asking about guns in the home seemed to become a phenomenon that started happening once the government took over the healthcare system. Doctors are likely starting to be mandated to ask these questions and mine data for big brother."
2. Comparison to other hazards, often with inaccurate quotation of statistics to reinforce points of view	"It would be more appropriate for doctors to ask parents of small children it they have stairs in their house. Much higher injury, and fatality, rate from stairs. But stairs aren't a political issue" "Right so should doctors routinely inquire about whether their patients own a motorcycle? How about extreme sports; do you rock climb? If so are we relying on doctors to provide instructions on safe riding practices or how to properly tie off, on a cliff?"

themselves and others. They advise them not to work with certain kinds of machinery for similar reasons. Why shouldn't docs advise patients on guns?"

Other Themes

Additional notable themes were identified among negative comments.

1. Firearm discussions are part of a hidden agenda for gun control

Distrust of medical and public health professionals was frequently coupled with commenters' belief that discussions regarding firearm access were gathering data to support gun control efforts.

"Doctors are likely starting to be mandated to ask these questions and mine data for big brother."

2. Comparison to other health hazards

Risk attributable to firearms as compared with other health concerns was mentioned frequently.

"Sure, but odd you never hear about Doctors wanting to talk safety about the 28,000 chain saw injuries per year, those killed by open dishwashers, or any of the myriad other safety issues, but guns by golly, that's the one they need to give you a colonoscopy on."

Many commenters noted dangers and deaths associated with medical errors and prescription medication misuse (with varying statistics quoted), supporting the notion that HCPs are not competent to counsel patients about safety in any context.

"98,000 people die from doctor mistakes per year. And gunshot wounds a little more than 30,000 per year. Think about that."

"The medical profession is responsible for 600,000+ unnecessary death each year, must we have a conversation with the NRA about seeking medical attention?"

DISCUSSION

While the opinions of Internet commenters are certainly not representative of the general population's opinions regarding firearm safety conversations, the extreme views expressed by this vocal minority offer unique insight into the perspectives of some who most vigorously oppose firearm safety discussions in a clinical context. A better understanding of these strongly held opinions could inform the strategies public health professionals use to implement prevention programming and providers' decisions about how to frame firearm safety conversations. It also supports future hypothesis-guided research on best practices for such conversations.

The majority of commenters agreed on the appropriateness of three aspects of patient-provider firearm safety conversations: (1) counseling and intervention with individuals posing risk to themselves or others; (2) counseling parents; and (3) including educational materials in these discussions, especially materials created in collaboration with firearm advocacy organizations. These areas of agreement highlight possibilities for collaborations among public health professionals, HCPs, firearm organizations, parenting groups, violence prevention advocates, civil society advocates, and other stakeholders.[16-19] Such collaborations could improve the quality and effectiveness of firearm safety discussions.

A key finding was that commenters viewed asking about gun ownership as different from educating about gun safety. This finding provides context to a recent survey of parents, in which slightly more supported counseling about safe firearm storage than asking about access (75% versus 66%).[9] Providing information about firearm safety without inquiring about access and without singling out firearms as source of high risk was viewed favorably by online commenters, irrespective of the clinical context. Conversations about firearms could be added to those covering household hazards and prescription medications.

Many comments revealed misinformation or stigma about the preventability of suicide, highlighting the importance of efforts to educate providers and the public about the preventability of suicide. In circumstances where the patient poses an immediate risk to self or others, asking directly about firearm access is an evidence-based component of a physician's

risk assessment and determination of care. Yet, in a national survey 74% of respondents thought most or all suicide decedents would have found another way to die, had their chosen method been blocked; and HCPs still report skepticism about the preventability of suicide. Our findings similarly reflect lack of familiarity with the large body of evidence on the effectiveness of lethal means restriction (temporary reduction in access to highly lethal methods of suicide) as a suicide prevention approach.[35, 36]

Others' work shows that high proportions of physicians believe they have a right and responsibility to talk to patients about firearm safety. Physician counseling about firearm safety is effective in changing home storage behavior in many circumstances,[5, 35, 37] and a recent survey of firearm-owning parents found that 14% of parents would follow, and 49% would consider, a pediatrician's advice to not have firearms in the home.[9] Yet physicians are reticent to initiate these conversations in practice. Perceived barriers include low perceived efficacy, lack of confidence in their own credibility and purview, and concern that such conversations will alienate patients.[10] Culturally competent materials on firearm safety discussions may help to overcome concerns about physician knowledge or trustworthiness. Educational materials created in collaboration with firearms groups may have greater credibility and acceptability to patients who own firearms. Indeed, some commenters in our data (who self-identified as HCPs) reported that they use materials from the National Rifle Association or National Shooting Sports Foundation, and materials are also available from other organizations.[38, 39] Other ways to increase physician competence may include training, collaboration with firearm organizations, and improved awareness of state and local laws.

LIMITATIONS

Limitations of this project include that the results are derived from discussions occurring between small sectors of generally anonymous online commenters, who are different than the general public in a variety of ways. People who comment online are more male and have lower educational attainment than people who read comments, but do not participate in discussions.[40] Internet comments sections are likely to represent more extreme or hyperbolic views than those appearing in other public discourse.[41] Online dialogue can be highly contentious, with many commenters defending positions they believed concordant with their global views on gun rights or control.

Unfortunately, we were not able to examine comments according to demographic characteristics, as gender was often unclear and other relevant factors (including age, race, and geographic area) were not available. Tension during the study period (May-June 2016) may have been heightened by partisan conversations following major news events and the U.S. presidential election. Indeed, many of the more extreme views arose in comments about gun control in general, rather than how to address firearm safety within healthcare. Prior studies suggest that many firearm owners have more positive views towards physician engagement in firearm safety than was illustrated in this analysis.[7, 9] On the other hand, while our results likely describe a subpopulation with strong, extreme opinions, the online forum does have the advantage of anonymity and thus may be effectively bypassing social acceptability bias and uncovering more honest opinions. In addition, our focus on news stories and comments about a single published article allows us to control for some variability in the subject matter.

CONCLUSION

This qualitative analysis of online comments about an article on HCP firearm safety discussions likely represents extreme views due to anonymity and the requisite motivation to engage in highly politicized conversation. Despite this, even some commenters with reservations about such discussions appeared to support them in particular circumstances. These circumstances, including counseling for those at risk to self or others, for parents, and with educational materials, echoed many of the primary points of the referenced article.[11] The other area of agreement – tthat HCPs generally lack knowledge and cultural competency regarding firearm ownership – is one of the barriers reported by physicians themselves to expanding firearm safety counseling. Future research to better understand the most effective messages and methods for discussions about firearm safety is critical. In the meantime, providers can use culturally competent approaches and existing guidelines and recommendations – enhanced by a growing understanding of the views of those skeptical or opposed – to help prevent firearm injuries and deaths.

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Using Geospatial Mapping to Determine the Impact of All-Terrain Vehicle Crashes on Both Rural and Urban Communities

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Introduction: Deaths and injuries from all-terrain vehicle (ATV) crashes result in approximately 700 deaths each year and more than 100,000 emergency department (ED) visits. Common misconceptions about ATV crashes are a significant barrier to injury prevention efforts, as is the lack of key information about where and how crashes occur. The purpose of this study was to determine ATV crash patterns within a state, and to compare and contrast characteristics of these crashes as a function of crash-site rurality.

Methods: We performed descriptive, comparative, and regression analyses using a statewide off-road vehicle crash and injury database (2002-2013). Comparisons were performed by rurality as defined using the Rural Urban Commuting Area (RUCA) coding system, and we used geographic information system (GIS) software to map crash patterns at the zip code and county levels.

Results: ATV crashes occurred throughout the state; 46% occurred in urban and 54% in rural zip code areas. Comparisons of rider and crash characteristics by rurality showed similarities by sex, age, seating position, on vs. off the road, and crash mechanism. Conversely, helmet use was significantly lower among victims of isolated rural crashes as compared to other victims (p=0.004). Crashes in isolated rural and small rural areas accounted for only 39% of all crashes but resulted in 62% of fatalities. In both rural and urban areas, less than one-quarter of roadway injuries were traffic related. Relative crash rates varied by county, and unique patterns were observed for crashes involving youth and roadway riders. During the study period, 10% and 50% of all crashes occurred in 2% and 20% of the state's counties, respectively.

Conclusion: This study suggests that ATV crashes are a public health concern for both rural and urban communities. However, isolated rural ATV crash victims were less likely to be helmeted, and rural victims were over-represented among fatalities. Traffic was not the major factor in roadway crashes in either rural or urban areas. Unique crash patterns for different riding populations suggest that injury prevention experts and public policy makers should consider the potential impact of geographical location when developing injury prevention interventions. [West J Emerg Med. 2017;18(5)913-922.]

INTRODUCTION

Since all-terrain vehicles (ATV) were introduced in the 1970s, U.S. Consumer Product Safety Commission (CPSC) data have shown a significant increase in ATV-related deaths and injuries.[1] Current estimates indicate that there are approximately 700 deaths each year and more than 100,000 emergency department (ED) visits.[1,2]

There are a number of independent risk factors for

ATV-related deaths and injuries. These factors include being male, under 16 years of age, inexperience, carrying passengers, alcohol use, and lack of helmets.[3-13] Numerous studies indicate that these unsafe riding practices are highly common.[9,14-24] Crash location has also been shown to be associated with the likelihood and severity of injuries. Specifically, deaths are more common on roadways than off, and severe injuries are more likely on the road.[3,7,25] Moreover, even after controlling for multiple variables including helmet use, ATV fatality victims in roadway crashes were nearly twice as likely to have suffered a head injury as compared to off-road victims.[5]

Consistent with these outcome results, epidemiologic and survey studies have shown that unsafe riding behaviors are more likely on the roads than off. For example, fatal roadway crashes were more likely than fatal off-road crashes to involve multiple riders and alcohol use, and victims of these fatal roadway crashes were less likely to be helmeted.[5] Alcohol use and lower helmet use were also found to be more likely in non-fatal roadway crashes as compared to non-fatal crashes off the road.[7]

Similarly, survey studies found a high prevalence of unsafe riding behaviors among adolescent students who had been on an ATV, with 92% reporting having ridden on an ATV with passengers and 81% reporting having ridden on a public road.[16] Students reporting both riding on the road and carrying passengers had a more than three-fold higher likelihood of reporting having been in a crash. Among adult participants surveyed at a large agricultural event, over 80% had ridden with passengers and two-thirds had ridden on public roads.[14] Over half of survey respondents reported never or almost never wearing a helmet.

Only two studies have examined the geographic patterns of ATV-related deaths and injuries. A West Virginia study of fatalities found that 20 out of 55 counties (36%) in their state accounted for nearly seven out of 10 fatal crashes from 2000 to 2008.[26] Another study showed that the eastern region of Texas had a higher ATV-related pediatric (<18 years old) death rate than the state as a whole.[27] The goals of the current study were to determine the ATV crash patterns in a Midwestern state using an off-road vehicle crash and injury database that combines information from multiple statewide sources, and to determine the extent to which crash site rurality was associated with crash characteristics.

Population Health Research Capsule

What do we already know about this issue?
ATV-related deaths and injuries are an important but often overlooked public health issue. Major vulnerable populations include youth under 16 years old and riders who take their ATV on the road.

What was the research question?
What are the ATV crash patterns within a state and are there differences in crash characteristics between urban and rural areas?

What was the major finding of the study?
Crash patterns differed for vulnerable riding populations and illustrated the need for targeted interventions at the county level.

How does this improve population health?
Injuries are a leading cause of death and disability. Using geospatial mapping to locate ATV crashes provides key information for targeted community-based injury prevention.

METHODS

Off-Road Vehicle Crash and Injury Database

We compiled an off-road vehicle crash and injury database that included records from the Iowa Department of Transportation (DOT), Iowa Department of Natural Resources (DNR) and State Trauma Registry (STR) for the years 2002-2013. The University of Iowa Institutional Review Board approved these studies.

Identifying ATV Crashes

The data sources for the database include more than one off-road vehicle type. To identify ATV crashes for inclusion in this study, we used several strategies. Vehicle type for DOT data was determined using the vehicle identification number (VIN). For DNR data, a vehicle type variable is included on the crash form and was usually documented. In some cases, make and model were also available. For STR data, we used E-Codes for initial identification (821.0-821.9). We then used cause-of-injury narratives to further identify vehicle type. For both DNR and STR data, ATVs were distinguished from side-by-sides (utility task vehicles, UTVs; recreational off-highway vehicles, ROVs) using the make and model when available or by reading all crash narratives for key words describing side-by-side features, i.e., rollover protection structures (ROPS) and seatbelts. Records without sufficient vehicle information were designated as unknown. Only records with vehicle type designated as an ATV were used in the current study. We resolved data for duplicate records in more than one database prior to analysis.

Study Variables

In analysis, we used variables that were moderately (e.g., crash mechanism, helmet use) to well documented (demographics) in the combined database. Because crash-related variables were coded from the trauma registry narrative, a limited number of these variables had documentation sufficient for inclusion in bivariate and multivariate analysis. Person-related variables used in this study were the victim's sex, age, seating position, helmet use, and whether the injury was fatal. Crash-related variables used were crash mechanism, whether the crash occurred on or off the road, and rurality of the crash location. Rurality was based on zip codes and was defined using the Rural Urban Commuting Area Codes (RUCA) 2.0 from the University of Washington (http://depts.washington.edu/uwruca/ruca-approx.php). Specifically, we combined the 10 levels in the original coding system into four categories: isolated rural, small rural, large rural, and urban as previously described.[28]

Mapping Crashes

We used ArcGIS (v10.2) to create visual representations of crash patterns at the zip code and the county level. Point-source mapping and analysis were not feasible as only DOT data provided geographic information system (GIS) coordinates, and DNR and STR data were limited in documentation of street address of the crash site. County and zip code locations were available for 1,832 unique crashes.

We mapped crashes in each county both as total number of crashes over the study period and as crash rate (crashes per 100 registered ATVs). ArcGIS selected cutoff points for the scale to optimize comparisons. The registration data used in the study was made available from the Iowa DNR but did have some limitations. Most importantly, the registrations provided were likely an underestimate of the total number of ATVs in the state both because ATVs used exclusively as farm equipment are not required to be registered and because there is no consistent enforcement of registration for non-occupational use. In addition, prior to 2012 only the number of newly purchased vehicles registered each year was available, not total registrations. So, we used registration data from 2012-2015 in the study. The total number of registered ATVs for 2012-2015 was 30,186, 25,564, 23,856, and 24,020, respectively.

To calculate a crash rate for each county, we divided the number of crashes in the county during the study period by the average number of registered vehicles for the county from 2012-2015. Values were multiplied by a factor of 100 to generate whole numbers. Due to inherent limitations in the ability to capture all ATV crashes in the state and the limitations in registration data, these numbers should be considered best estimates and used as relative rather than as absolute values to compare counties.

To indicate the rurality of the crash location for mapped data, zip code areas were shaded based on RUCA coding, with darker shades indicating more urban areas. Relative crash numbers and crash rates by county are shown as a shaded scale with darker shades representing higher values.

Data Analysis

We used SPSS (IBM Statistics Package for the Social Sciences, v22) to perform all analyses. Descriptive analysis generated frequencies of study variables, and comparisons of categorical variables were performed using the chi-square test. We used logistic regression analysis to calculate adjusted odds ratios and 95% confidence intervals (CI) for categorical outcomes, after controlling for significant covariates. Persons with missing data for one or more of the variables in the model were not included in analysis. Only helmet use was identified in bivariate analysis as being different by rurality. Thus, helmet use was the only outcome variable used in regression modeling. The number of records with values for all variables in this model was 479.

RESULTS

Crash Characteristics

The database contained 2,202 unique ATV crashes involving 2,326 crash victims for the study period. Victims were 78% males and 29% were youth less than 16 years of age (Table 1). Operators were 83% of crash victims and only 25% of all victims were wearing helmets at the time of the crash. Among persons in the database who were injured, 2.6% died.

The major crash mechanism was a non-collision event like a rollover (74%), and less than 10% of all crashes involved a collision with another motorized vehicle. One in four crashes occurred on the road. Even on roadways, however, only 23% of crash victims (101 out of 445) were involved in a traffic collision. Similarly, although more ATV-related fatalities (8 of 56 victims, 14%) than non-fatal injuries (107 of 2176 victims, 5%) resulted from traffic-collisions (p=0.005), still more than eight out of 10 fatalities were from single-vehicle crashes.

Approximately 83% of crashes (1,832 of 2,202) in the database had location information for mapping by the zip code area of the crash site. Figure 1 shows the pattern of crashes in the state with zip code areas shaded by rurality. Mapping showed crashes occurred throughout the state.

Comparisons by Crash-Site Rurality

Using the RUCA coding system, 46% and 54% of all crashes occurred in urban and rural zip code areas, respectively, with a similar proportion for the three rural designations (Table 1). Comparisons of demographics and crash characteristics by rurality are shown in Table 2.

Table 1. Person and crash related characteristics for ATV crashes in the Iowa Off-Road Vehicle Crash and Injury Database from January 1, 2002 through December 31, 2013.

Variable	n[1]	Col %
Sex		
Male	1809	78%
Female	497	22%
Age		
<6 years old	61	2.6%
6-11 years old	212	9.1%
12-15 years old	384	17%
16-17 years old	192	8.3%
18-30 years old	641	28%
31-45 years old	426	18%
46-60 years old	259	11%
>60 years old	98	4.2%
Seating		
Operator	1386	83%
Passenger	277	17%
Helmet use		
No	935	75%
Yes	311	25%
Fatality		
No	2257	97.4%
Yes	60	2.6%
Roadway crash		
No	1127	75%
Yes	371	25%
Crash mechanism[2]		
ATV-ATV	82	4.4%
ATV-VEH	94	5.0%
ATV-OTHER	307	16%
NON-COLLISION	1385	74%
Rurality		
Isolated rural	313	19%
Small rural	321	20%
Large rural	237	15%
Urban	738	46%

Col, column.
[1]Column totals (n) for each variable may not equal total n for persons or crashes due to missing data.
[2]ATV-ATV, collision between 2 or more ATVs; ATV-VEH, collision of ATV with a motor vehicle that is not another ATV; ATV-OTHER, ATV collision with a fixed or unfixed object that is not a motor vehicle; NON-COLLISION, event did not involve a collision with a motor vehicle or object.
Crashes n=2,202; Victims n=2,326.

We observed no significant differences as a function of rurality, except for helmet use. Differences in the proportion of fatal versus non-fatal crashes and for crashes on roadways vs. off-road approached but did not reach significance. Of note, almost three-fourths of fatalities (35 of 49, 71%) were in rural zip codes and over half of all fatal crashes (24 of 43, 56%) occurred on the road.

We used regression analysis to further characterize the potential association of helmet use with rurality and other variables (Table 3). Results indicated that passenger victims, riders in roadway crashes, and crash victims in isolated rural areas were 55%, 61%, and 62% less likely to be helmeted than operators, off-road riders, and crash victims from urban areas, respectively. Consistent with results from bivariate analysis, we saw no differences in likelihood of helmet use by sex or age of the crash victims.

Crash Patterns by County

We mapped total crashes and crash rates per 100 registered ATVs at the county level for all crashes in the database (Figure 2, Panels a, b), for those involving youth less than 16 years old (Figure 2, Panels c, d) and for those that occurred on the road (Figure 2, Panels e, f). Patterns show county-level variability in each case.

With respect to all crashes, the highest numbers were most often observed in counties with major cities. In Figure 2 (Panel a), stars represent the location of the top 12 largest cities in the state. The larger star represents four of these cities that are contiguous. While counties with the highest total crash numbers were primarily in central and eastern parts of the state, areas with the highest crash rates based on registered ATVs were in rural southern counties (Figure 2, Panel b).

As with total crashes, the number of crashes in each county involving youth (Figure 2, Panel c) or on the road (Figure 2, Panel e) was highest near population centers. However, in contrast to data for all crashes, counties with the highest crash rates for youth-related (Figure 2, Panel d) and roadway crashes (Figure 2, Panel f) were more widely distributed throughout the state. The crash patterns by county were also different for these two high-risk riding populations.

Counties were sorted by number of crashes per county for all crashes, for youth-related crashes, and for crashes on the road. We calculated total crashes for the counties with the highest numbers and determined their percentage of total crashes (Table 4). Results showed that in all three cases, 2%, 20%, and 33% of counties accounted for approximately 10%, half, and two-thirds of all crashes, respectively.

DISCUSSION

Scope of the Problem

Overall knowledge and public awareness of ATV safety appears to be limited.[14,29,30] In addition, survey results of knowledge and safety behaviors show that many riders

Table 2. Comparison of victim and crash characteristics as a function of rurality for ATV crashes in the Iowa Off-Road Vehicle Crash and Injury Database from January 1, 2002, through December 31, 2013.

	Rurality (RUCA[1]) n (Column%)[2]				
	Isolated rural	Small rural	Large rural	Urban	p value[3]
Person-related variables					
Sex					
Male	296 (79%)	276 (80%)	196 (78%)	608 (77%)	0.68
Female	72 (21%)	68 (20%)	56 (22%)	181 (23%)	
Age					
<6 years old	9 (3%)	13 (4%)	9 (4%)	18 (2%)	0.1
6-11 years old	41 (12%)	25 (7%)	20 (8%)	66 (8%)	
12-15 years old	67 (20%)	59 (17%)	41 (17%)	146 (19%)	
16-17 years old	24 (7%)	24 (7%)	20 (8%)	75 (10%)	
18-30 years old	87 (26%)	97 (29%)	86 (35%)	193 (25%)	
31-45 years old	53 (16%)	58 (17%)	40 (16%)	152 (20%)	
46-60 years old	37 (11%)	42 (12%)	18 (7%)	97 (12%)	
>60 years old	15 (5%)	22 (6%)	13 (5%)	31 (4%)	
Helmet use					
No	156 (83%)	133 (68%)	104 (71%)	338 (68%)	0.004
Yes	28 (17%)	51 (32%)	36 (29%)	136 (32%)	
Seating					
Operator	219 (84%)	204 (82%)	154 (81%)	448 (83%)	0.89
Passenger	42 (16%)	44 (18%)	36 (19%)	95 (17%)	
Fatality					
No	323 (97%)	331 (97%)	245 (99%)	777 (99%)	0.089
Yes	13 (3%)	14 (3%)	8 (1%)	14 (1%)	
Crash-related variables					
Crash mechanism[3]					
ATV-ATV	10 (4%)	11 (4%)	14 (7%)	28 (4%)	0.75
ATV-VEH	15 (5%)	18 (7%)	11 (5%)	48 (8%)	
ATV-OTHER	51 (19%)	42 (16%)	33 (16%)	100 (16%)	
NON-COLLISION	197 (72%)	191 (73%)	146 (72%)	447 (72%)	
Roadway crash					
No	173 (77%)	186 (78%)	149 (78%)	387 (77%)	0.089
Yes	70 (29%)	54 (23%)	42 (22%)	159 (29%)	

[1]Rural Urban Commuting Area coding system
[2]Column total (n) for each variable may not equal total n due to missing data.
[3]Categorical variables were compared using the chi square test.
[4]ATV-ATV, collision between 2 or more ATVs; ATV-VEH, collision of ATV with a motor vehicle that is not another ATV; ATV-OTHER, ATV collision with a fixed or unfixed object that is not a motor vehicle; NON-COLLISION, event did not involve a collision with a motor vehicle or object. Crash n=2,202; Victim n=2,326.

either do not know what is safe or do not practice safe riding behaviors despite this knowledge.[2,9,16,18-20,24,31,32] The high proportions of ATV crash victims who exhibit unsafe behaviors at the time of the crash is consistent with these survey results.[5-7,25] Although previous studies showed that location, on vs. off the road, is associated with differences in

riding behaviors and outcomes,[5,7,25,33] no studies had previously examined associations between rurality of the crash site and ATV-related deaths and injuries. Both similarities and differences between rural and urban areas are informative.

Rurality and Demographics

Our study showed, for the first time, that helmet use was independently associated with rurality. Specifically, we found that helmet use was significantly lower among crash victims in isolated rural crashes, as compared to victims of crashes in other areas. This finding is consistent with results from a school-based survey study.[16] Students from school districts in isolated rural areas were less likely to report wearing helmets than their peers in other school districts. In contrast to helmet use, comparisons of other rider characteristics in this study showed no significant differences between riding populations in rural and urban settings.

Fatal Crashes

Among ATV crash victims in the database, 2.6% were killed. Whereas isolated rural and small rural zip code areas accounted for only 39% of all crashes, 62% of fatal crashes occurred in these areas. The reason for this finding is currently unknown. However, because both the crash mechanism and proportion of roadway crashes were not different by rurality in this study, neither likely account for the higher proportion of fatal crashes in rural areas. Previous studies have shown that rural victims have a higher risk of death from traumatic injury than their urban peers, though the basis for this increased risk also remains elusive.[34] We speculate that longer response times for emergency medical services to rural crash victims and, in some cases, longer times before more remote crashes are detected may contribute to the differences observed. Lower rates of helmet use among rural crash victims may also be a factor.

Youth ATV Crashes

Younger age has been identified as an independent risk factor for ATV-related deaths and injuries.[4] The American Academy of Pediatrics' policy states that no child under the age of 16 should be allowed on an ATV,[35], and the Consumer Product Safety Commission and manufacturers warn against youth under 16 years of age riding on adult-size vehicles. Crash rates (per 100 registered ATVs) for youth in the study varied from county to county. These differences suggest more frequent riding by youth in some counties than in others and/or that youth in counties with higher crash rates are more likely to have engaged in risky riding behaviors.

Table 3. Likelihood of crash victim being helmeted.[1] Multivariable regression analysis related to crash-victim helmet use in the Iowa Off-Road Vehicle Crash and Injury Database from January 1, 2002, through December 31, 2013.

Covariates[2]	aOR	95% CI
Sex		
Male	1.15	0.67-1.97
Female	Ref (1.0)	
Age		
< 16 years old	1.38	0.88-2.16
≥ 16 years old	Ref (1.0)	
Seating		
Operator	Ref (1.0)	
Passenger	0.45	0.23-0.88
Roadway		
No	Ref (1.0)	
Yes	0.39	0.24-0.64
Rurality		
Isolated rural	0.38	0.21-0.70
Small rural	0.81	0.49-1.37
Large rural	0.87	0.49-1.55
Urban	Ref (1.0)	

aOR, adjusted odds ratio.
[1]Reference is not being helmeted.
[2]Model included the indicated covariates. Cases missing data for one or more of the variables were not included in the model. Final included cases = 479.

Table 4. Proportion of crashes in the state as a function of the counties with the highest number of crashes for each of the indicated crash categories in the Iowa Off-Road Vehicle Crash and Injury Database from January 1, 2002 through December 31, 2013

Crashes (Total n)	Counties[1] n (%)	Crashes n (%)
All[2] (n=1,805)	2 (2%)	175 (10%)
	20 (20%)	907 (50%)
	33 (33%)	1196 (66%)
Youth[2] (n=552)	2 (2%)	52 (9%)
	20 (20%)	272 (49%)
	33 (33%)	369 (67%)
Roadway[2] (n=424)	2 (2%)	34 (8%)
	20 (20%)	209 (49%)
	33 (33%)	285 (67%)

[1]Total number of counties = 99.
[2]The counties in order from highest to lowest crash number for the three populations are similar but not identical.

Roadway Crashes

A commonly held misconception is that ATV riding on public roads is safe. This is not supported by the findings in this and previous studies.[5,7,25] Nearly 30% of all crashes and more than half of fatal crashes in the database occurred on the road, and the proportion of roadway crashes was similar for rural and urban areas. Previous studies also showed more than half of all fatal U.S. crashes occurred on the road and that both paved and unpaved roads represented greater risks than riding off-road.[5,25] As with youth-related crashes, the rate of roadway crashes varied by county. This suggests that roadway riding may be occurring to a greater extent in some counties than in others and/or that riders in high crash-rate counties are engaging in risky behaviors (e.g., multiple riders on the ATV) to a greater extent on the road than riders in counties with lower rates.

Crash Mechanism

We have noted at state and local traffic safety meetings that traffic engineers tend to make the assumption that roadway crashes of other off-road vehicles, e.g., tractors, provide a model for thinking about how to prevent ATV crashes on the road. Directly comparing farm vehicle and ATV roadway crashes, however, demonstrates that this is not the case.

A previous study of roadway farm equipment crashes (not including ATVs) across a nine-state Midwest region found that almost one-third (30%) of crashes occurred in urban RUCA zip codes.[28] However, a closer look showed that most of these crashes occurred at the interface of rural and urban areas. The current study found that 46% of crashes occurred in urban zip codes, but the pattern showed a relatively broad distribution in both rural and urban areas, with no apparent aggregation at rural-urban interfaces (Figure 1).

There is also a significant difference in crash mechanism between farm vehicles and ATVs. For the former, motor vehicle collisions accounted for nearly 90% of all crashes,[28] and this may explain in part increased crash rates as vehicles reach rural-urban interfaces. In sharp contrast to these results, approximately three out of every four roadway ATV crashes were not traffic-related. This was true in both rural and urban areas. Thus with respect to crash pattern and mechanism, ATVs and farm vehicles are dramatically different, and rural roads with low traffic density should not be considered "safer" for ATVs than roads/streets in other areas. In fact, as stated earlier, mortality risk is higher in rural areas, possibly due to delayed emergency medical responses.

Potential Implications for ATV Injury Prevention

If public policy makers or healthcare providers hold the common misconception that ATV crashes are mostly a problem for farm families, then it seems less likely they will perceive ATV injury prevention as a statewide priority. Moreover, because urban areas tend to command more resources than rural ones, this misconception could create a barrier to finding sufficient support for ATV injury-prevention efforts in a state.

Although survey studies for ATVs[16] and mopeds[36] previously showed lower reported helmet use among rural vs. urban youth, this is the first study to show that helmet use is independently associated with rurality for ATVs. These data also suggest that lack of a helmet safety culture may be more pronounced in smaller rural communities. Helmet laws remain a critically important issue in public health and would significantly help reduce both fatal and non-fatal traumatic brain injuries from crashes of ATVs and other open motorized vehicles.

There remains a disturbing trend toward counties and cities passing ordinances allowing recreational ATV riding on public roads.[37] This study provides yet more evidence that roadway riding is dangerous, including on rural roads. Moving forward, it will be important to monitor the extent to which legalizing riding on roadways impacts ATV crashes and injuries using approaches similar to these study methods.

The study identified counties in the state with higher numbers of ATV crashes and with higher relative crash rates. Safety-minded collaborators in these counties could be recruited to develop specific injury prevention programs for those areas. Using this approach may be valuable to other organizations and agencies that wish to determine their statewide crash patterns and to identify vulnerable riding populations and specific regions for which targeted interventions could be developed.

LIMITATIONS

These studies have the limitations inherent in retrospective research and those experienced by other ATV injury prevention researchers. These limitations include incomplete capture of crash and injury records and/or incomplete variable documentation. The data sources used in this study are more likely to record moderate to serious crashes and injuries, rather than crashes resulting in injuries not requiring medical attention or those that only required medical care in an outpatient clinical setting.

Additionally, because of limitations in trauma registry crash narratives, some side-by-sides (UTVs, ROVs) may have been documented as ATVs and included in the study. Even if true, however, we hypothesize that it did not introduce significant bias in the results, as identified side-by-sides only comprised around 3% of the off-road vehicle crashes in our database.

Whether victims were wearing a helmet was documented in less than half of all cases, largely due to lower documentation in the state trauma registry. We speculate that there may also have been a bias toward

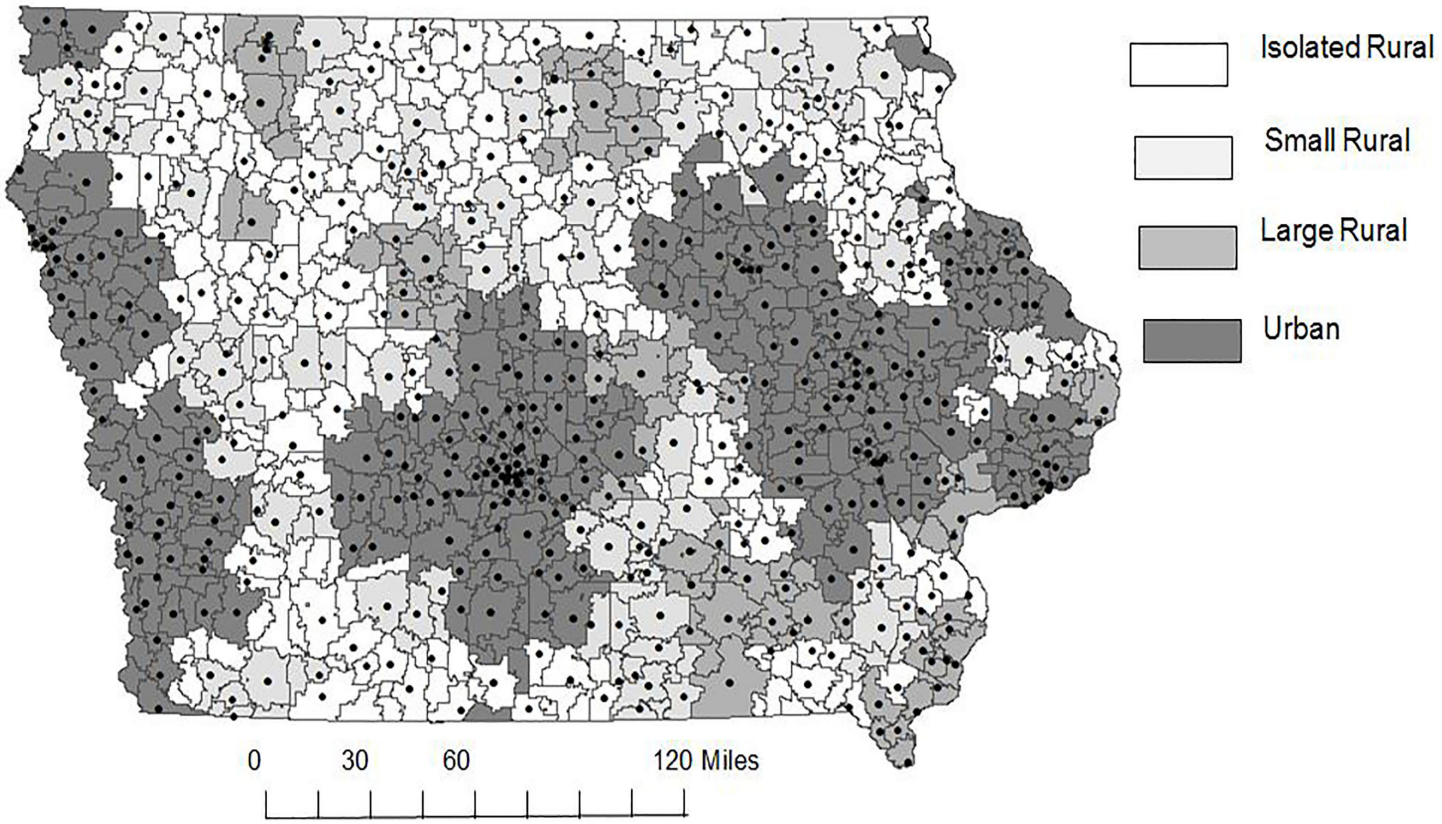

Figure 1. Zip code pattern of all-terrain vehicle (ATV) crashes in Iowa recorded in the Off-Road Vehicle Crash and Injury Database for the years 2002-2013 (n=1,832 crashes). Map shows zip code location of crashes with shading based on the Rural Urban Commuting Area (RUCA) coding system.

documenting whether victims were helmeted (notable fact) vs. not (highly common) in trauma records. If this bias does exist, however, then reported helmet use in this study would be an over-estimate. Of note, helmet use in the study was similar to that seen in other studies, including those using national data.[5] Moreover, regression analysis demonstrated associations between lack of helmet use and seating position or crash location (on road vs. off) that were also seen previously with national data.[5] Thus, the finding that helmet use is inversely associated with rurality may be more generalizable.

This study represents a single state. However, it should be noted that demographics and crash characteristics in the study are very similar to those reported by other states and to national data and that all states have rural areas and urban areas similar to those in Iowa.

As outlined in the "Methods" section, caution should be used in interpreting crash rates because of the limitations in ATV registration data and capture of crashes and injuries. However, if one assumes these limitations apply equally across the state, then it seems reasonable to consider values as relative crash rates when comparing counties.

CONCLUSION

Results from these studies demonstrate that ATV crashes are a public health concern for both rural and urban communities. They further highlight concerns regarding youth on ATVs, low helmet use (particularly in smaller rural communities), and riding on public roads, including those in rural areas. Demographics, location (on vs. off the road), and crash types (collisions vs. non-collisions) did not differ significantly by rurality suggesting that riding populations and riding behaviors are similar across the state. However, variability in crash rates suggests county-based differences in riding frequency and/or unsafe riding behaviors. Approaches used in this study provide a better understanding of where crashes occur, and can help safety advocates identify areas for which injury prevention interventions may be most needed and/or have the greatest impact. These findings may also help the public, as well as city, county and state governments, understand the wider nature of the problem and the need to invest state resources in ATV injury prevention efforts. Similar approaches could be valuable in other states.

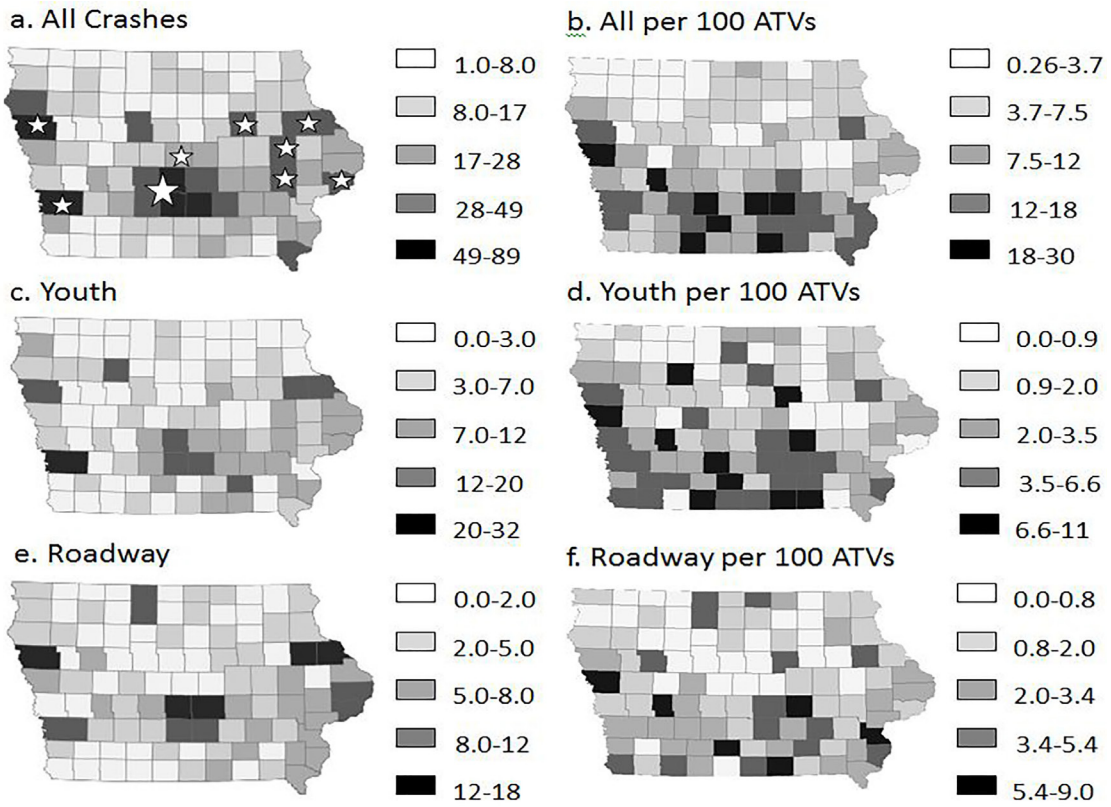

Figure 2. Patterns of all-terrain vehicle (ATV) crashes in the Off-Road Vehicle Crash and Injury Database for the years 2002-2013 by county (n=1,832 crashes). Values in the indicated ranges (automatically selected by ArcGIS for optimal grouping of crashes) are represented using a shaded scale. Crash rates were based on an estimated number of registered vehicles per county and are expressed as crashes per 100 registered ATVs. Panel a, b: Maps show crash number and crash rate for all crashes in each county. Stars represent the largest cities with the larger star representing four cities in the Des Moines metropolitan area. Panel c, d: Maps show crash number and crash rate for crashes in each county involving youth <16 years old. Panel e, f: Maps show crash number and crash rate for roadway crashes in each county.

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Pediatric Exposures to Topical Benzocaine Preparations Reported to a Statewide Poison Control System

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Introduction: Topical benzocaine is a local anesthetic commonly used to relieve pain caused by teething, periodontal irritation, burns, wounds, and insect bites. Oral preparations may contain benzocaine concentrations ranging from 7.5% to 20%. Pediatric exposure to such large concentrations may result in methemoglobinemia and secondarily cause anemia, cyanosis, and hypoxia.

Methods: This is a retrospective study of exposures reported to a statewide poison control system. The electronic health records were queried for pediatric exposures to topical benzocaine treated at a healthcare facility from 2004 to 2014. Cases of benzocaine exposure were reviewed for demographic and clinical information, and descriptive statistical analysis was performed.

Results: The query resulted in 157 cases; 58 were excluded due to co-ingestants, or miscoding of non-benzocaine exposures. Children four years of age and younger represented the majority of cases (93%) with a median age of 1 year. There were 88 cases of accidental/ exploratory exposure, while 6 cases resulted from therapeutic application or error, 4 cases from adverse reactions, and 1 case from an unknown cause. Asymptomatic children accounted for 75.5% of cases, but major clinical effects were observed in 5 patients. Those with serious effects were exposed to a range of benzocaine concentrations (7.5-20%), with 4 cases reporting methemoglobin levels between 20.2%-55%. Methylene blue was administered in 4 of the cases exhibiting major effects.

Conclusion: The majority of exposures were accidental ingestions by young children. Most exposures resulted in minor to no effects. However, some patients required treatment with methylene blue and admission to a critical care unit. Therapeutic application by parents or caregivers may lead to adverse effects from these commonly available products. [West J Emerg Med.2017;18(5)923–927.]

INTRODUCTION

Topical benzocaine is a local anesthetic preparation commonly used to relieve pain caused by burns, wounds, insect bites, teething, and mouth or gum irritation. Over-the-counter topical benzocaine is marketed for teething pain in pediatric patients despite the American Academy of Pediatrics' recommendation against its use.[1] The widespread utilization of these products can lead to misuse by caregivers or exploratory exposures by children themselves. Benzocaine preparations used in teething (e.g. Orajel™ and Anbesol™) have concentrations ranging from 7.5-20%, which may lead to significant adverse effects.[2] As a potent inducer of oxidative

stress, benzocaine can result in methemoglobinemia and secondarily cause cyanosis, dyspnea, syncope, seizures, and coma.[3-4] The broad availability and popular use of topical benzocaine preparations is a public health risk, especially in the pediatric population and in those with poor dental hygiene or follow-up dental care.

Prior literature related to benzocaine teething preparations is limited to a few case reports and one retrospective review.[5-11] Case reports or series have previously documented incidents involving children becoming cyanotic and subsequently having elevated methemoglobin levels after benzocaine use and accidental ingestions.[6-11]

Some studies have documented potentially lethal methemoglobin levels with benzocaine exposure, some as high as 69%. The most common setting for exposure was benzocaine gel being administered to children for teething pain or application of "burn cream" applied to superficial burns. We conducted a systematic review of pediatric benzocaine exposures reported to a statewide poison control system.

METHODS

This was a retrospective study performed at the California Poison Control System (CPCS). We queried electronic medical records of the CPCS for all calls from January 2004 to December 2014 associated with benzocaine using unique substance codes created by the American Association of Poison Control Center (AAPCC) to track benzocaine exposures. Data were abstracted by two researchers, and a kappa score greater than 0.7 on 10% of the data was established prior to subsequent data abstraction.

The inclusion criteria were all cases involving exposures to topical benzocaine in patients less than 18 years old who presented to a healthcare facility. We excluded cases if they were information calls, non-human exposures, non-healthcare facility exposures, exposures to non-benzocaine products, and exposures occurring with other co-ingestants. Data abstraction consisted of both demographic and clinical outcomes, including the following: age, gender, amount of benzocaine ingested, the concentration of the benzocaine product, adverse effects, presence of methemoglobinemia, interventions received, and the patient's disposition or highest level of care provided within the healthcare facility. We used descriptive analysis and frequencies to characterize the study population and clinical outcomes related to topical benzocaine exposures.

RESULTS

The CPCS received 157 reported benzocaine exposure cases in children less than 18 years of age who presented to a healthcare facility from January 2004 to December 2014. Of those cases, 58 met exclusion criteria, leaving 99 cases for subsequent data analysis. Patient ages ranged from one month to 12 years (median age, one year) with 93% of patients under the age of four years. Males represented the majority (56%, n=55) of exposures.

Most cases were caused by unintentional exposures related to exploratory behavior in toddlers (88.9%, n=88). Therapeutic error was the cause of six cases (benzocaine concentration higher than indicated or increased frequency of application), while four cases were considered to be "allergic reactions" and one case had an unknown cause/intent. Allergic-reaction signs and symptoms were considered as a type of adverse drug reaction, and findings recorded as described by the treating team. Route of exposure was primarily ingestions (n=88), with four dermal exposures, four cases of both ingestion and dermal exposure, two ocular exposures, and one case involving an undetermined route of exposure. In 92 exposures, the benzocaine product was used for oral indications. The majority of exposures (95%) occurred within the patients' homes with three cases occurring at a daycare facility, one case occurring at a healthcare facility, and one case occurring in a public space. Benzocaine concentrations ranged from 7.5%-20%, with 32 cases involving the 20% formulation, 21 cases involving the 7.5% formulation, 14 cases involving the 10% formulation, and 31 cases with an unknown formulation.

Outcomes and adverse effects reported in these exposures are summarized in Table. Ninety cases resulted in no effect or minor effect (75.5% and 16.3%, respectively). Of these 90 cases, 73 patients were treated and released from the emergency department (ED), 13 presented to the ED but were lost to follow-up, two were evaluated by their primary care provider, and two had an unknown disposition. All three cases with moderate effects were treated in the ED, with two of the cases ultimately released from the ED and the remaining case lost to follow-up after presentation. One patient of the moderate-effects group required ocular irrigation, while the rest were observed and discharged. Of the five cases with major effects, two patients were admitted to an intensive care unit, two were admitted to the medical floor, and one was treated and released from the ED.

Methemoglobin concentration was measured in seven patients, and ranged from 1%-55%, with an average measured value of 24%. Methemoglobin concentration was reported in four of the cases with major effects: 20.2%, 40%, 48%, and 55%. All four cases with documented elevated methemoglobin concentration received intravenous (IV) methylene blue and supplemental oxygen. Four out of the five cases with major effects involved parents or caregivers administering the benzocaine product to the child.

DISCUSSION

This large case series of benzocaine exposures reported to a statewide poison control system suggests that the wide availability of topical benzocaine products marketed towards pediatric-age populations continues to pose a child health hazard.

In 2000, Spiller. et al published a retrospective review of oral benzocaine exposures involving four regional poison centers.[5] They found only minor effects associated with

Table. Adverse effects following over-the-counter benzocaine gel exposure in children.

Outcome and clinical effects	Number of cases (n=99)†
No effect	74
Minor effect	16
Drowsiness	6
Vomiting	3
Reported wheezing/trouble breathing (normal upon MD exam)	2
Swollen cheek	1
Blisters/erythema on cheek	1
Cough	1
Cyanosis (normal upon MD exam)	1
Ocular pain/irritation	1
Tachycardia	1
Hypertension	1
Moderate effect	3
Corneal abrasion	1
Difficulty breathing	1
Cyanosis	1
Lethargic	1
Vomiting	1
Major effect	5
Elevated methemoglobin levels	4
O2 saturation < 90%	3
Cyanosis	3
Seizure	1
Metabolic acidosis	1

†The outcome of one case was lost to follow-up.

benzocaine exposure, and only one child with a methemoglobin concentration greater than 1%. By contrast, our study demonstrates a higher rate of complications and hospitalization rates in a large cohort of affected children. Although most of our cases were treated and released from the ED with minimal complications, a few patients had major adverse effects, mainly related to methemoglobinemia. Most cases in this study were the result of unintentional exposures to benzocaine products; however, the majority of cases showing major effects were due to intentional administration by a caregiver or parent. Besides the effects related to methemoglobinemia such as dyspnea, cyanosis, and tachycardia, there were also reports of irritant effects (e.g. vomiting and skin, throat, and ocular irritation) following exposures.

Previous reports have documented severe methemoglobinemia in pediatric patients following parental application of an oral benzocaine product. Chung et al. described a six-year-old child who presented to the ED with a methemoglobin concentration of 69.9% after being administered benzocaine gel for a toothache.[7] Bong et al. shared a case study of a 15-month-old toddler with a complex medical history who developed a methemoglobin concentration of 42.5% after appropriate application of benzocaine gel for teething.[8] Both children were successfully treated with IV methylene blue and oxygen therapy.

There are also reports of parent-administered dermal exposures to benzocaine. Eldadah and Fitzgerald described the case of a two-year-old child who presented with severe methemoglobinemia requiring intubation and IV methylene blue after parental application of a benzocaine cream to a rash.[10] Poredos et al. shared a case report of a four-year-old child with deep dermal and subdermal burns who was administered a 1.2% benzocaine cream, and subsequently developed cyanosis and lethargy with a methemoglobin level of 13%.[7] Although dermal exposures to benzocaine products were not prevalent in our study, it is prudent to acknowledge the common theme—a high incidence of toxicity following parental or caregiver application.

In April 2011 the United States Food and Drug Administration (FDA) released a drug safety communication regarding the potential for serious side effects, including methemoglobinemia, associated with the use of topical benzocaine products.[12] Our data showed a decline in the number of benzocaine exposure cases called into the CPCS in the years following the release of the FDA drug safety communication (Figure). However, this study indicates that exposures are still occurring, underscoring the need for further education of parents and caregivers regarding the appropriate pediatric indications and application instructions for benzocaine-containing products. Restricting these products at the retail level, perhaps by placing them "behind the counter" at pharmacies and related vendors, may also help prevent overuse of these products and alert parents and caregivers about their risks.

LIMITATIONS

This study has several limitations. Many of the pediatric benzocaine cases called into the CPCS from 2004-2014 did not meet inclusion criteria. This discrepancy may be the result of substance misclassification upon initial data entry at the time of the phone call. A second limitation of the study is the exclusion of well-appearing or asymptomatic exposed patients who were managed at home. Per CPCS guidelines, many children were managed at home if they were asymptomatic following exposures. For this study, which was designed to identify trends with the most critical cases, we chose to focus only on those patients who were treated at healthcare facilities in order to better characterize the extent of severe reactions following

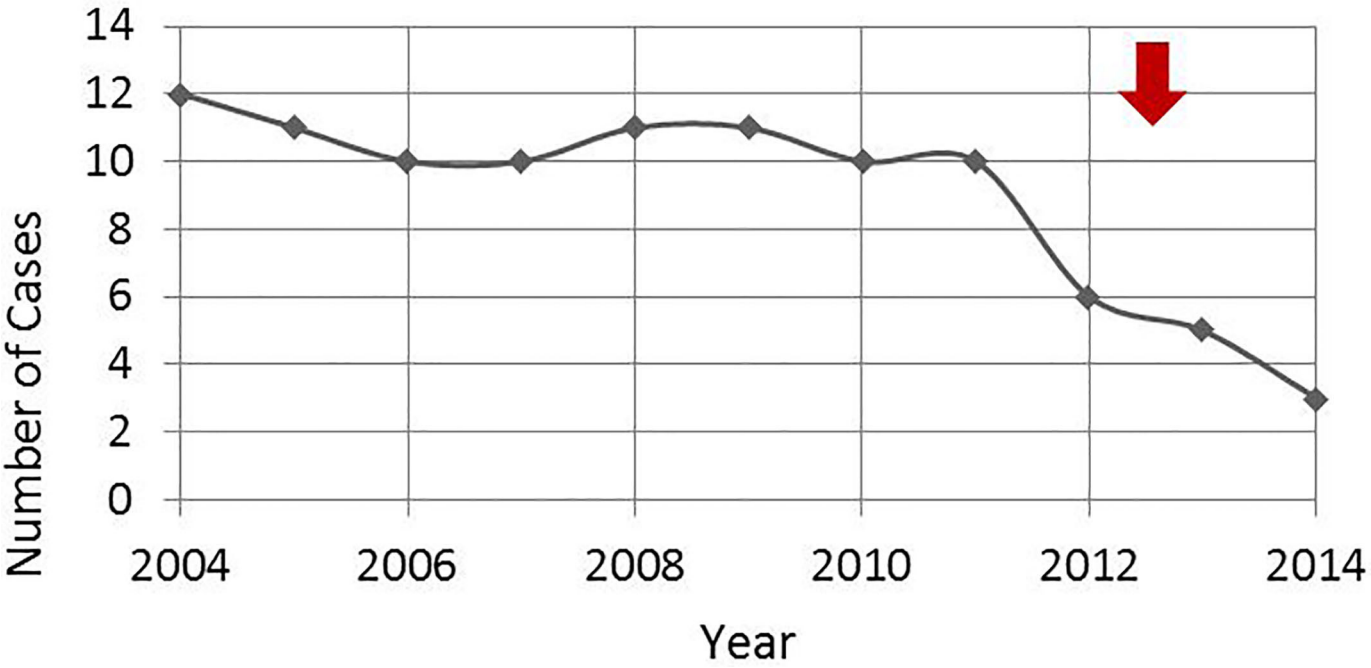

Figure 1. Benzocaine cases called into the CPCS from 2004 through 2014 classified by year. The red arrow indicates the publication of the FDA drug safety communication regarding benzocaine toxicity.
CPCS, California Poison Control System; *FDA*, Food and Drug Administration.

an exposure. Analyzing all benzocaine exposures (home + healthcare facility) would have given a larger sample size and perhaps a more complete picture of the problem.

As a retrospective review, many variables could not be controlled in this study, and the data collected were not recorded with our study parameters in mind, making it impossible to draw conclusions regarding causation. One particular drawback to this study is that information was incomplete due to undercoding of clinical signs and symptoms at the time of poison control assessment. More thorough information regarding the amount ingested, product concentration and patient disposition, perhaps collected prospectively, could have allowed for a more detailed characterization of benzocaine exposures.

CONCLUSION

The availability of topical benzocaine preparations over the counter poses a challenge to pediatric patient safety, as parents or caregivers may not be fully informed regarding the hematologic risks associated with benzocaine toxicity. To reduce the incidence of topical benzocaine toxicity in children, the general public and clinicians treating children should be made aware about appropriate clinical indications, safe concentrations and doses, and application instructions relevant to these products. More rigorous regulations at the commercial retail level, as with ephedrine-based decongestants, may also help curb adverse reactions to these products.

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What Did You Google? Describing Online Health Information Search Patterns of ED patients and Their Relationship with Final Diagnoses

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Introduction: Emergency department (ED) patients' Internet search terms prior to arrival have not been well characterized. The objective of this analysis was to characterize the Internet search terms patients used prior to ED arrival and their relationship to final diagnoses.

Methods: We collected data via survey; participants listed Internet search terms used. Terms were classified into categories: symptom, specific diagnosis, treatment options, anatomy questions, processes of care/physicians, or "other." We categorized each discharge diagnosis as either symptom-based or formal diagnosis. The relationship between the search term and final diagnosis was assigned to one of four categories of search/diagnosis combinations (symptom search/symptom diagnosis, symptom search/formal diagnosis, diagnosis search/symptom diagnosis, diagnosis search/formal diagnosis), representing different "trajectories."

Results: We approached 889 patients; 723 (81.3%) participated. Of these, 177 (24.5%) used the Internet prior to ED presentation; however, seven had incomplete data (N=170). Mean age was 47 years (standard deviation 18.2); 58.6% were female and 65.7% white. We found that 61.7% searched symptoms and 40.6% searched a specific diagnosis. Most patients received discharge diagnoses of equal specificity as their search terms (34% flat trajectory-symptoms and 34% flat trajectory-diagnosis). Ten percent searched for a diagnosis by name but received a symptom-based discharge diagnosis with less specificity. In contrast, 22% searched for a symptom and received a detailed diagnosis. Among those who searched for a diagnosis by name (n=69) only 29% received the diagnosis that they had searched.

Conclusion: The majority of patients used symptoms as the basis of their pre-ED presentation Internet search. When patients did search for specific diagnoses, only a minority searched for the diagnosis they eventually received. [West J Emerg Med. 2017;18(5)928-936.]

INTRODUCTION

The Internet has become an important source of health information for patients. According to the most recent Pew Internet and American Life Project national survey (2013), 81% of adults use the Internet and 72% looked up online health information in the preceding year.[1] Although many of these online health searches may be more general or related to an already-diagnosed condition or planned treatment, 35% of Americans reported looking online specifically to determine what medical condition they may have; 46% of those online diagnosers reported that the information they found online led them to think they needed medical attention.[1]

Within the context of emergency medicine, previous studies asked patients if the health information they found online made them more likely seek care in the emergency department (ED). Among ED patients with Internet access, estimated rates of Internet searches prior to ED presentation varied from 15.1% to 47%.[2-4] Many companies and health systems have produced online "symptom-checking" websites to harness these searches and attempt to improve self-triage, with variable success.[5] On a population level, healthcare website traffic measurements have been used to forecast ED visit volume.[6] Similarly, epidemiologic trends for certain conditions such as influenza correlated well with Internet searches for related symptoms.[7] These prior studies suggest that patient Internet use affects patient concerns, and impacts their choice to seek medical care.

What remains unexplored in the current literature is exactly what individual patients are searching prior to their ED visit. We believe it is important for the emergency physician (EP) to understand what the patient is seeking with an Internet search because an awareness of these patient concerns may inform the conversations and counseling in the ED. What types of information are patients seeking when they turn to the Internet and how does their ultimate diagnosis relate to their original search? We sought to answer these questions through a qualitative analysis.

Population Health Research Capsule

What do we already know about this issue?
The Internet is an important source of health information, and prior studies estimate up to half of ED patients search the Internet prior to ED presentation.

What was the research question?
We sought to describe what types of information patients are searching for in their pre-ED Internet searches.

What was the major finding of the study?
Patients searched for symptoms more often than diagnoses. Correlation between search and ED diagnosis was poor.

How does this improve population health?
Many discharged patients have symptom-based diagnoses (similar to pre-ED symptom-searches). Discussing the lack of a formal diagnosis may be warranted.

METHODS

This analysis is part of a larger prospective survey study focused on how patients use the Internet and their primary physician for health information prior to an ED visit.[8] This study uses qualitative methods to further analyze the responses of participants who conducted an Internet search prior to visiting the ED (data from primary study reported separately).

Participants and Procedure

Data collection occurred at an urban academic medical center (>88,000 annual patient visits) with patients enrolled from May 23, 2014, to July 21, 2014. Trained research assistants (RAs) enrolled patients on weekdays 9am-9pm and Saturday 9am-5pm, based on RA availability. All adult patients (age >17) were eligible. The larger study specifically investigated differences in access to health information between adult and geriatric patients. Therefore, there was intentional oversampling of the geriatric population to achieve a balance between geriatric and adult patients; sample-size calculations targeted a total enrollment of 720 participants based on the primary outcome of the larger study. The exclusion criteria included an inability to complete the written survey for any reason (e.g., physical impairment, clinical condition, language barrier).

Participants provided written informed consent. RAs administered the survey on paper, and it took approximately five minutes to complete. Participants received compensation with a $5 gift card. RAs later entered data into REDCap, a secure, web-based application designed to support data capture for research. The institutional review board approved all study procedures.

Survey Measures

This qualitative analysis includes the subset of patients from the larger study who answered "yes" when asked, "Before coming to the emergency room today, did you search the Internet about your current symptoms or condition?" As a follow-up question, patients listed the search terms entered and the Internet

site(s) visited to look up the information. The top six most frequently accessed health websites were listed, as well as a free-text space for "other" websites.[9] Additionally, the survey contained questions regarding demographic information (age, sex, race/ethnicity), socioeconomic information (education, household income), access to a primary care physician, and questions related to number of devices owned capable of accessing the Internet. Following survey completion, we extracted additional patient-specific clinical data from the electronic medical record (EMR), including triage acuity, chief complaint, ED disposition (admission, discharge), and ED discharge diagnosis.

Qualitative Measures and Analysis

Three qualitative metrics are reported. First, based on a review of the literature, we developed an a priori coding schema to categorize the Internet search terms based on content.[10-12] The categories included search terms related to a symptom, a specific diagnosis, treatment options, anatomy, processes of care or physicians, or "other." Table 2 contains a detailed definition of each category.

The second qualitative analysis phase investigated the relationship between the patients' initial search term and their final ED diagnosis for those patients who had searched either a symptom or a diagnosis. Many discharge diagnoses in the ED are, in fact, "symptom-based" (e.g., chest pain) as opposed to a more "formal" diagnosis (e.g., myocardial infarction). Therefore, we divided final diagnoses into two large groups: symptom-based diagnoses and formal diagnoses. We considered an ED discharge diagnosis a symptom-based diagnosis if it met one of two criteria: 1) *ICD-9* code range 780-799 (symptoms, signs and ill-defined conditions) (e.g., malaise, abdominal pain, fever, rash); or 2) it named an anatomical body part followed by pain (e.g., ankle pain, wrist pain). Therefore, every encounter received a designation in one of these two categories, either the more general symptom-based diagnosis group or the more specific formal diagnosis group.

After the designation of symptom-based or formal diagnosis, we assigned the relationship between the search term and diagnosis to one of four categories of search/diagnosis combinations representing different "trajectories." If patients had more than one search term listed, the analysis used the most specific search term. (Diagnosis searches were rated as being more specific than symptom searches.) This analysis excluded patients who had only used search terms related to treatment, anatomy, ED processes, or "other." A patient's trajectory from pre-ED presentation Internet search to post-ED-care doctor-assigned discharge diagnosis was defined as *flat trajectory—symptoms* if they searched for a symptom and received a final diagnosis of a symptom. It was defined as *flat trajectory—diagnosis* if they searched for a diagnosis and received a final formal diagnosis. Patients' diagnosis search term accuracy was recorded. If a patient searched for a symptom and ultimately received a formal diagnosis, they were categorized as having *general to specific trajectory*, whereas if they searched for a specific diagnosis by name and left the ED with a symptom-based diagnosis they were categorized as having a *specific to general trajectory*.

The two qualitative analyses described above examine the bookends of the visit, the initial search and the final diagnosis. An additional analysis conducted describes an intermediate step in the process—the chief complaint. Although it may be of interest to know how the patient's search influenced the wording of his/her presenting complaint, the concordance between search term and chief complaint *was not* examined because of concerns that chief complaints were potentially influenced by nurse interpretation. The EMR allowed for free-text entry of the chief complaint or for selection from a drop-down menu by the triage nurse; therefore, the chief complaint may not have fully captured the patient's concern at the time of presentation. For example, "I'm having chest pain, I'm worried it is a heart attack" may have been recorded as "chest pain." This limitation did not allow for use of the chief complaint as a proxy measure for how the Internet search may have influenced the patient's statement of his complaint. However, of interest from the *physician perspective*, we assessed the concordance between the chief complaint and the final diagnosis. Even allowing for nursing influence on the chief complaint, the chief complaint recorded in the record was the first introduction that the physician had to the patient, and therefore we assessed the concordance between the complaint and the final diagnosis. Table 4 defines the concordance scale and provides examples.

Two coders analyzed all cases independently. A kappa analysis for a 10% random subsample of cases ensured reliability prior to coding the entire sample. The coders reconciled all disagreements through discussion and selected a final code through consensus. Frequencies are reported for demographic characteristics and for each of the codes. The Fischer's exact test assessed the association between demographic variables and Internet search terms. All analyses were conducted using STATA software version 13.1 (StataCorp, College Station, TX). We could not pre-determine optimal power or estimate an effect size for this study because the qualitative analysis was exploratory and not testing a quantifiable hypothesis.

RESULTS

Of the 723 participants, 177 (24%) who completed the larger study searched the Internet prior to ED presentation. Seven participants had incomplete data, resulting in a final sample of 170 (see Figure). The participants had a mean age of 47 years (standard deviation 18.2) and slightly more than half were female (58.6%). The vast majority owned at least one device capable of Internet access (98.2%) (Table 1).

In our sample, 32% (N=55) reported using more than one search term, resulting in a total of 243 search terms.

Table 1. Sample demographics in an analysis of the use of health-related Internet searches by patients prior to presentation at the emergency department (ED).

Variable	n (%)
Age, mean (standard deviation)	47 (18.2)
Geriatric (age >65)	45 (26.5)
Female	99 (58.6)
Race	
African American	33 (19.5)
White	111 (65.7)
Other	25 (14.8)
Education	
High school or less	23 (13.6)
Some college	34 (20.1)
College graduate	59 (34.9)
Advanced degree	53 (31.4)
Household income level ($)	
<50,000	50 (32.9)
50,000-100,000	50 (32.9)
>100,000	52 (34.2)
Triage acuity (ESI)	
2-Emergent	72 (42.3%)
3-Urgent	77 (45.3%)
4-Semi-urgent	21 (12.4%)
ED disposition	
Discharged home	105 (61.8%)
Admit-observation status	32 (18.8%)
Admit-inpatient status	33 (19.4%)
Number of devices owned with internet access	
0	3 (1.8)
1	30 (16.6)
2	52 (30.6)
3	85 (50.0)
Report daily internet use	162(95.9)

ESI, Emergency Severity Index.

When conducting their Internet searches, the majority of search terms focused on symptoms (54.7%) rather than a diagnosis by name (31.7%) (Table 2). Participants accessed a variety of websites to gather information; 58% of the sample reported searching on WebMD, followed by 40% using the Mayo Clinic website. Although not a formal option on the survey instrument, 37 patients (21.8%) wrote in the "other" category that they simply conducted a Google search and looked at the top hits.

Overall, 56% of the sample left the ED with a formal diagnosis and the remaining 44% received a symptom-based diagnosis upon discharge. The second qualitative analysis excluded 13 patients because they only searched for treatment, anatomy, ED processes or "other," resulting in a sample of 157 patients. Looking specifically at the relationship between pre-ED presentation Internet search terms and final ED diagnosis, the largest grouping of patients appeared in the *flat trajectory-symptoms* category (34%, 95% confidence interval [CI] for proportions: [27%-41%]). These patients searched for a symptom and were discharged (or admitted) with a diagnosis of a symptom. Approximately a fifth of patients (22%, 95% CI [16%-28%]) had a *general-to-specific* trajectory. For those categorized as *flat trajectory-diagnosis,* 20 patients (13%, 95% CI [8%-18%]) had perfect accuracy in their Internet search (having searched for a diagnosis and received the same, correct final diagnosis). Although this trajectory was flat, it was accurate. In contrast, 33 patients (21%, 95% CI [15%-27%]) searched for a diagnosis and received a different formal diagnosis. Finally, 16 patients (10%, 95% CI [5%-15%]) had a *specific-to-general* trajectory wherein they searched for a specific diagnosis and left the ED with a symptom-based diagnosis (Table 3). Among all of the patients who searched for a diagnosis by name (n=69), 23% received a symptom-based final diagnosis, 48% received a different detailed final diagnosis, and only 29% received the diagnosis that they had searched.

In nearly two-thirds of cases, the chief complaint and final diagnosis showed near or complete concordance (Table 4). This does not, however, imply that a formal diagnosis was made in all of these cases. For example, a chief complaint of "chest pain" and a final diagnosis (symptom-based) of "Chest Pain, *ICD-9*: 786.5" was considered complete concordance; yet no definitive cause of the pain was identified (despite numerous causes likely being ruled out).

There was no relationship between patient age (younger adult versus geriatric), gender, or education level and the category of search term used. Patients who reported talking to their primary care provider prior to presentation did not have a different distribution of search terms than those who did not talk to (or did not identify) a primary care provider (data not shown).

DISCUSSION

We characterized ED patients' pre-visit Internet search terms using a qualitative approach and looked at the relationship between these search terms and the patients' final diagnoses. We found the majority of patients searched online for symptoms rather than for specific diagnoses. Previous studies using web-analytics of Internet queries similarly noted that the majority of searches focused on symptoms.[11] However, in contrast to studies in other settings, in this sample of ED patients very few

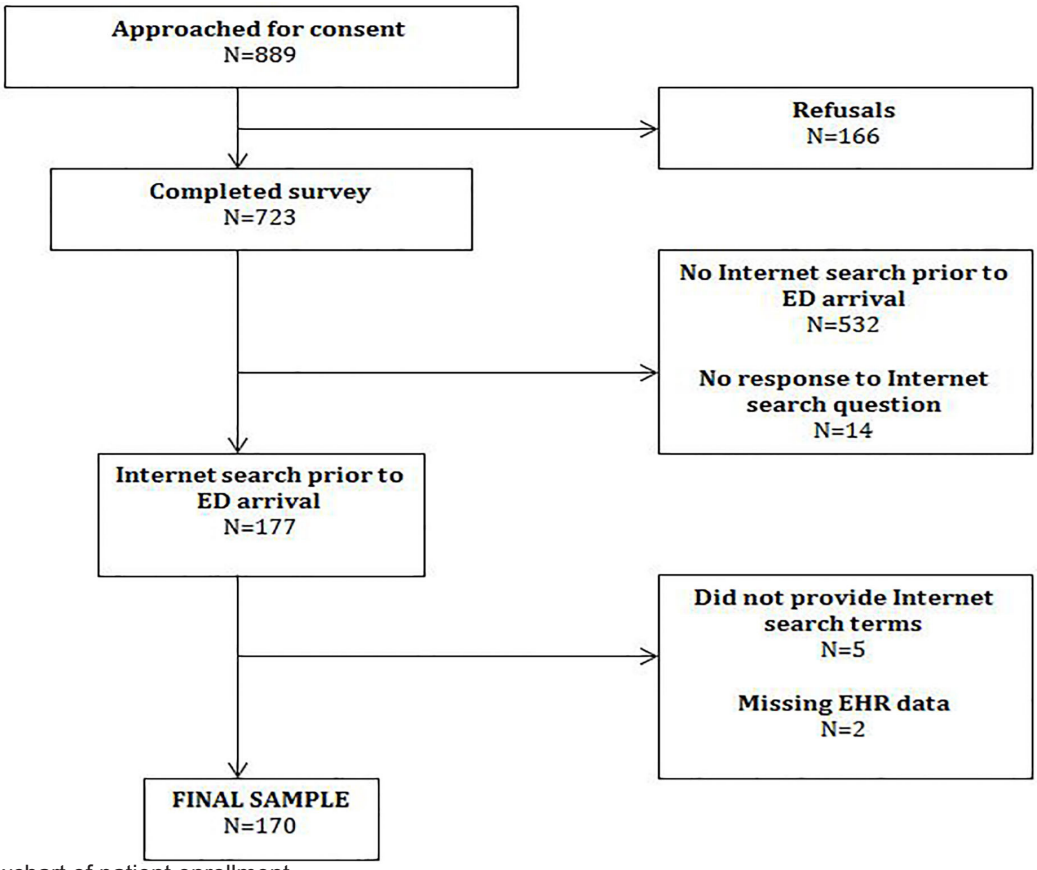

Figure. Flowchart of patient enrollment.

Table 2. Distribution of Internet search terms.

Search term groupings*	Description	n (%)	
Symptom	A search term querying a descriptive symptom, but not a specific diagnosis by name	133 (54.7%)	"Blood in urine" (pt 386) "stiff neck" (pt 768) "pressure in the ears" (pt 610)
Diagnosis	A search term querying a diagnosis by name (and or symptoms related to a diagnosis by name)	77 (31.7%)	"UTI" (pt 452) "meningitis" (pt 459) "heart attack" (pt 375)
Treatment options	A search term querying treatment options for different diagnoses or symptoms	3 (1.2%)	"elbow surgery" (pt 466) "natural alternatives to reduce swelling" (pt 315)
Anatomy	A search term querying items related to anatomy without clear reference to symptoms, diagnosis or treatment	10 (4.1%)	"gall bladder" (pt 725) "stomach" (pt 666)
ED processes or physicians	A search term querying things related to the hospital (e.g., availability of specialists), the emergency department and its processes (e.g., wait time) or specific physicians	1 (0.5%)	"hand doctors" (pt 142)
Other	Questions in which the main topic was unclear or did not fit into any of the above categories	19 (7.8%)	"how often should I check my fever" (pt 495) "colonoscopy and kidney stone correlation" (pt 468)

*N=243 search terms from 170 patients.
pt, patient, *ED,* emergency department; *UTI*, urinary tract infection.

Table 3. The trajectory between initial Internet search term and final emergency department diagnosis.

Trajectory grouping	Examples from our sample	
n (%)	Search term	Final diagnosis (ICD-9)
Flat trajectory—symptoms		
53 (34%) searched symptoms	final diagnosis symptom based	
	abdominal pain⟶	abdominal pain, other unspecified site (789.09)
	side pain, fever, shaking⟶	abdominal pain, unspecified site (789)
Flat trajectory—diagnosis		
20 (13%) searched diagnosis⟶	final "formal" diagnosis (original search correct)	
	COPD ⟶	obstructive chronic bronchitis, with exacerbation (491.21)
33 (21%) searched diagnosis⟶	final "formal" diagnosis (original search incorrect) ⟶ Severed tendons hand and wrist	sprain or strain of unspecified site of wrist (842)
General to specific trajectory		
35 (22%) searched symptoms ⟶	final "formal" diagnosis	
	fever ⟶	pneumonia (486)
Specific to general trajectory		
16 (10%) searched diagnosis⟶	final diagnosis symptom based	
	stress fracture ⟶	pain in soft tissues of limb (729.5)

N=157 (excluded 13 patients who only searched for treatment, anatomy, ED processes or "other").

Table 4. Concordance between chief complaint on ED presentation and final diagnosis on ED discharge.

			Example from our sample	
Concordance grouping	Description	n (%)	Chief complaint	Final diagnosis
No concordance	No relationship between chief complaint and final diagnosis in body system or disease	20 (11.8%)	"Chest pain"	⟶ UTI
			"Headache/Dizziness"	⟶ Rhabdomyolysis
Partial concordance	CC and FD are mostly unrelated, but have one aspect of similarity (e.g., region of the body involved)	44 (25.9%)	"Abdominal pain"	⟶ Malignant neoplasm of bladder
			"SOB"	⟶ Acute Anxiety state, unspecified
Near concordance	CC and FD are mostly unrelated, but have one aspect of similarity (e.g., region of the body involved)	51 (30.0%)	"Right lower quadrant pain"	⟶ Appendicitis
			"Finger injury"	⟶ Closed fracture of the middle or proximal phalanx of the hand
Complete concordance	CC is the same as FD (allowing for differences in medical and lay terminology)	55 (32.3%)	"Numbness L side since yesterday"	⟶ Disturbance of skin sensation
			"Infection to R leg"	⟶ Cellulitis and abscess of Leg
			"Pancreatitis"	⟶ Pancreatitis

CC, chief complaint; *FD*, final diagnosis; *L*, left; *R*, right; *SOB*, shortness of breath; *UTI*, urinary tract infection.

searches focused on treatment. For example, in a sample of orthopedic patients 21% sought information about treatment, and in a sample of melanoma patients 96% sought information about treatment.[12,13] The higher ratio of treatment-related searches in the outpatient clinic and specialty context contrasts with our ED data. However, our report is unique in illuminating the frequency and nature of Internet search strategies that may serve as the genesis of the decision to seek unscheduled ED care. Additionally, understanding these symptom-based searches may help EPs address concerns that arise after Internet searches.

Previous data from the Pew Internet and American Life Project highlighted that 41% of "online diagnosers" say that a medical professional confirmed their suspicions, whereas 18% said a medical professional did not agree or offered a different opinion.[1] We did not specifically query patients about their leading diagnosis post-search; however, in our sample only 11.8% of patients originally searched a diagnosis that perfectly matched their final diagnosis. In contrast, a much higher rate of patients displayed complete (32.3%) or near (30%) concordance between their chief complaint and their discharge diagnosis. This finding may be because the chief complaint represented the patient's post-search leading diagnosis; however, this metric was likely also influenced by nurse entry of the chief complaint, and the frequent use of symptom-based discharge diagnoses.

The correlation between Google-searched diagnosis and ED diagnosis was poor. One explanation is patients accessing misinformation on the Internet; however, patients' limited medical knowledge and hypersensitivity to dangerous or deadly diagnoses (e.g., heart attack, stroke) may drive this poor correlation. We are currently in an era of medicine with unprecedented attention to patient satisfaction, and as such, matching patient expectations with experience is necessary for the EP to ensure a satisfied patient. If EPs ask patients about Internet searches and concerns that arose from those searches, the physicians can directly address patients' concerns and highlight how those concerns have been ruled out. This process may help to match patient experience to their expectations and may ultimately improve patient satisfaction. Future studies measuring the impact of EPs asking about Internet searches, directly addressing patients' concerns after searching the Internet, and the impact on patient satisfaction are warranted.

Many of the patients in our sample departed the ED with a similar level of specificity in terms of diagnosis as when they presented. EPs see value in ED encounters that do not result in a formal diagnosis. Such visits serve many functions, such as excluding life-threating causes of the symptoms, providing reassurance to patients regarding the severity of illness, and the urgency with which to seek future care. However, for patients seeking a diagnosis these visits (and the associated physicians) may be viewed negatively because the patient's ultimate question (what is wrong with me?) was not definitively answered. Armed with the knowledge garnered from this study, EPs can better explain to patients the value of an ED visit by asking about Internet searches and addressing the concerning diagnoses patients encountered after searching for their symptoms online.

The lack of a "formal" diagnosis is a frequent occurrence in the ED; a recent study reported that at least 37% of discharged ED patients do not receive a pathologic diagnosis.[14] Faced with this uncertainty, patients often experience fear and anxiety that negatively influences their mental and physical health in the post-discharge period.[15,16] We did not follow patients after their visit to learn about post-visit Internet searches. However, it seems likely that the lack of a formal diagnosis mentioned above could also be associated with post-visit Internet searches. Bell et al. evaluated the factors patients named as prompting a post-visit Internet search (not specific to ED patients) and found that patients were more likely to use the Internet post-visit when their anxiety was high and their trust in the physician was low.[17]

Interestingly, irrespective of their search terms and concordance, patients used a variety of websites to gather medical information. Although the survey specifically asked patients which destination sites they used to gather information, many volunteered that they used Google to start their search. A similar pattern exists in other settings as well with an estimated eight out of ten health-related Internet searches starting at a search engine such as Google, Yahoo! or Bing.[1] Interestingly, evaluation of the content of the "top hits" on Google, Yahoo! and Bing searches with respect to critical symptoms that would prompt an acute evaluation revealed that a minority of sites contained a clear set of critical symptoms or recommendations for further care.[18] These metrics make it easy to criticize such websites for not clearly defining symptoms that warrant emergent evaluation. At the same time, it is difficult to imagine how an online list of symptoms could appropriately capture the nuanced combination of patient risk factors, presenting symptoms, and physical examination (as well as years of clinical experience) that allow physicians to accurately diagnose and risk-stratify patients.

LIMITATIONS

This was a small sample of patients from a single site, containing English-speaking participants with generally high income, education and ease of access to the Internet. Data collection occurred over an eight-week timeframe on a convenience sample basis during daytime hours and limited to patients who were not too severely ill to participate. Although the decision to omit individuals

unable to read the survey may have introduced sampling bias, we believe this to be minimal as we were asking patients about an activity that requires basic writing and reading skills (namely, typing a search term into the Internet and reading the results of the search). These factors limit the generalizability.

We only present data on patients who answered "yes" to performing an Internet search prior to arrival. We did not investigate why patients did not perform an Internet search if they answered "no" and therefore cannot comment on whether this lack of search was related to their clinical condition, Internet access or trust in the Internet. Additionally, there are limitations inherent in the metrics. The patient search terms were based on self-report and are subject to recall bias. In some cases, a prior healthcare encounter (either an established diagnosis or another same-day encounter via phone or in-person) likely influenced the search terms and chief complaint. For example, one patient searched online for "kidney infection" and their chief complaint was "kidney infection, seen yesterday." Nurse interpretation, as noted above, also potentially influenced the recording of the chief complaints. Although this limitation prevented us from conducting an analysis of the relationship between search terms and chief complaint, it is an accurate reflection of the working environment of the ED.

Finally, the use of *ICD-9* codes is also potentially flawed. In our system the ED attending or resident physician enters the diagnosis into the EMR at either the time of ED note completion or the time of disposition. Variable amounts of information may be available depending on the timing and could result in a less specific *ICD-9* (e.g., viral syndrome instead of influenza). Since the time of data collection, ICD coding has advanced to the currently used *ICD-10* coding system that contains 155,000 codes and procedures compared to only 17,000 codes in the *ICD-9* system.[19] The expansion of the coding system may have resulted in more specificity in ED discharge diagnoses; however, this topic requires further study.

CONCLUSION

A quarter of our sample reported using the Internet prior to their ED visit and approximately half used a symptom-based approach for their search strategy. Similarly, nearly half of these patients left the ED with a symptom-based (or non-pathologic) diagnosis. When patients did search for a specific diagnosis, only 29% searched for the diagnosis they eventually received. Physicians who discharge patients with a symptom-based diagnosis may benefit from understanding that patients had similar symptom-based searches prior to coming to the ED, and more fully explain how the ED workup has ruled out specific diagnoses patients were concerned about after an Internet search and changed the treatment plan prior to discharge. Such conversations may address the fear and anxiety that other studies have reported being associated with diagnostic uncertainty at the time of discharge.

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Diagnostic Accuracy of Ultrasound for Identifying Shoulder Dislocations and Reductions: A Systematic Review of the Literature

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Introduction: Patients with shoulder dislocations commonly present to the emergency department. Ultrasound has the potential to save time, radiation exposure, healthcare costs, and possible need for re-sedation. We conducted this systematic review to compare the diagnostic accuracy of ultrasound compared with plain radiography in the assessment of shoulder dislocations.

Methods: We searched PubMed, Scopus, the Cochrane Database of Systematic Reviews, and the Cochrane Central Register of Controlled Trials for relevant trials. Primary data and test characteristics were obtained for all included studies. We used QUADAS-2 to assess study quality. Meta-analysis was not performed due to significant heterogeneity.

Results: Four studies met our inclusion criteria, comprising 531 assessments with 202 dislocations. Most studies had a sensitivity of 100% for identifying dislocations. One study demonstrated a sensitivity of 54%, and another had only one dislocation that was misidentified. All studies were 100% specific for detecting dislocation.

Conclusion: Ultrasound may be considered as an alternative diagnostic method for the detection of shoulder dislocation and reduction, but further studies are necessary before routine use. [West J Emerg Med. 2017;18(5)937-942.]

INTRODUCTION

Shoulder dislocations are a common presentation to the emergency department (ED) with an estimated incidence of 23.9 dislocations per 100,000 person-years in the United States.[1] These injuries affect 1.7% of the population, resulting in 200,000 ED visits each year.[2] Most shoulder dislocations are reduced in the ED with radiographs performed to both identify the dislocation and confirm the reduction. With increasing availability and comfort with ultrasound (US), multiple case reports have suggested that US may be a valuable adjunct for identifying dislocations and confirming reductions.[3-6] Using US for the assessment of shoulder dislocations and reductions may save time, radiation exposure, healthcare costs, and the potential need for re-sedation in select patients (due to more rapid identification of unsuccessful reductions). However, it is important to ensure that this technique is accurate and reliable before routine clinical application.

We conducted a systematic review to determine the diagnostic accuracy of US to detect shoulder dislocation and reduction when compared with plain radiographs.

METHODS

We conducted a systematic search of PubMed, Scopus, the Cochrane Database of Systematic Reviews, and the Cochrane Central Register of Controlled Trials to include citations from inception to April 3, 2017, using a combination

of the keywords and Medical Subject Headings (MeSH) "shoulder dislocation," "shoulder relocation," "shoulder reduction," and "ultraso*" with no limitations or language restrictions (Appendix). We reviewed the bibliographies of identified studies and review articles for potential missed articles. We also consulted with topic experts to help identify any further relevant studies.

Inclusion criteria included all original, published, primary research articles assessing the accuracy of US for identifying shoulder dislocation and/or reduction. We included prospective, observational studies and randomized, controlled trials. Review articles, case reports, case series, retrospective reviews, and isolated abstracts were excluded. Two physician-investigators independently assessed studies for eligibility based upon the above criteria. All abstracts meeting initial criteria were reviewed as full manuscripts. Studies determined to meet the eligibility criteria on full text review by both extractors were included in the final data analysis. Any discrepancies were resolved by consensus.

Two physician-investigators independently extracted data from the included studies into a data collection form. The following information was abstracted: last name of the first author, study title, publication year, study design, total study population size, total number of dislocations within the study population, US machine, US probe type, US training protocol, US criteria for the diagnosis of shoulder dislocation, gold standard for the diagnosis, true positives, true negatives, false positives, and false negatives. We assessed studies for quality using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS-2) tool.[7]

We created two-by-two contingency tables for each study with sensitivities and specificities and 95% confidence intervals derived from this data. To standardize the interpretation, we determined sensitivity and specificity with respect to the identification of shoulder dislocation regardless of whether the exam was performed before or after a reduction attempt. Data were not combined for meta-analysis due to significant clinical heterogeneity with regard to training and US protocol.

Population Health Research Capsule

What do we already know about this issue?
Shoulder dislocations are a common presentation to the emergency department. Ultrasound has been proposed as an alternate diagnostic modality in place of radiographs.

What was the research question?
This systematic review was performed to determine the diagnostic accuracy of ultrasound for identifying shoulder dislocations.

What was the major finding of the study?
Ultrasound was both sensitive and specific for identifying shoulder dislocations, but further studies are needed.

How does this improve population health?
If supported with additional data, ultrasound may be used in place of radiography to save time, radiation exposure, healthcare costs, and the potential need for re-sedation.

RESULTS

The search of PubMed yielded 154 total studies. Scopus identified 243 total studies. Cochrane Central Register of Controlled Trials located six studies and the Cochrane Database of Systematic Reviews identified no further studies. Of the 403 total studies identified with this search strategy, only four met the inclusion criteria and were included in this review (Figure).

All four studies were prospective, observational studies comparing US with conventional radiography for assessing shoulder dislocations and/or reductions. Two studies included data sets for both initial dislocation assessment and subsequent relocation assessment separately.[8,9] There were a total of 531 total assessments performed with 202 shoulder dislocations (38%); 260 (49%) were performed to assess for the initial dislocation and 271(51%) assessments were performed to assess for persistent dislocation after the initial reduction attempt. All assessments were performed in an ED setting.

The studies varied with respect to the US training protocol, ranging from reliance on existing experience[8,11] to various combinations of lectures and hands-on practice.[8-11] The US examinations also significantly varied between studies. Abbasi et al. used an anterior and lateral approach.[8] The anterior technique involved visualizing the coracoid process and humeral head assessing for the position of the humeral head (i.e., inferior in dislocation and lateral in reduction). The lateral approach involved visualizing the acromion process and the humeral head assessing for the proximity of the humeral head (i.e., wide in dislocation and narrow in reduction). Aykol et al. traced the humerus from the posterior aspect to view the glenohumeral joint.[9] Dislocation was suggested by an inferiorly displaced humerus, posteriorly displaced humerus, or lack of rotational articulation on internal and external rotation. Lahham et al. placed the transducer in a transverse orientation on the posterior aspect of the patient's shoulder and measured the distance between the glenoid fossa and humeral head with a positive distance representing an anterior dislocation, a negative distance representing a posterior dislocation, and zero centimeters representing normal anatomic alignment.[10] Ahmadi et al.

visualized the glenoid fossa from both an anterior and lateral direction, though they did not further describe their protocol or measurements.[11]

Most studies were 100% sensitive, with two studies having less than 100% sensitivity (Table 1). Ahmadi et al. demonstrated 53.8% sensitivity in confirming persistent dislocation after a reduction attempt among 108 patients with 13 dislocations.[11] Akyol misidentified the one persistent dislocation as reduced among 94 patients after a reduction attempt.[9] Specificity was 100% in all studies. As discussed above, meta-analysis was not performed due to significant differences with respect to the protocols.

Using the QUADAS-2 tool, all studies were deemed at overall low risk of bias (Table 2). All four studies used convenience sampling, so there was unclear risk of bias with respect to patient selection. Ahmadi et al.[11] had unclear risk of bias with respect to reference standard due to the use of a single-view radiograph for confirmation of joint reduction. Additionally, the attending emergency physician's interpretation of the post-reduction radiograph, who was not blinded to the patient, served as the criterion standard. Aykol et al.[9] had unclear applicability concerns for the index test due to the use of two different types of US transducers for the exam.

DISCUSSION

This systematic review suggests that US is sensitive and highly specific for the diagnosis of shoulder dislocation. All studies assessing the accuracy of US for detecting shoulder dislocation and reduction identified shoulder dislocation with 100% specificity.[8-11] Most studies were also 100% sensitive, with the exception of one study demonstrating a sensitivity of 54%[11] and another demonstrating misidentification of the

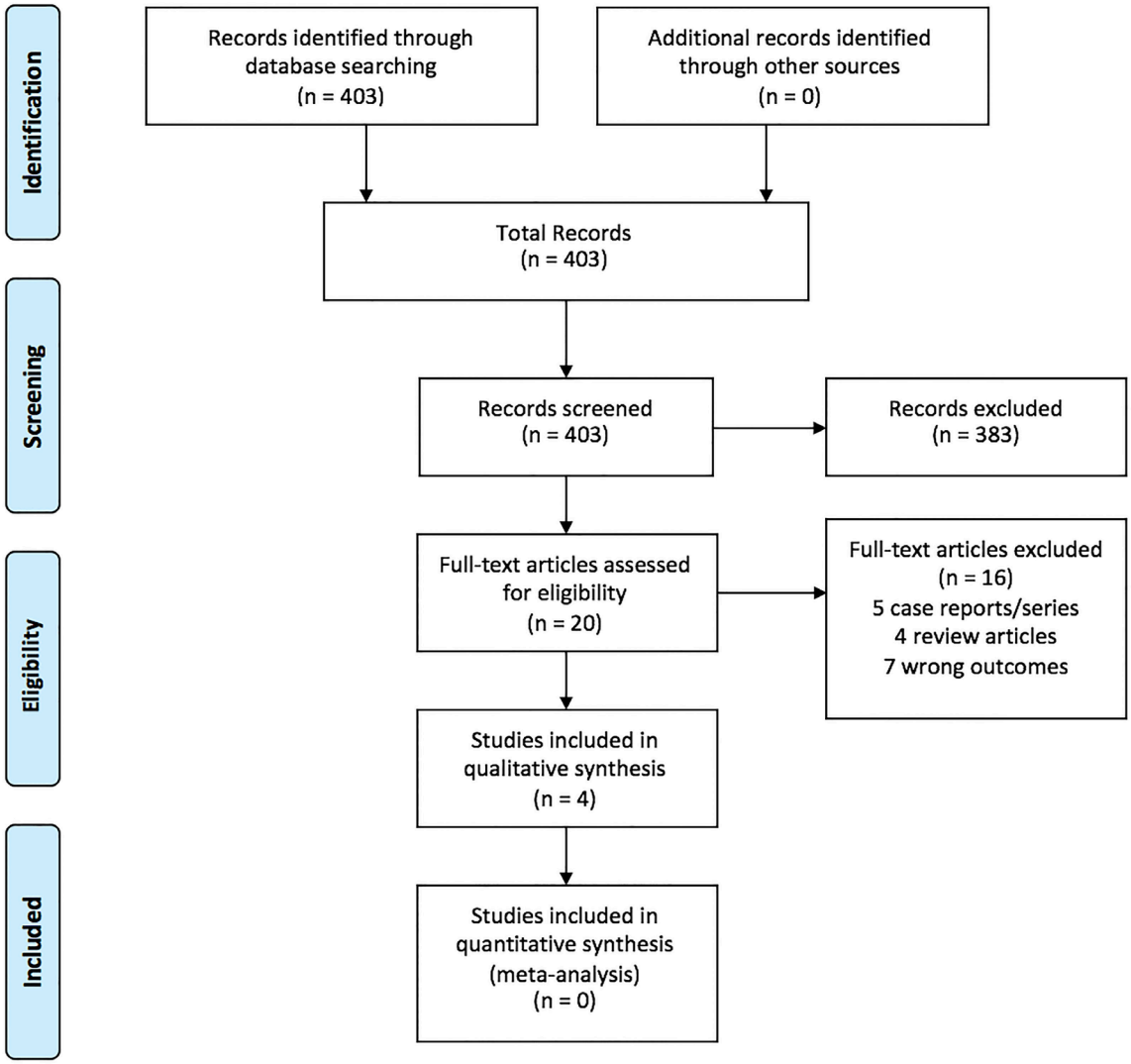

Figure. Outline of study selection and inclusion.

Table 1. Summary of existing studies on the accuracy of ultrasound for shoulder dislocation and reduction.

Study	Study design	Study population size (% dislocated)	Ultrasound probe and machine	Ultrasound training	Examination protocol	Sensitivity (95% CI)	Specificity (95% CI)
Abbasi 2013[8]	Prospective, observational	73 (94.5%)[A] 69 (2.9%)[B]	7.5-10 MHz linear transducer, SonoAce X8	Sonographer #1 prior experience (>5 years musculoskeletal ultrasound) Sonographer #2 1-hour lecture and 10 shoulder sonographic procedures supervised by the first sonographer	Anterior (coraco-humeral distance) and lateral (acromio-humeral distance) technique	100% [A] (93.4%-100%) 100%[B] (19.7%-100%)	100% [A] (39.5%-100%) 100%[B] (93.2%-100%)
Akyol 2016[9]	Prospective, observational	103 (95.1%)[A] 94 (1.1%)[B]	7.5 MHz linear transducer, Mindray M5 and ESAOTE	30- minute lecture and two hours of hands-on practice	Posterior view of glenohumeral joint and assessment of rotational articulation on internal and external rotation	100% [A] (96.3%-100%) 0%[B] (0%-97.5%)	100% [A] (47.8%-100%) 100%[B] (96.1%-100%)
Lahham 2016[10]	Prospective, observational	84 (22.6%)[A]	5-10 MHz linear transducer, Sonosite Edge	30-minute lecture and 30 minutes of hands-on practice	Single view measurement of glenohumeral separation distance	100%[A] (82.4%-100%)	100% [A] (94.5%-100%)
Ahmadi 2016[11]	Prospective, observational	108 (12.0%)[B]	7 MHz linear transducer, Honda	Ultrasound training course in the radiology department	Anterior and lateral views of the humerus and glenoid fossa	53.8%[B] (29.1%-76.8%)	100%[B] (96.1%-100%)

CI, confidence interval; *A*, assessment of initial dislocation; *B*, assessment of persistent dislocation after reduction attempt.

Table 2. QUADAS-2 assessment.

	Risk of bias				Applicability concerns		
Study	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Abbasi 2013[8]	U	L	L	L	L	L	L
Akyol 2016[9]	U	L	L	L	L	U	L
Lahham 2016[10]	U	L	L	L	L	L	L
Ahmadi 2016[11]	U	L	U	L	L	L	U

QUADAS-2. Quality Assessment of Diagnostic Accuracy Studies; *L*, low risk of bias; *U*, unclear risk of bias; *H*, high risk of bias.

only dislocation.[9] Of note, the study with a sensitivity of 54% suffered from a number of methodologic flaws including unclear sonographer training, unclear US protocol, and an inadequate criterion standard (i.e., single view antero-posterior shoulder radiograph).

There was one prior systematic review published on this topic in 2016.[12] However, this review was performed prior to the publication of the three most recent studies[9-11] and provides only a short review of the existing evidence. The current review expands upon this by performing an updated review and using multiple databases to identify all relevant studies.

The use of US to identify shoulder dislocations and reductions has the potential to save patients time. One study demonstrated that the pre-reduction radiographs alone increased

time to treatment by 30 minutes.[13] By using point-of-care ultrasound (POCUS), the provider may reduce the total time that the patient spends in the ED and improve throughput efficiency. The reduction in time to imaging may be particularly important for patients undergoing procedural sedation. Rather than waiting for the patient to recover and sending him or her to the radiology suite for confirmation, the use of POCUS could allow rapid identification of a persistent shoulder dislocation. This would allow repeat reduction while the patient remains sedated, rather than having to repeat the procedural sedation. While the isolated radiation associated with a single radiograph is low, patients with shoulder dislocations may undergo several series of radiographs during their initial presentation, as well as during repeat dislocations. The use of US could reduce their total radiation exposure significantly over time. Finally, the use of repeated radiographs increases costs to both the patient and healthcare system. Incorporating US could have significant healthcare cost implications, especially given the high incidence and prevalence of this condition.[1,2]

As with all US applications, there is potential operator variability depending upon US skills. However, in the three studies in which training was described,[8-10] providers demonstrated excellent accuracy despite short training sessions, suggesting that shoulder sonography for dislocation and relocation may have a short learning curve.

The variation in examination protocols does pose a challenge. However, the high sensitivity and specificity for shoulder dislocation identification in these studies suggests that multiple different sonographic approaches may be used to make this diagnosis. Two studies used different variations on an anterior and lateral approach,[8,11] while the other two studies used variations on a posterior approach.[9,10] Interestingly, Lahham et al. was the only study to use a numerical cut-off value.[10] Future studies should compare the different techniques to determine which technique is the most accurate with a focus on standardizing techniques.

LIMITATIONS

While the overall data is favorable, it is important to consider several limitations to the above studies. First, each study used a different protocol to assess for shoulder dislocation and reduction, which limits the ability to combine the test characteristics. Additionally, there were significant variations in training, ranging from specialty training in shoulder sonography to inexperienced undergraduate researchers.[8,10] While this does result in increased heterogeneity, it also suggests that the learning curve may not be as steep as with other US applications. Another limitation is the potential for physical examination findings to influence the sonographer's interpretation. While this may bias the potential of US to diagnose dislocation in isolation, we believe this is acceptable because sonographers will always be exposed to physical examination findings when performing an US examination.

It is important to note that the majority of dislocations assessed were anterior with only two posterior dislocations identified, thereby limiting the ability to extrapolate to posterior dislocations.[8] Furthermore, the small proportion of non-dislocated shoulders on initial assessment in most studies resulted in wider confidence intervals (CI) and a lower limit of the CI for specificity as low as 50%.[9] While the overall data is quite favorable, it is possible that the true specificity may be lower than suggested and more investigation is needed to validate this data. Finally, as US is operator-dependent, it is important to ensure that providers have undergone sufficient training and are aware of their limitations.

CONCLUSION

While the data is supportive of the use of ultrasound for the diagnosis of shoulder dislocation, further studies are needed prior to routine implementation. Future studies should compare the different techniques to determine which is most accurate, record performance time for the ultrasound, include more data on posterior dislocations, include more data on fracture identification, and validate one of the above techniques with increased sample sizes.

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Impact of Internally Developed Electronic Prescription on Prescribing Errors at Discharge from the Emergency Department

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Introduction: Medication errors are common, with studies reporting at least one error per patient encounter. At hospital discharge, medication errors vary from 15%-38%. However, studies assessing the effect of an internally developed electronic (E)-prescription system at discharge from an emergency department (ED) are comparatively minimal. Additionally, commercially available electronic solutions are cost-prohibitive in many resource-limited settings. We assessed the impact of introducing an internally developed, low-cost E-prescription system, with a list of commonly prescribed medications, on prescription error rates at discharge from the ED, compared to handwritten prescriptions.

Methods: We conducted a pre- and post-intervention study comparing error rates in a randomly selected sample of discharge prescriptions (handwritten versus electronic) five months pre and four months post the introduction of the E-prescription. The internally developed, E-prescription system included a list of 166 commonly prescribed medications with the generic name, strength, dose, frequency and duration. We included a total of 2,883 prescriptions in this study: 1,475 in the pre-intervention phase were handwritten (HW) and 1,408 in the post-intervention phase were electronic. We calculated rates of 14 different errors and compared them between the pre- and post-intervention period.

Results: Overall, E-prescriptions included fewer prescription errors as compared to HW-prescriptions. Specifically, E-prescriptions reduced missing dose (11.3% to 4.3%, p <0.0001), missing frequency (3.5% to 2.2%, p=0.04), missing strength errors (32.4% to 10.2%, p <0.0001) and legibility (0.7% to 0.2%, p=0.005). E-prescriptions, however, were associated with a significant increase in duplication errors, specifically with home medication (1.7% to 3%, p=0.02).

Conclusion: A basic, internally developed E-prescription system, featuring commonly used medications, effectively reduced medication errors in a low-resource setting where the costs of sophisticated commercial electronic solutions are prohibitive. [West J Emerg Med. 2017;18(5)943-950.]

INTRODUCTION

Medication errors frequently result in adverse drug events. These errors greatly impact patient safety, representing the leading cause for injuries and death.[1] Studies have reported at least one error per patient encounter.[2] An emergency department (ED) setting is believed to be particularly sensitive to medication errors due to exposure to new patients, time constraints, frequent interruptions and limited patient history.[1,3] Additionally, there is

a higher frequency of prescriptions in this setting, with more than 75% of ED visits resulting in drug administration or prescription dispensing.[4] Errors at discharge in particular are also common, varying from 15%-38%.[5, 6, 7, 8] Of discharged patients from the hospital, 23% encountered at least one adverse event and 72% of the adverse events were attributed to medications errors.[9]

To our knowledge, a total of two studies have looked at the impact of electronic (E)-prescription error rates at discharge from the ED. Bizovzi et al. found that a commercial E-prescription system was three times less likely to result in errors and five times less likely to demand pharmacist clarification than hand-written (HW) prescriptions within the ED.[10] A similar effect was reported at discharge in a pediatrics ED with a commercially-based system.[11]

This study examined the effect of introducing a low-cost, internally developed E-prescription system with a list of commonly prescribed medications to the ED at a tertiary care center in Lebanon, on prescription errors compared to HW-prescriptions.

Population Health Research Capsule

What do we already know about this issue?
Commercially available electronic prescription systems decrease prescription errors at ED discharge however they are cost-prohibitive in resource limited settings.

What was the research question?
Assess the impact of introducing an internally developed, low-cost electronic prescription system on prescription error rates at ED discharge.

What was the major finding of the study?
An electronic prescription system featuring commonly used ED medications reduced prescription errors at ED discharge.

How does this improve population health?
Reducing prescription errors at discharge from the ED, by applying a basic electronic prescription system, can prevent adverse drug events and improve quality of care.

METHODS

Study Setting

This study was conducted at the ED of the American University of Beirut Medical Center, the largest tertiary care center in Lebanon, with around 49,000 patient visits per year. The ED is staffed by attendings around the clock along with residents from multiple different services for adult patients (internal medicine, family medicine, surgery and obstetrics residents) and pediatric patients (family medicine and pediatrics residents). The majority of our patients are covered by private third-party payers (67%), while the remaining pay out of pocket. The ED uses an internally developed dashboard system that allows for patient tracking, electronic diagnostics ordering and review of prior visits and diagnostics results. All ED medication ordering throughout the ED stay is done through hand-written orders (HW), including at discharge.

Study Design

We conducted a pre- and post-intervention study with a random sample of patients selected from the pre- and post-intervention period. The pre-intervention phase, which included the HW-prescription at discharge, ran from November 1, 2010-June 30, 2011, while the post-intervention phase, which included the E-prescriptions, ran from November 1, 2011-June 30, 2012. These periods were selected to allow for a wash-out period, specifically one month pre-introduction of the E-prescription and two months post-introduction, during which piloting and implementation was occurring. Approval for this study was granted by our institutional review board.

Sample selection

Patients eligible in this study were of all ages, genders, and diagnoses, with at least one prescription at discharge, either HW or electronic. We excluded patients whose charts were not scanned into the electronic medical record or if the discharge prescription was missing. We randomly selected charts for the pre-intervention month, by selecting every 10th admission medical record number, checking for the presence of a discharge prescription. If so, the patient was included in the study. This process was repeated until the target number of patients was reached. We also used this method for the post-intervention group.

Power calculation

Although the HW-prescribing error rate in the literature ranges between 15-46%,[12, 13] for the sample size calculation of the current study, we considered a rate of 50%, since it yields the highest sample size (most conservative). Accordingly, we estimated that a sample size of 770 patients in each group was needed to detect a 7% reduction in error rates post-intervention, with an 80% power and an alpha level of 5%, assuming one discharge prescription per patient.

Intervention

An electronic discharge process was internally developed

by a team that included an emergency-physician champion working with the hospital information technology (IT) team and director of pharmacy. The electronic discharge module was introduced on August 1, 2011. The new system included forced fields for diagnoses, an optional section for follow-up care, optional patient education handouts and a prescription section that included 166 commonly prescribed medications with the generic name of the medication, strength, dose, frequency, route, and duration. The list was developed based on historical data of commonly prescribed medications from the ED, in addition to faculty input. When deciding on common medication categories where multiple options exist, we included the ones on hospital formulary, e.g., esomeprazole rather than pantoprazole. For pediatrics, the list included the medication, strength and recommended dosing only on a mg/kg basis, where the final dose required manual calculation. Hospital pharmacy reviewed the final list for accuracy and availability of medications in the local market. The system did not include allergy- or medication-reconciliation functions. Physicians could also free text additional medications without forced fields. The time to complete and print the E-prescription was around 30 seconds. The total cost of development and implementation including IT personnel time, ED medical director time and pharmacist time was approximately $4,300 U.S. in our setting.

Data collection

The methods followed in this study adhere to the criteria suggested by Worster et al. for retrospective chart review.[14] We used a data collection sheet to facilitate extracting the information and to de-identify the phase of the study. Two research assistants who were trained prior to data collection and monitored throughout transcribed both the HW- and E-prescriptions into a Microsoft Excel database. We reviewed medical charts retrospectively to collect patient-specific demographic and medical data including age, gender, emergency severity index (ESI), discharge diagnosis, allergies, home and discharge medications (number and all prescription-related information on medication name, dose, strength, frequency, route, and duration) and number of handovers as reflected by attending shift changes during the patient's stay.

Moreover, we used an administrative database to collect workload and scheduling metrics that might affect error rates. These included ED visit volume per day, weekday/weekend shift, shift type (morning shift, which ran from 8am-4pm; evening shift, 4pm to midnight; and night shift, midnight to 8am).

Definitions and identification of errors

The definition of errors in each prescription was according to the error list provided in Table 1. Duplication with discharge medication was considered an error when two medications of the same family were included in the discharge prescription, for example, ibuprofen and naproxen. We considered duplication with home medications an error when at least one of the discharge medications was of the same family as one of the home medications and there were no instructions to hold or stop the home medication. Drugs were reviewed for interactions with all the medications listed in the discharge prescription list and the home medication list. We used Lexicomp® drug interaction software to check for all interactions and risk ratings as per the software, where risk A involved no known interaction, risk B required no action, risk C required monitoring therapy, risk D required consideration of therapy modification and risk X required avoidance of combination.[15] All risk D and X interactions were considered an error.

We included drug allergy error if the patient was discharged on a medication that was listed as an allergy in the patient record, or was of the same family of the allergy medication. Lexicomp software was also used to review all medication dosing, frequency, and duration recommendations. A prescription was considered to have an error in these categories if there was deviation from the Lexicomp recommendation. Incorrect strength was considered an error if the strength of the medication was not one available in the local market per the Lebanese Ministry of Public Health formulary list.[16] A medication was considered illegible if the research assistant was unable to read it. The two research

Table 1. Types of errors in prescriptions for discharge medication, and corresponding risk level.

Description	Risk level classification
High-risk errors	
Duplication with discharge medication	High
Duplication with home medication	High
Drug/drug interaction (D/H)	High (type D and X)
Drug/drug interaction (D/D)	High (type D and X)
Drug/allergy interaction	High
Incorrect dose	High
Incorrect frequency	High
Incorrect strength of drug	High
Low-risk errors	
Incorrect route	Low
Missing duration	Low
Missing dose	Low
Missing frequency	Low
Missing strength of drug	Low
Illegibility	Illegible

Drug/drug interaction (D/H): interaction of discharge medications with home medications. Drug/drug interaction (D/D): interactions of discharge medication with another discharge medication. Type D required consideration of therapy modification and type X required avoidance of combination.

assistants who extracted the data completed the error scoring. Moreover, to verify the scoring, a clinical pharmacist, who was blinded to the purpose and phase of the study, reviewed the de-identified data and scored them independently. Finally, any discrepancy between the scoring of the research assistants (RAs) and the pharmacist was resolved by discussion with the principal investigator (PI) of the study, as well as the director of clinical pharmacy at our institution.

Outcomes and classification of errors

Primary outcomes

We classified errors directly impacted by the intervention as primary outcomes. These included incorrect route, dose, or frequency, or strength, illegibility and missing duration, dose, frequency, or strength.

Other outcomes

Errors that were not directly targeted by the intervention but were felt to potentially impact patient safety were considered other outcomes. These included the following: duplication with discharge medication, duplication with home medications, interactions of discharge medication with another discharge medication, interaction of discharge medications with home medications and drug/allergy interaction.

Classifications

A priori, we categorized those under 14 years of age as pediatric, and those above as adults. This classification was based on a previous study, where the age group corresponds to a typical weight of 50kg or less and is likely to need weight-based prescription dosing.[10] The error types were classified into three groups: incorrect errors (incorrect route, dose, frequency, and strength), missing information errors (missing duration, dose, frequency, and strength) or illegible errors. Error types were also grouped as high or low risk. We considered errors high risk if they had the potential to cause significant harm and were not part of routine pharmacist verification practice. All missing-information errors were considered low risk as pharmacy verification would be required to fill the prescription. High-risk errors included duplication with discharge medication, drug/drug interaction with home medications, drug/drug interaction with discharge medications, drug/allergy interaction, incorrect dose, incorrect frequency, incorrect strength, and duplication with home or discharge medication. Low-risk errors included incorrect route, missing duration, missing dose, missing frequency, and missing strength.

Statistical Analysis

We used the Statistical Package for Social Sciences (SPSS)® for the data management and analyses. The distribution of the medication errors and the predictors (sociodemographic characteristics, ED scheduling, ED workload and patient medical status) are presented as means ± standard deviations (SD) and frequencies and percentages for the continuous and categorical variables, respectively. We used Pearson's chi-squared and one-way Student's t-test to assess the significance of the association between the predictor factors (continuous and categorical) and the medication error.

We performed a multivariate analysis using logistic regression to find the best model that fit the data and explained the association between medication error and all predictor variables, which included the following: type of prescription, age, gender, ESI, number of home medications, number of discharge medications, shift type, ED volume per day and handovers per visit. We conducted a backward selection procedure by fitting medication error with all risk factors found to be significant at the bivariate level, in addition to those considered clinically meaningful. Furthermore, the magnitude of association between the predictor variables and medication errors was determined by calculating the adjusted odds ratios (aOR) and their corresponding 95% confidence intervals (CI). Missing data were not modified, and statistical significance was established at the p-value of 0.05.

RESULTS

We included a total of 2,883 prescriptions in the study, of which 1,475 (51.2%) were in the pre-intervention period (HW), and 1,408 (48.8%) in the post-intervention (E). Table 2 presents the results of the comparison of the demographic characteristics and the ED workload data between the pre- and post-intervention periods. Overall, characteristics of both patient populations were similar, although there was a slight decrease in the number of home medications and discharge medications per patient in the post-intervention period (1.3 prescription per patient compared to 1.1, p=0.002). As for the workload characteristics, the ED workload per day, though not clinically significant, was lower in the post-intervention period (132.4 vs 134.1, p=0.002) with more patients presenting during the night shift (31.1% vs 25.2%, p=0.001).

Overall, E-prescriptions were significantly associated with a reduced error rate (67.7% vs 45.5%, p<0.0001) (OR=0.40, 95%, CI [0.34–0.46]) (Table 3). More specifically, E-prescriptions were associated with a significant reduction of "missing dose" errors (11.3% vs. 4.3%, OR=0.36, 95% CI [0.26–0.48], p <0.0001), "missing frequency" errors (3.5% vs. 2.2%, OR=0.63, 95% CI [0.40–0.99], p=0.04), and "missing strength" errors (32.4% vs 10.2%, OR=0.24, 95% CI [0.1–0.29], p <0.0001). "Legibility" also significantly improved with E-prescriptions (0.7% vs 0.1%, OR=0.10, 95% CI [0.01–0.73], p=0.005). On the other hand, E-prescriptions were associated with a significant increase of "incorrect strength" errors (1.5% vs. 3.6%, OR=2.48, 95% CI [1.50–4.12], p <0.0001) and "duplication with home medication" (1.7% vs. 3.0%, OR=1.78, 95% CI [1.08–2.94], p = 0.02).

When classified into broad categories of prescription error types, "missing information" (which includes missing duration, route, dose, strength, name, and frequency) was

Table 2. Association between the demographic variables and the use of handwritten (HW) or electronic (E) prescription.

		Pre-intervention HW number (%)	Post-intervention E number (%)	
Total sample		N=1475	N=1408	p value
Patient characteristics				
Age (years)	(Mean, ±SD)	31.4 (±20.9)	31.3 (±20.0)	0.81
Male gender		746 (50.6%)	715 (50.8%)	0.91
ESI	(Mean, ±SD)	3.3 (±0.6)	3.3 (±0.7)	0.10
Pediatric patients	Pediatric	320 (21.7%)	268 (19.0%)	0.08
Number of home medications/patient	(Mean, ±SD)	1.3 (±1.7)	1.1 (±1.6)	0.002
Number of discharge medications/patient	(Mean, ±SD)	2.4 (±1.0)	2.3 (±1.0)	0.001
ED workload				
Shift				0.001
Morning		528 (35.8%)	485 (34.4%)	
Evening		575 (39.0%)	485 (34.4%)	
Night		372 (25.2%)	438 (31.1%)	
Handovers per visit	(Mean, ±SD)	1.1 (±0.3)	1.2 (±0.4)	0.33
ED volume per day	(Mean, ±SD)	134.1 (±13.4)	132.4 (±16.4)	0.002

HW, handwritten prescriptions*; E,* electronic prescriptions; *ESI*, Emergency Severity Index; *SD*, standard deviation.

Table 3. Association between the type of errors and the use of handwritten (HW) or electronic (E) prescriptions.

	Pre-intervention HW number (%)	Post-intervention E number (%)		
Total sample	N=1475	N=1408	Crude OR (95% CI)	p value
All type errors	999 (67.7%)	641 (45.5%)	0.40 (0.34 – 0.46)	<0.0001
Duplication with discharge medication	5 (0.3%)	4 (0.3%)	0.84 (0.22 – 3.13)	1.00
Drug/drug interaction (D/H)	107 (7.3%)	96 (6.8%)	0.94 (0.70 – 1.25)	0.65
Drug/drug interaction (D/D)	51 (3.5%)	55 (3.9%)	1.14 (0.77 – 1.67)	0.52
Drug/allergy interaction	0 (0.0%)	2 (0.1%)	-	0.24
Incorrect drug	2 (0.1%)	1 (0.1%)	0.52 (0.05 – 5.78)	1.00
Incorrect dose	40 (2.7%)	26 (1.8%)	0.68 (0.41 – 1.11)	0.12
Incorrect frequency	51 (3.5%)	57 (4.0%)	1.18 (0.80 – 1.73)	0.40
Illegibility	11 (0.7%)	1 (0.1%)	0.10 (0.01 – 0.73)	0.005
Missing duration	398 (27.0%)	410 (29.1%)	1.11 (0.95 – 1.31)	0.20
Missing dose	166 (11.3%)	61 (4.3%)	0.36 (0.26 – 0.48)	<0.0001
Missing frequency	51 (3.5%)	31 (2.2%)	0.63 (0.40 – 0.99)	0.04
Missing strength	478 (32.4%)	144 (10.2%)	0.24 (0.19 – 0.29)	<0.0001
Incorrect strength	22 (1.5%)	51 (3.6%)	2.48 (1.50 – 4.12)	<0.0001
Duplication with home medication	25 (1.7%)	42 (3.0%)	1.78 (1.08 – 2.94)	0.02

HW, handwritten prescriptions; *E*, electronic prescriptions.
Drug/drug interaction (D/H): interaction of discharge medications with home medications. Drug/drug interaction (D/D): interactions of discharge medication with another discharge medication.

the most common type of error to occur overall (47.5%) and was significantly less common in E-prescriptions as compared to the HW-prescriptions (35.5% vs 59.0%, respectively, p <0.0001) (Table 4). On the other hand, "incorrect information" (which includes incorrect route, dose, and frequency) errors were more common in E-prescriptions, with borderline statistical significance (8.9% vs 7.0%, p=0.05).

Table 5 presents the comparison between the HW- and E-prescriptions by risk level of errors. Low-risk prescribing errors were the most common type of errors in both groups, yet it was found to be less in the E-prescriptions as compared to the HW (35.5% vs. 59.1%, p <0.0001). Similarly, the illegible errors were less in the E-prescription (0.1% vs 0.7%, p= 0.005). On the other hand, high-risk errors were more common in the E-prescriptions as compared to the HW ones (18.2% vs 15.0%, p = 0.02).

The results of the multivariate logistic regression analysis for the predictors of all types of medication errors are presented in Table 6. After adjusting for potentially confounding factors, it was found that E-prescriptions were a strong predictor of fewer errors (adjusted OR = 0.40, 95% CI [0.35 – 0.47], p<0.0001).

DISCUSSION

This pre- / post-intervention study demonstrates that the implementation of a low-cost, internally developed E-prescription system, featuring a list of commonly used medications, with no decisional support features, can effectively reduce the number of medication errors. While multiple studies have demonstrated the impact of sophisticated E-prescription system on reducing prescribing errors at discharge, the expense of such systems may be prohibitive in low-resource settings.

The types of errors significantly reduced with E-prescriptions in our study were the following: missing dose, missing frequency, missing strength, and illegibility errors. In terms of broad categories of errors, low-risk errors, illegible errors and missing-information errors emerged as significantly reduced by E-prescription. By contrast, incorrect information errors were more common in E-prescriptions. This was mainly due to an incorrect strength of one commonly used medication that was included in the final list and perpetuated in all the E-prescriptions.

Our study revealed no improvement in the other outcomes. In fact, duplication with home medications increased upon E-prescription use while no such effect was noted for drug-interaction errors and drug-allergy errors. This was likely because the design of the internally

Table 4. Association between the types of prescribing errors by broad categories and the use of electronic or handwritten prescription

	Pre-intervention HW number (%)	Post-intervention E number (%)	
Total sample	N=1475	N=1408	p value
Drug interaction errors	128 (8.7%)	140 (9.9%)	0.24
Incorrect information errors	103 (7.0%)	126 (8.9%)	0.05
Illegible errors	11 (0.7%)	1 (0.1%)	0.005
Missing information errors	870 (59.0%)	500 (35.5%)	<0.0001
Drug allergy errors	0 (0.0%)	2 (0.1%)	0.24

HW, handwritten prescriptions, *E*, electronic prescriptions

Table 5. Comparison between handwritten and electronic prescriptions according to the risk level.

	Pre-intervention HW number (%)	Post-intervention E number (%)	
Total sample	N=1475	N=1408	p value
All errors	985 (66.8%)	626 (44.5%)	<0.0001
Low-risk errors	871 (59.1%)	500 (35.5%)	<0.0001
High-risk errors	221 (15.0%)	256 (18.2%)	0.02
Illegible errors	11 (0.7%)	1 (0.1%)	0.005

HW, handwritten prescriptions, *E*, electronic prescriptions

Table 6. Multivariate analysis for the predictors of all types of medication errors vs no errors (hierarchical method imposing the type of prescription).

Predictors	Adjusted OR (95%CI)	P value
Type of prescription (handwritten/electronic)	0.40 (0.35 – 0.47)	<0.0001
Age	1.01 (1.01 – 1.02)	<0.0001
Pediatrics	1.38 (1.06 – 1.78)	0.02
Number of home medications per patient	1.18 (1.11 – 1.25)	<0.0001

Variables entered in the model include the following: type of prescription, total visits, ED volume, age, gender, (Emergency Severity Index), pediatric (as compared to adult) patients, number of home medications per patient, number of discharge medications per patient, shift evening, shift night.

developed system in our study did not specifically target high-risk errors or include drug-allergy checking, medication reconciliation, and drug-drug interaction features. Since no controls for these errors were introduced, the difference in corresponding error rates between pre- and post-intervention was expectedly not large. Overall, this is in line with previous studies in which computerized systems were not as effective with high-risk medication errors.[17, 18] Such high-risk errors would require developing more sophisticated programs that include fields for entering home medications and allergies, which could then be cross-checked with the discharge medications for interactions/contraindications.

In addition, although the current system includes a list of commonly prescribed medications, a free-text option remained available to providers. This may have reduced the impact on missing-information errors. Implementing a program that makes some elements mandatory would be an easy, low-cost modification that would further mitigate this type of error.

Features of commercially available E-prescription systems range from basic medication lists to robust decision-making support with medication reconciliation processes. While decision support capability to address high-risk errors is an important component of commercially available E-prescription systems, such complex systems can cost up to $29,000 per physician for the first year and $4,000 annually thereafter.[19] Even the cost of commercially available E-prescriptions systems with basic features is high, ranging between $1,500 and $4,000 per physician. Such costs are likely unaffordable in low-resource settings where internally developed solutions may offer more feasible options.

LIMITATIONS

There are a few limitations to this study. Firstly, this intervention was implemented across a single institution, which may limit generalizability. Given the pre- / post study design, some physician- and patient-related characteristics may have varied and introduced a bias into the results. Additionally, the outcome and consequences of medication errors and their severity, including adverse drug events, were not measured and assessed. Moreover, although discrepancy between abstractors was resolved through a systematic process with the PI, nevertheless, inter-observer reliability was not tested.

CONCLUSION

An E-prescription system that includes a common list of ED medications considerably decreased the frequency of the majority of prescription errors. To date, no studies have investigated the impact of a low-cost electronic, internally developed system in an ED where resources are limited and acquiring comprehensive and commercial E-solutions is cost-prohibitive. The developed system is comparatively more basic than currently available systems and uses entirely internal resources. The decrease in error rates introduced by this cost-effective system supports its implementation, particularly in developing countries with limited financial resources.

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Sepsis Definitions: The Search for Gold and What CMS Got Wrong

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On October 1, 2015, the United States Centers for Medicare and Medicaid Services (CMS) issued a core measure addressing the care of septic patients. These core measures are controversial among healthcare providers. This article will address that there is no gold standard definition for sepsis, severe sepsis or septic shock and the CMS-assigned definitions for severe sepsis and septic shock are premature and inconsistent with evidence-based definitions. [West J Emerg Med. 2017;18(5)951-956.]

INTRODUCTION

The Centers for Medicare and Medicaid Services (CMS) issued core measures for the management of sepsis on October 1, 2015, which state that "the evidence cited for all components of this measure is directly related to decreases in organ failure, overall reductions in hospital mortality, length of stay, and costs of care."[1] This is an admirable statement but may not be the case when these core measures are applied at bedside mainly because statements within the measure are not fully supported with evidence-based literature. These problems start at the very beginning with the CMS-designated definitions of severe sepsis and septic shock.

Since 1992, the definitions of sepsis, severe sepsis and septic shock have been heavily debated. Multiple consensus statements have been released.[2-4] Each iteration has attempted to incorporate concepts reflecting an updated understanding of the pathophysiology of sepsis. Yet none have been perfect or accepted as gold standard.[2-9]

CMS neglected to acknowledge that there is no perfect definition available for sepsis, severe sepsis and septic shock and it is premature to institute government-mandated sepsis core measures. Additionally, the definitions they selected are inconsistent with the definitions used in evidence-based studies since 2001.The problems continue as these imperfect and inconsistent mandatory definitions serve as the trigger to a cascade of resuscitative efforts. To add to the dilemma, if a clinician is noncompliant with *any* portion of this measure, hospital reimbursement is withheld.

The CMS-proposed definitions are a deviation from the definitions that clinicians have used in their medical practice for nearly 15 years. The major difference is with the value of lactate and whether fluid resuscitation has occurred. We detail the history of the definitions in the sepsis syndrome continuum from their inception to present day and demonstrate that the CMS-proposed definitions are not supported by evidence and should not be used as a trigger to initiate the rest of the CMS resuscitation cascade.

CASE

A 55-year-old, morbidly obese male presents to the emergency department (ED) with a chief complaint of severe abdominal pain. The pain started approximately two days ago and he also reports anorexia, nausea and dysuria. His vitals signs are T 101.5°F, BP 134/68, HR 110, RR 20, pulse oximetry 98% on room air, weight 138 kilograms. On physical exam, he has dry mucous membranes, is tachycardic, and has diffuse lower abdominal pain. Basic labs are drawn, an intravenous line is started and crystalloid fluids are given at a rate of wide open.

A leukocytosis of 23,000 without a bandemia and a lactate of 4 mmol/L was found on review of his labs. Urine analysis reveals presence of a urinary tract infection; the rest of his lab tests are unremarkable. Appropriate antibiotics are started. The question now: Is your patient septic, severely septic or in septic shock?

A HISTORY LESSON

The American College of Chest Physicians (ACCP) and Society for Critical Care Medicine (SCCM) released a consensus statement in 1992 that provided the first published definitions for systemic inflammatory response syndrome (SIRS), sepsis, severe sepsis, septic shock, sepsis-induced hypotension and multiple organ dysfunction syndrome (MODS). The consensus statement provided robust verbal definitions and assigned objective clinical criteria for SIRS criteria, but did not supply specific clinical criteria to define end-organ dysfunction.[2] These definitions are provided in Table 1.

A study by Sands et al. in 1997 used strict criteria to define the epidemiology of the sepsis syndrome, which was defined as the presence of either temperature > 38.2°C or < 35.6°C measured rectally, respirations > 20 breaths per minute or the need for mechanical ventilation, heart rate > 90 beats per minute AND clinical evidence of infection OR one or more blood cultures positive for a pathogen at 48 hours. Additionally, the study provided the first clinical criteria used to define severe sepsis and septic shock, which included any one of the following: 1) PaO2/FiO2 < 280, arterial pH < 7.30; 2) urine output < 30mL/h; 3) systolic blood pressure (SBP) < 90 mm Hg or fall in SBP > 40 mm Hg sustained for two hours despite fluid challenge; 4) systemic vascular resistance < 800 dynes/s/cm; 5) prothrombin time or partial thromboplastin time > normal; or 6) platelets < 100.0 x 10^9/L or platelets decreased to < 50% of most recent measurement before current day; or 7) documentation of deterioration in mental status within 24 hours.[10]

Emmanuel Rivers' landmark sepsis trial in 2001 cited both the ACCP/SCCM consensus definitions ***and*** the Sands study definitions for sepsis, severe sepsis and septic shock. In the Rivers' trial, patients were included when two of four SIRS criteria were present and a SBP of no higher than 90 mm Hg after crystalloid fluid challenge or the patient had a blood lactate concentration of 4 mmol per liter or greater.[11] Many subsequent studies have evaluated patients with severe sepsis and septic shock using these Rivers' definitions.

In 2003 Levy et al. published an article in *Intensive Care Medicine* that detailed the 2001 SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions. This publication introduced updated concepts in sepsis pathophysiology and clinical data to expand the definitions first published in 1992. It is in these definitions that hyperlactatemia, defined as > 3mmol/L, is first mentioned as diagnostic criteria for sepsis. It is also in this publication that the authors stated, "*Unfortunately, a clinically useful set of criteria for diagnosing sepsis and related conditions will necessarily be somewhat arbitrary. There is no 'gold standard' against which the diagnostic criteria can be calibrated*." [3]

In 2004 the Surviving Sepsis Campaign released its initial guidelines for sepsis management in the journals of *Critical Care Medicine* and *Intensive Care Medicine*. Since that time,

Table 1. Adapted from ACCP/SCCM consensus statement.

	Definition
SIRS	
Criteria	Two or more of the following
	Temperature > 38°C or < 36°C
	Heart rate > 90 beats per minute
	Respiratory rate > 20 breaths per minute or PaCO2 < 32 mm Hg
	White blood cell count > 12,000/cu mm, < 4,000/cu mm or
	> 10% immature (band) forms
Sepsis	The systemic response to infection manifested by 2 or more SIRS criteria
Severe sepsis	Sepsis associated with organ dysfunction, hypoperfusion or hypotension that may include but are not limited to, lactic acidosis, oliguria or an acute alteration in mental status
Septic shock	Sepsis-induced with hypotension despite adequate fluid resuscitation along with the presence of perfusion abnormalities that may include, but are not limited to, lactic acidosis, oliguria, or an acute alteration in mental status. Patients who are receiving inotropic or vasopressor agents may not be hypotensive at the time that perfusion abnormalities are measured.
Sepsis-induced hypotension	A systolic blood pressure < 90 mm Hg or a reduction of >/- 40 mm Hg from baseline in the absence of other causes for hypotension
MODS	Presence of altered organ function in acutely ill patients such that homeostasis cannot be maintained without intervention

ACCP, American College of Chest Physicians; *SCCM*, Society of Critical Care Medicine; *SIRS*, systemic inflammatory response syndrome; *PaCO2*, partial pressure of carbon dioxide in arterial blood; *MODS*, multiple organ dysfunction syndrome.

three additional editions of the Surviving Sepsis Campaign Guidelines (SSCG) have been published with the most recent being in 2016.[5-8] The 2012 definitions are the last to include specific clinical criteria to identify sepsis. Within the article were two conflicting values for an abnormal lactate level. In one table, a lactate > 1 mmol/L defined hyperlactatemia and the Levy article was cited for this value. In a separate table, "*Lactate above upper limits of laboratory normal*" was listed as evidence of end-organ dysfunction.[7]

In 2012 the National Quality Forum published definitions and quality measures for the management of sepsis, severe sepsis and septic shock. The definitions and bundles of this measure were the 2012 SCC guidelines verbatim.[12]

Between 2014 and 2015, three separate randomized controlled trials were published (PROCESS, ARISE, and PROMISE) that evaluated the mortality of patients receiving early goal-directed therapy (EGDT) versus usual care. The PROCESS study recruited ED patients who on presentation had two or more SIRS criteria, lactate > 4mmol/L and who had refractory hypotension as a SBP that either was less than 90 mm Hg or required vasopressor therapy to maintain 90 mm Hg despite an intravenous (IV) fluid challenge of crystalloid. A fluid challenge was defined as 20 ml or more per kilogram of body weight, administered over 30 minutes at the beginning of the study, but was later simplified to 1,000 ml or more administered over 30 minutes.[13] The ARISE trial investigators included patients with a suspected or confirmed infection, two or more SIRS criteria, and evidence of refractory hypotension or hypoperfusion (defined as lactate > 4 mmol/L). Refractory hypotension was defined as a SBP < 90 mm Hg or a mean arterial pressure (MAP) < 65 mmHg after an IV fluid challenge of 1,000 ml or more of crystalloid administered over a 60-minute period.[14] The PROMISE trial investigators enrolled patients with a known or presumed infection, two or more SIRS criteria and either refractory hypotension (i.e., the same definition as the ARISE trial) or hyperlactatemia (lactate > 4 mmol/L).[15]

In 2016 Singer and authors released the Sepsis-3 consensus paper, which eliminated severe sepsis entirely and changed the definitions for sepsis and septic shock. The Sepsis-3 definition of sepsis is a "*life-threatening organ dysfunction cause by a dysregulated host response to infection."* Clinically this is detected by suspected or documented infection and two or more quick Sequential Organ Failure Assessment (qSOFA criteria (Table 2). Septic shock is a "*subset of sepsis in which underlying circulatory and cellular/metabolic abnormalities are profound enough to substantially increase mortality.*" Clinically this is detected in the setting of sepsis and vasopressor therapy needed to elevated MAP ≥ 65 mm Hg AND a lactate > 2 mmol/L despite adequate fluid resuscitation. The authors highlight those concerns addressed in the Levy paper by saying, "*sepsis is a broad term applied to an incompletely understood process. There are, as yet, no simple and unambiguous clinical criteria or biological, imaging, or laboratory features that uniquely identify a septic patient."*[4]

Table 2. Quick Sequential Organ Failure Assessment criteria.

Altered mental status
Systolic blood pressure < 90 mm Hg
Respiratory rate ≥ 22 breaths per minute

The most recent Surviving Sepsis Campaign guidelines were released in early 2017. Unlike the previous releases, this version accepted some of the Sepsis-3 proposals and eliminated severe sepsis as a category. SSC also accepted the proposed verbal definitions for sepsis and septic shock. However, qSOFA was not accepted or recommended as best practice, and SIRS along with all other specific clinical parameters of end-organ dysfunction were eliminated from the recommendations.[8]

WHAT ARE THE CMS DEFINITIONS?

The CMS sepsis core measures detail different clinical criteria and parameters that define the qualifications for severe sepsis and septic shock. The CMS definition of severe sepsis is an infection or suspected infection with two or more SIRS criteria plus one sign of organ dysfunction (Table 3).

The definition of septic shock is a patient with either 1) SBP < 90 mm Hg, 2) a mean arterial pressure < 65 mm HG, or 3) a reduction in SBP by more than 40 mm Hg from a previously recorded measurement (e.g., in a clinic visit). These criteria are valid only after the patient has received a 30 mL/kg crystalloid fluid bolus or with the initial lactate level greater than or equal to 4 mmol/L.[1] Table 4 illustrates the evolving and proposed definitions for sepsis, severe sepsis and septic shock.

Table 3. CMS evidence of organ dysfunction.

Lactate > 2 mmol/L
INR > 1.5 or aPTT > 60 seconds
Platelet count < 100,000 μL^{-1}
Bilirubin > 2mg/dL
Creatinine > 2 mg/dL
Urine output < 0.5mL/kg/hour x 2 hours
Acute respiratory failure by need for new invasive or noninvasive ventilation.
Systolic blood pressure < 90 mm Hg or MAP < 65 mm Hg or decreased in SBP more than 40 mm Hg from previously recorded patient normal.

CMS, Centers for Medicare and Medicaid Services; *INR*, international normalized ratio; *aPTT*, activated partial thromboplastin time, *MAP*, mean arterial pressure; *SBP*, systolic blood pressure.

Table 4. Evolution of sepsis, severe sepsis and septic shock definitions with clinical criteria.

	1992 ACCP/SCCM Consensus statement	Levy	2012 SCCG	NQF	CMS	Sepsis-3	2016 SCCG
SIRS	Temperature > 38°C or < 36°C Heart rate > 90 bpm Respiratory rate > 20 or PaCO2 < 32 mm Hg White blood cell count > 12,000/cu mm, <4,000/cu mm or >10% bands	No change	No change	No change	No change	Eliminated and qSOFA introduced for purpose of risk stratification	No SIRS. No qSOFA.
Sepsis	Infection + 2 or more SIRS	No change	No change	No change	No change	Infection + 2 qSOFA criteria	Infection + end organ dysfunction. No clinical criteria offered.
Severe sepsis	Sepsis + end-organ dysfunction. No specific lactate level offered.	Sepsis + end- organ dysfunction. Lactate > 3*	Sepsis + end- organ dysfunction. Lactate > 4	No change	Sepsis + end- organ dysfunction. Lactate > 2	Eliminated	Eliminated
Septic shock	Sepsis + a SBP <90 mm Hg or a reduction of 40 mm Hg from baseline or evidence of low perfusion after adequate fluid bolus. No specific lactate level offered.	Same as 1992 with addition of MAP < 60 mm Hg despite adequate fluid bolus.	MAP threshold increased to < 70 mm Hg and fluid bolus defined as 30 mL/kg	No change	Initial lactate > 4 or SBP < 90 mm Hg after 30 mL/kg fluid bolus	SBP < 90 mm Hg AND lactate > 2 after adequate fluid resuscitation	Subset of sepsis with circulatory and cellular/ metabolic dysfunction associated with a higher risk of mortality. No clinical criteria offered.

MAP, mean arterial pressure, *SBP*, systolic blood pressure.
* all lactate levels in mmol/L values.

SO WHAT'S WRONG WITH THE CMS DEFINITIONS?

There are two main problems with the CMS proposed definitions. First, the CMS definition-selected lactate values are below the threshold of widely accepted and studied lactate levels. The second is the very existence of government-issued definitions for a disease state that presents with a great deal of variability and where no gold standard definitions exist.

The CMS definitions are derived from the SCC and NQF definitions, but CMS definitions independently altered the threshold values for lactate. According to CMS, a lactate > 2 mmol/L now represents a patient with severe sepsis and an initial lactate > 4 mmol/L defines a patient in septic shock. You will recall that prior studies used a lactate cutoff of greater than 4mmol/L to define severe sepsis. It was only if the lactate level remained elevated after a fluid resuscitation were patients categorized as being in septic shock. The derivation of these specific lactate values and the proposed values included in the CMS definitions is unknown because CMS does not reference the source of these values.

Studies have demonstrated a distinct leap in mortality rates of septic patients presenting with a lactate level > 4mmol/L.[11,16-20] Mikkelson et al. demonstrated that an elevated lactate is an independent predictor of mortality. In their study, they evaluated the significance of intermediate lactate levels (2–3.9 mmol/L) and found a two-fold increase in mortality when compared to severely septic patients with values less than 2 mmol/L.[18]

Other studies have also demonstrated increased mortality rates in intermediate lactate groups,[17,20] but did not evaluate the benefit of aggressive resuscitation in these patients. One study conducted by Liu et al. demonstrated improved mortalities after initiation of aggressive resuscitative measures in patients with intermediate lactate levels.[21]

Yet many other studies have illustrated the negative effects of overly aggressive resuscitation in septic, severely septic and septic shock patients.[22-26]

In changing the clinically significant value of lactate, CMS mandated that clinical practice, hospital protocols, and medical education had to adopt the lower threshold of 2 mmol/L to define severe sepsis and an initial lactate of greater than 4 mmol/L to define septic shock in the absence of robust supportive literature. Physicians are being forced to use government-issued standards of practice and patient care that have not been fully investigated as appropriate and safe. Doctors are no longer permitted to doctor but rather forced to practice cookie cutter one-size-fits-all algorithms with regard to sepsis care. These constraints leave the clinician in the predicament of using best practices versus following mandated guidelines.

We have demonstrated that there are various proposed definitions for sepsis, severe sepsis and septic shock. This is likely due to the fact that unlike myocardial infarction, which has a very precise pathophysiology and organic effect, sepsis is a spectrum of any number of factors. It is not due to one distinct insult but can be caused by a large variety of infectious agents that can infect a variety of anatomic locations. It is not due to one region of the body suffering hypoxia; rather it is due to a dysregulated host response to infection. And that host response is dependent on a variety of uncontrolled factors such as age, sex and comorbidities. It may be impossible to develop definitions that appropriately identify a disease state that is so dependent on multiple variables. Each patient is different and cannot be defined and treated exactly the same way. The CMS definitions are premature and, unlike the various other definitions presented, are mandatory and must be followed by clinicians practicing in the United States.

BACK TO OUR CASE

Is your patient septic, severely septic or in septic shock? The answer is dependent on the set of definitions being used.

Using the CMS definition, the patient above is in septic shock and requires a 30 mL/kg bolus of fluids, which translates to a mandated 4,140 milliliters of fluid bolus, a perfusion reassessment physical exam, repeat lactate and vasopressors if the patient develops hypotension. Based on 2012 SSC guidelines, the patient is severely septic and is suggested to receive a 30 mL/kg bolus of fluid and have a repeat lactate drawn. Based on the Sepsis-3 definitions, the patient is neither septic nor in septic shock and no treatment cascade exists as these are a consensus statement and not treatment guidelines. This patient meets three vastly different definitions, a quandary that highlights the variability of existing definitions. It also highlights the differences between government-mandated definitions versus recommendations versus consensus papers. Mortality rates differ among patients with sepsis, severe sepsis and septic shock. This is the same patient who can have a mortality rate from 4% to 40% depending on which definition is used. Lastly, these vastly different definitions influence the disposition of the patient. Regardless of the set of definitions under use, the majority of clinicians recognize that this patient requires IV antibiotics, fluid resuscitation and hospital admission. Unfortunately for this patient, the hospital reimbursement is based solely on compliance with the CMS core measures and administration of just over four liters of fluids and not a physician's clinical acumen.

CONCLUSION

The field of medicine is fluid and dynamic. The practices of today are vastly different from 20 years ago and will be different in 20 years from now. But these changes that our field undergoes are based on evidence and science. Government-issued and -mandated health policy incongruent with evidence-based medicine is detrimental and counterproductive to patient care. If the goal is indeed to achieve "decreases in organ failure, overall reductions in hospital mortality, length of stay, and costs of care" then the core measures must be backed by evidence-based medicine. It is premature to assign mandated definitions to a complex disease spectrum. It is premature to lower lactate thresholds without the backing of robust studies to demonstrate the safety of aggressive resuscitation in these patients. These definitions are a weak start to a broken healthcare policy.

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Appropriateness of Bolus Antihypertensive Therapy for Elevated Blood Pressure in the Emergency Department

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Introduction: While moderate to severely elevated blood pressure (BP) is present in nearly half of all emergency department (ED) patients, the incidence of true hypertensive emergencies in ED patients is low. Administration of bolus intravenous (IV) antihypertensive treatment to lower BP in patients without a true hypertensive emergency is a wasteful practice that is discouraged by hypertension experts; however, anecdotal evidence suggests this occurs with relatively high frequency. Accordingly, we sought to assess the frequency of inappropriate IV antihypertensive treatment in ED patients with elevated BP absent a hypertensive emergency.

Methods: We performed a retrospective cohort study from a single, urban, teaching hospital. Using pharmacy records, we identified patients age 18-89 who received IV antihypertensive treatment in the ED. We defined treatment as inappropriate if documented suspicion for an indicated cardiovascular condition or acute end-organ injury was lacking. Data abstraction included adverse events and 30-day readmission rates, and analysis was primarily descriptive.

Results: We included a total of 357 patients over an 18-month period. The mean age was 55; 51% were male and 93% black, and 127 (36.4%) were considered inappropriately treated. Overall, labetalol (61%) was the most commonly used medication, followed by enalaprilat (18%), hydralazine (18%), and metoprolol (3%). There were no significant differences between appropriate and inappropriate BP treatment groups in terms of clinical characteristics or adverse events. Hypotension or bradycardia occurred in three (2%) patients in the inappropriate treatment cohort and in two (1%) patients in the appropriately treated cohort. Survival to discharge and 30-day ED revisit rates were equivalent.

Conclusion: More than one in three patients who were given IV bolus antihypertensive treatment in the ED received such therapy inappropriately by our definition, suggesting that significant resources could perhaps be saved through education of providers and development of clearly defined BP treatment protocols. [West J Emerg Med. 2017;18(5)957-962.]

INTRODUCTION

Over half of patients with chronic hypertension have uncontrolled blood pressure (BP),[1] a problem particularly prevalent in urban, African-American communities.[2-4] Hypertension is frequently encountered in the emergency department (ED),[5] and differs management widely.[6] Despite the existence of evidence-based clinical policy statements by the American College of Emergency Physicians (ACEP) discouraging acute BP reduction in hypertensive patients who lack acute end-organ injury,[7] and studies suggesting no harm without treatment,[8] emergency physicians often feel compelled to administer antihypertensive therapy when systolic BP is markedly elevated.[9] Even so, the incidence of true hypertensive emergencies among ED patients with or without chronic hypertension is well below 1%, and post-discharge adverse events are uncommon,[10,11] suggesting that such concerns are largely unfounded.[12]

Inappropriate administration of antihypertensive therapy to patients without a hypertensive emergency, especially bolused intravenous (IV) medication, is not without risk and represents avoidable resource utilization.[13] While evidence suggests that inappropriate IV antihypertensive therapy occurs with relative frequency in the ED,[8,11] no prior study has sought to specifically characterize the appropriateness of bolus IV antihypertensive administration in ED patients with elevated BP.

Population Health Research Capsule

What do we already know about this issue?
Severely elevated blood pressure is common in emergency care. Hypertensive emergencies, however, are rare.

What was the research question?
We hypothesized that bolus intravenous antihypertensive treatment occurs frequently when hypertensive emergencies are neither suspected nor present.

What was the major finding of the study?
We found that one in three patients inappropriately received bolus antihypertensive treatment.

How does this improve population health?
Avoidance of such treatment has the potential to reduce cost and reduce potential complications across populations with severe blood pressure elevation.

METHODS

Study Design and Setting

We performed a retrospective cohort study of patients who presented to the ED of an urban, teaching hospital from January 2011 to July 2012. The hospital had a total annual census of approximately 110,000 adult patients during the study period, more than 80% of whom are African-American. Our institutional review board approved the study prior to data abstraction.

Selection of Participants

Patients aged 18 to 89 years who received one or more IV bolus doses of labetalol, hydralazine, enalaprilat, or metoprolol in the ED were identified by a query of electronic pharmacy orders. We selected these four bolus-dosed medications as they are most often used to manage elevated BP in the ED and, unlike antihypertensive infusions, are more likely (though not exclusively) to be used in patients for whom there is uncertainty about a true hypertensive emergency.[6] Use of pharmacy orders rather than baseline BP to identify the study cohort was deliberate, allowing us to efficiently address our study aim, which was to evaluate appropriateness of bolus IV antihypertensive therapy, and not the ED management of hypertension itself.

Once patients were identified, a single investigator performed chart abstraction using a predefined data dictionary and compiled demographic, medical history and clinical information for each patient including presenting symptoms, ED vital signs and ED laboratory data. Potential adverse effects related to antihypertensive treatment during the ED or hospital stay were also tracked. These adverse effects included documented hypotension, bradycardia (heart rate < 55 beats per minute), and syncope. In addition, abstraction included in-hospital mortality and ED repeat visits within 30 days. A second, independent investigator performed double chart abstraction on a random selection of 40 cases. Data were cross-checked for internal consistency and showed high agreement (> 95%). All data were obtained from the health system electronic medical record (EMR) .

Methods and Measurements

To determine whether or not the use of the IV antihypertensive bolus was appropriate, investigators pre-defined that the following four scenarios qualified as appropriate use. First, treatment was appropriate if administered to a patient with a documented hypertensive emergency, inclusive of acute myocardial infarction, acute heart failure or cardiogenic pulmonary edema, acute aortic dissection, acute stroke (hemorrhagic or ischemic), acute subarachnoid hemorrhage, hypertensive encephalopathy, preeclampsia/eclampsia, or acute renal failure. Second, treatment was appropriate if administered to a patient in whom there was ED documentation expressing

concern for a potential hypertensive emergency but this diagnosis was not confirmed. Third, treatment was appropriate if administered to a patient in whom documentation indicated that a reason for hospital admission was further workup of a possible hypertensive emergency. Fourth, treatment was appropriate if administered to a patient with documented inadequate response to oral medications. Investigators considered treatment inappropriate if the patient received treatment solely for chronic, uncontrolled hypertension, the patient had no specified workup for hypertension (such as electrocardiogram or serial cardiac biomarkers), the patient was discharged from the ED or admitted to the hospital without any diagnoses related to hypertension, or the patient was admitted with a diagnosis of hypertension diagnosis without associated symptoms or clinical findings of end-organ damage.

Statistical Analysis

Statistical analysis was primarily descriptive. We present mean values with associated standard deviation (SD). Group comparisons were performed using t-tests and chi-square or Fisher exact test as appropriate. A p-value of < 0.05 was considered statistically significant. We conducted all data analysis using SAS 9.0 (Cary, NC).

RESULTS

Characteristics of Study Participants

Over the study period, we identified 411 patients who received bolus IV antihypertensive medications, 54 (13.1%) of whom were excluded, primarily for age and antihypertensive administration, after the ED visit (Figure). Baseline characteristics for the final sample of 357 are shown in Table 1. Mean (SD) age was 54.7 (14) years, and patients were mostly African American (93%) with a high prevalence of known underlying chronic hypertension (88.2%). The mean (SD) initial ED BP for all patients was 201/114 (30/22) mm Hg. The mean (SD) BP post-treatment at 30 minutes was 177/100 (29/20) mmHg (n=217), difference -24/14 mmHg (12% SBP reduction). The mean

Table 1. Baseline demographics and characteristics of patients in a study examining the appropriateness of antihypertensive bolus administration when no true hypertensive emergency was present.

Characteristic	All patients (n = 357)	Appropriate use (n = 230)	Inappropriate Use (n = 127)	p-value
Demographics				
Age, years (mean ± SD)	54.7 ± 13.9	56.5 ± 13.8	51.4 ± 13.5	< 0.01
Male sex	183 (51.2)	117 (50.9)	66 (52)	0.84
African American	332 (93)	218 (94.8)	114 (89.8)	0.08
Past medical history				
Hypertension	315 (88.2)	210 (91.3)	105 (82.7)	0.02
Diabetes	91 (25.5)	63 (27.4)	28 (22)	0.27
Coronary artery disease	55 (15.4)	42 (18.3)	13 (10.2)	0.04
Chronic kidney disease	55 (15.4)	43 (18.7)	12 (9.5)	0.02
Heart failure	47 (13.2)	40 (17.4)	7 (5.5)	< 0.01
Stroke	31 (8.7)	23 (10)	8 (6.3)	0.23
No past medical history	31 (8.7)	15 (6.5)	16 (12.6)	0.05
Social history				
Tobacco use	141 (39.5)	89 (38.7)	52 (40.9)	0.68
Alcohol use	66 (18.5)	29 (12.6)	37 (29.1)	< 0.01
Cocaine use	31 (8.7)	23 (10)	8 (6.3)	0.23
Heroin use	21 (5.9)	13 (5.7)	8 (6.3)	0.80
Presenting symptoms				
Shortness of breath	86 (24.1)	76 (33)	10 (7.9)	< 0.01
Chest pain	64 (17.9)	51 (22.2)	13 (10.2)	< 0.01
Headache	47 (13.2)	30 (13)	17 (13.4)	< 0.01
Altered mental status	38 (10.6)	32 (13.9)	6 (4.7)	< 0.01
Numbness or weakness	33 (9.2)	31 (13.5)	2 (1.6)	< 0.01

*All values represented as n(%) unless otherwise indicated.

(SD) BP post-treatment at 60 minutes was 176/97 (27/19) mmHg (n=207), difference from baseline -25/17 mmHg (12% SBP reduction).

Table 2 shows the antihypertensive agents administered to patients. Overall, 91% of patients received a single IV antihypertensive dose. Labetalol was the most common medication administered (60.8%), followed by enalaprilat (18.2%), hydralazine (17.9%), and metoprolol (3.1%).

Main Results

As shown in Figure, 230 out of 357 patients received antihypertensive treatment for suspected or confirmed hypertensive emergency (64.4%) and met criteria for appropriate treatment. The majority of these patients had a primary ED diagnosis of hypertensive emergency (n=88; 38.3%), were evaluated in the ED for hypertensive emergency with an alternate primary diagnosis (n=78; 33.9%), or were admitted to the hospital for further workup of hypertensive emergency (n=54; 23.5%). In the inappropriate treatment group, the most common diagnosis was uncontrolled hypertension (n=52; 40.9%). There were 37 (29.1%) patients in this group who were discharged from the ED with no hypertension-related workup or diagnosis, and 12 (9%) patients were admitted to the hospital without a hypertension-related diagnosis. Compared to the appropriate treatment group, these patients were younger and less likely to have a prior history of cardiovascular disease. The patients in the inappropriate treatment group were also less likely to present to the ED with dyspnea, chest pain or confusion.

Patients were markedly hypertensive in both groups with no difference between in average initial BP. Baseline BP (SD) was 202/115 (29/23) mmHg in the appropriate treatment group and 198/112 (31/19) mmHg in the inappropriate treatment group (p=0.23). A majority of patients in the appropriate group (n=210, 91%) and in the inappropriate group (n=115, 91%) received a single bolus of medication (p=0.81). As show in Table 2, labetalol was used with similar frequency while enalaprilat administration was more commonly administered in the appropriate treatment group (22% vs 11%, p< 0.01).

There was no difference in mean (SD) BP post-treatment at 30 or 60 minutes between groups. Blood pressure in the appropriate group was 178/100 (31/21) mmHg compared to 176/98 (25/17) mmHg in the inappropriate group at 30 minutes post-treatment (p=0.54). At 60 minutes, mean (SD) BP of the appropriate group was 177/97 (28/21) mmHg compared to 172/97 (26/16) mmHg in the inappropriate group (p=0.19). Hypotension developed in three patients, one of whom was being treated for suspected hypertensive emergency and two of whom had no documented suspicion for end-organ injury. These latter two patients required initiation of vasopressor support. One patient in each group developed iatrogenic bradycardia after use of labetalol that required the administration of atropine and additional telemetry monitoring. There was no statistical difference in in-hospital mortality between patients treated appropriately (2%) versus those treated inappropriately (0%). In addition, rates of 30-day ED revisit rates were high but equivalent (18.3% versus 17.3% respectively).

DISCUSSION

Published data regarding management of severe hypertension with bolus IV antihypertensive therapy in the ED setting are limited. In this single center study, we found that more than one-third of patients with elevated BP who received bolus IV antihypertensive therapy in our ED received it inappropriately. Although we found only a few cases where this resulted in potential harm, this practice is contrary to current recommendations from ACEP to avoid BP reduction in asymptomatic patients in the ED.[7] We suspect that in most cases of inappropriate treatment, rapid BP lowering occurs out of convenience. Anecdotedly, emergency physicians

Table 2. Antihypertensive medication administration.

First dose of IV antihypertensive	All patients n = 357	Appropriate use n = 230	Inappropriate use n = 127	p-value
Labetalol	217 (60.8)	131 (57)	86 (67.7)	0.08
Enalaprilat	65 (18.2)	51 (22.1)	14 (11)	< 0.01
Hydralazine	64 (17.9)	39 (17)	25 (19.7)	0.59
Metoprolol	11 (3.1)	9 (3.9)	2 (1.6)	--
Second dose of IV antihypertensive (n = 86)				
Labetalol	57 (66.3)	43 (66.2)	14 (66.7)	0.87
Enalaprilat	17 (19.7)	4 (6.2)	2 (9.5)	0.62
Hydralazine	6 (7)	13 (20)	4 (19)	0.87
Metoprolol	6 (7)	5 (7.7)	1 (4.8)	--

IV, intravenous.

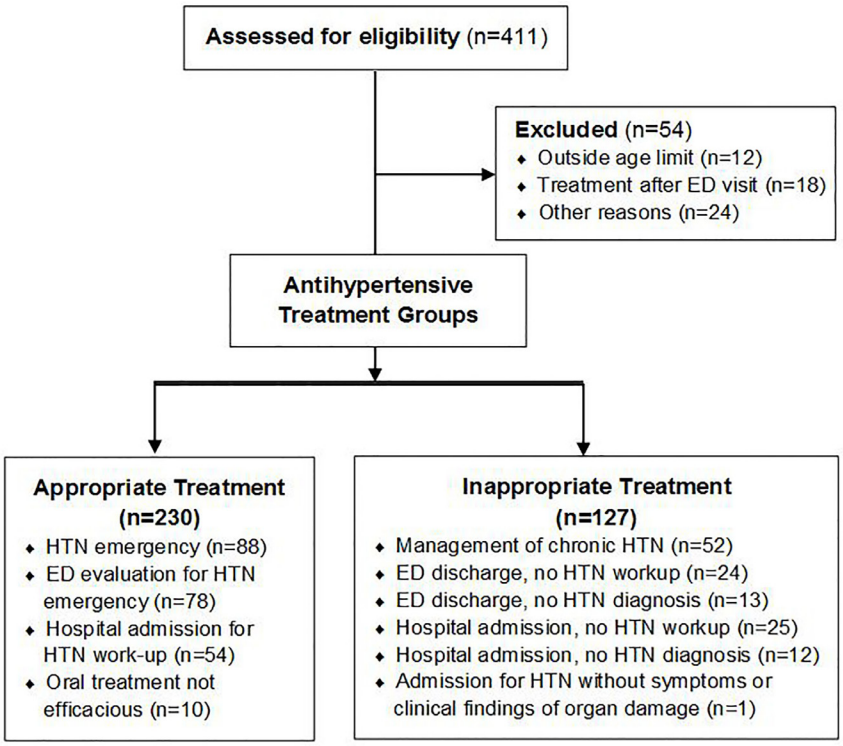

Figure. Flow diagram of participants* in a study that examined frequency of bolus intravenous antihypertensive treatment when hypertensive emergencies were not present.
ED, emergency department; *HTN*, hypertension.

commonly describe that they rapidly improve a patient's BP to "look better" upon discharge to home or transfer to an inpatient bed. Hospital clinicians may also request BP normalization prior to transfer to an inpatient bed.

Because acute management of chronically uncontrolled hypertension has not been shown to improve long-term outcomes and in fact could be detrimental, care is warranted in deciding which patients may benefit from IV antihypertensive bolus medications.[11,14,15] Patients presenting with suspected or confirmed hypertensive emergency should continue to be managed with IV antihypertensive medications according to evidence-based recommendations. For patients presenting with severe BP elevation absent concern for hypertensive emergency, clinicians should be cognizant of the risks of IV antihypertensive therapy and manage these patients through appropriate oral antihypertensive regimens in conjunction with their primary care providers. While our study did not demonstrate a statistically significant difference in adverse effects or in-hospital mortality for patients in the group without documented suspicion for end-organ injury, two patients developed hypotension that required vasopressor treatment, suggesting the potential for serious consequences with indiscriminate use of IV antihypertensive therapy.

Although not directly assessed in our study, widespread use of IV antihypertensive therapy has other consequences including contributing to increased costs associated with IV treatment and critical drug shortages. Inappropriate use of labetalol, by far the most common medication given in our setting, in particular may be problematic as this drug has many indications for management of hypertensive emergency but has been in short supply at various points over the last five years.[16] Automated order queries with indication-specific order justifications in the EMR could be implemented to reduce inappropriate use of IV antihypertensive therapy.

LIMITATIONS

Our study has a number of limitations. Although we captured all available patients over the study time period by pharmacy records, the final number of patients was relatively small for the overall number of ED visits and limited to one site. Because of the nature of retrospective chart abstraction, the characterization of patients was dependent upon available documentation. Unknown factors may have contributed to treatment decisions that could not be accounted for with available documentation. Nevertheless, in the experience of the authors, treatment of severe hypertension with IV medications is commonly performed for the convenience of rapid lowering rather than clinical necessity. Also, while we found no evidence of harm with treatment of patients without documented suspicion for end-organ injury, more subtle adverse events such as confusion, mild stroke, or acute kidney

injury related to hypoperfusion may have been underreported or unidentifiable through chart abstraction. We did not gather complete follow-up data from other health systems, limiting the assessment of readmissions and adverse events within 30 days. Lastly, the patients in this study were 93% African American and 88% had a known history of hypertension. The results of this study may not apply to different patient populations.

CONCLUSION

In this cohort, IV antihypertensive therapy was administered inappropriately to patients without documented suspicion for end-organ injury nearly one third of the time. Systematic efforts to curtail this practice could have a lasting impact on healthcare resource utilization and warrant further exploration.

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Severe Hyperkalemia: Can the Electrocardiogram Risk Stratify for Short-term Adverse Events?

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Introduction: The electrocardiogram (ECG) is often used to identify which hyperkalemic patients are at risk for adverse events. However, there is a paucity of evidence to support this practice. This study analyzes the association between specific hyperkalemic ECG abnormalities and the development of short-term adverse events in patients with severe hyperkalemia.

Methods: We collected records of all adult patients with potassium (K+) ≥6.5 mEq/L in the hospital laboratory database from August 15, 2010, through January 30, 2015. A chart review identified patient demographics, concurrent laboratory values, ECG within one hour of K+ measurement, treatments and occurrence of adverse events within six hours of ECG. We defined adverse events as symptomatic bradycardia, ventricular tachycardia, ventricular fibrillation, cardiopulmonary resuscitation (CPR) and/or death. Two emergency physicians blinded to study objective independently examined each ECG for rate, rhythm, peaked T wave, PR interval duration and QRS complex duration. Relative risk was calculated to determine the association between specific hyperkalemic ECG abnormalities and short-term adverse events.

Results: We included a total of 188 patients with severe hyperkalemia in the final study group. Adverse events occurred within six hours in 28 patients (15%): symptomatic bradycardia (n=22), death (n=4), ventricular tachycardia (n=2) and CPR (n=2). All adverse events occurred prior to treatment with calcium and all but one occurred prior to K^+-lowering intervention. All patients who had a short-term adverse event had a preceding ECG that demonstrated at least one hyperkalemic abnormality (100%, 95% confidence interval [CI] [85.7-100%]). An increased likelihood of short-term adverse event was found for hyperkalemic patients whose ECG demonstrated QRS prolongation (relative risk [RR] 4.74, 95% CI [2.01-11.15]), bradycardia (HR<50) (RR 12.29, 95%CI [6.69-22.57]), and/or junctional rhythm (RR 7.46, 95%CI 5.28-11.13). There was no statistically significant correlation between peaked T waves and short-term adverse events (RR 0.77, 95% CI [0.35-1.70]).

Conclusion: Our findings support the use of the ECG to risk stratify patients with severe hyperkalemia for short-term adverse events. [West J Emerg Med. 2017;18(5)963-971.]

INTRODUCTION

Severe hyperkalemia can lead to lethal cardiac dysrhythmias. Hyperkalemia produces cardiotoxicity through early depolarization of the cell membrane, slowing of ventricular conduction and decreased durations of the action potential. [1,2] These changes at the cellular level correlate with the electrocardiogram (ECG) manifestations of hyperkalemia. Traditional teaching describes the sequential appearance of ECG abnormalities seen with rising potassium (K^+) levels as follows: peaked T waves, PR interval prolongation, QRS prolongation, loss of P wave, escape rhythms, "sine wave" configuration, ventricular fibrillation, and pulseless activity or asystole[1,2] The presence or absence of these ECG manifestations of hyperkalemia are frequently used to determine how aggressively a hyperkalemic patient is treated.[3-5]

However, studies have demonstrated that ECGs without any findings consistent with hyperkalemia are seen in 50-64% of patients with $K^+ \geq 6.5$ mEq/L.[6-8] Cases of patients with extreme hyperkalemia (10.1-10.3 mEq/L) and normal ECGs have also been reported.[9,10] Furthermore, dysrhythmia and cardiac arrest have been reported in hyperkalemic patients without preceding peaked T waves.[11] The role of the ECG in the management of hyperkalemia has thus been increasingly called into question.[2,7,11-14] Leading FOAMed (free online open-access medical education) educators have deemphasized the role of ECG in management decisions, warning that patients with relatively normal ECGs may still experience sudden hyperkalemic cardiac arrest.[12,14] A recently published guideline for the management of severe hyperkalemia called for further research to both characterize the actual risk of cardiac instability in hyperkalemic patients without ECG abnormalities and to identify which hyperkalemic ECG changes are the greatest predictors of outcome.[15]

The practice of using the ECG to determine how aggressively to treat hyperkalemia assumes that ECG changes reliably occur prior to hyperkalemic dysrhythmia or cardiac arrest. While this is a widely held belief, the level of evidence needed to support this teaching does not currently exist. The objective of this study was to determine the association between specific hyperkalemic ECG abnormalities and the development of short-term adverse events in patients with severe hyperkalemia. This study could represent the first step in creating a predictive model for the risk stratification of hyperkalemic patients based on ECG changes.

Population Health Research Capsule

What do we already know about this issue?
Hyperkalemic ECG abnormalities do not consistently occur in hyperkalemic patients. Whether the ECG identifies patients at higher risk for adverse events is unclear.

What was the research question?
What is the association between ECG abnormalities and short-term adverse events in patients with hyperkalemia?

What was the major finding of the study?
All short-term adverse events in hyperkalemic patients were preceded by ECG abnormalities.

How does this improve population health?
This study suggests that the ECG is a useful tool in the risk-stratification of hyperkalemic patients.

METHODS

Study Design

This was an observational retrospective cohort study. The study received institutional review board approval, with a waiver of informed consent.

Study Setting and Population

The study was performed at a suburban community hospital that supports an emergency medicine residency program. The annual emergency department (ED) census is approximately 72,000 patients. Patients are primarily adults (90%); approximately 90% are White, 4% are Hispanic, and 2% are Black.

A list of medical record numbers for all adult patients (age ≥ 18 years) with $K^+ \geq 6.5$ mEq/L from August 15, 2010, through January 30, 2015, was electronically generated from the hospital laboratory database. This database contains all laboratory data for ED and hospitalized patients, which ensured that all hyperkalemia values were captured.

We developed inclusion and exclusion criteria prior to data collection. Cases selected for inclusion were required to have a documented serum or plasma K^+ of ≥6.5 mEq/L and an ECG performed within one hour of the laboratory draw. The $K^+ \geq 6.5$ mEq/L cutoff is considered a threshold for initiating emergency therapy, and has been used in prior publications.[2,16] The ECG could be performed either during the 60 minutes prior to the acquisition of the K^+ sample, or during the 60 minutes after the laboratory draw. When a serum and plasma K^+ level were both obtained, the plasma level (also known as a heparinized K^+) was used. Only one episode of hyperkalemia per patient was included

in the study. We excluded recurrent episodes of hyperkalemia in the same patient.

Exclusion criteria included laboratory notation of a hemolyzed sample, platelet count ≥ 500 x 10^9 /L, paced rhythm on ECG, and treatment for hyperkalemia prior to obtaining the ECG and laboratory sample. Hemolyzed samples were excluded because the release of K^+ from red blood cells during hemolysis can lead to false elevation of the serum potassium. Similarly, we excluded patients with platelet count ≥ 500 x 10^9 /L because this degree of thrombocytosis can cause pseudohyperkalemia. Treatment for hyperkalemia was defined as the administration of any of the following prior to the time the ECG was obtained and the laboratory sample was collected: calcium chloride or gluconate, sodium bicarbonate, albuterol, insulin, dextrose, sodium polystyrene sulfonate, and/or hemodialysis. Patients who received prior treatment for hyperkalemia were excluded so that the measured K^+ level more accurately reflected the K^+ value at the time of the ECG. We also excluded patients if they received atropine, dopamine, epinephrine, norepinephrine, or vasopressin prior to the time the ECG was obtained. We excluded these patients because of the potential of these medications to alter the ECG, such as precipitating ventricular tachycardia or masking hyperkalemic bradycardia.

Study Protocol

We abstracted data from the electronic medical record (EMR), including ED record, admission history and physical, daily progress notes, discharge summary, and electronic medication administration record. A standardized, closed-ended electronic data collection form was used. All reviewers (AB, SD, BL, JV) were trained in the data collection rules and definitions using sample medical records. All EMRs and data collection forms of the final study group (n=188) were reviewed for accuracy by a second reviewer (ND).

The following information was abstracted from each record: (1) demographics (age, sex, race); (2) serum and plasma K^+ levels and time obtained; (3) patient location at time of hyperkalemia (ED vs inpatient); (4) ECG and time obtained; (5) medications administered prior to obtaining ECG (including medications administered by emergency medical services in the prehospital setting) and in the six hours after the ECG; (6) laboratory values (sodium, calcium, glucose, creatinine, CO_2, platelets) obtained on the same lab draw as the K^+ level; (7) whether the patient was an established dialysis patient at the time of the episode of hyperkalemia; and (8) occurrence of a study-defined adverse event in the six hours after the ECG. All charts were reviewed by two reviewers for the presence or absence of an adverse event (BL, AB, JV). Disagreement was resolved by the primary investigator (ND).

We obtained a copy of the ECG performed within one hour of laboratory draw, and prior to treatment. When available, we also obtained a copy of the most recent previous ECG to serve as a baseline. K^+ level was confirmed to be <5.0 mEq/L at time of previous ECG.

We created a separate document containing only the initial ECG, previous ECG (when available) and an event identifier. A second standardized, closed-ended electronic data collection form was used to review all ECGs. All ECGs were reviewed by two experienced board-certified emergency physicians (VL, ES). Both reviewers were blinded to the objectives and methods of the study, the potassium value, associated medical history, clinical information, and all other data collected for the patient. The ECG reviewers were also blinded to the formal interpretation documented by the attending cardiologist, as well as each other's readings. The reviewers independently examined each ECG for rate, rhythm, peaked T wave, PR interval duration, QRS wave duration, and type of intraventricular conduction delay (if present). If the reviewer agreed with the computer-generated values of PR interval and QRS wave duration (in milliseconds), then we used the computer-generated values. To keep the ECG reviewers blinded to the study objective, additional data that did not pertain to the objective of the study (left ventricular hypertrophy, ST elevation, ST depression and/or T wave inversion) were included in the data collection form.

We categorized the ECG as "PR prolongation" if the PR interval was >200 ms, and either there was no previous ECG for comparison or the PR interval was <200 ms on the previous ECG. If the previous ECG had a PR interval >200 ms, then the ECG was categorized as "PR prolongation" if the current PR interval was longer than the previous PR interval. Similarly, we categorized the ECG as "QRS prolongation" if the QRS duration was >110 ms, and either there was no previous ECG for comparison or the QRS duration was <110 ms on the previous ECG. If the previous ECG had a QRS duration of >110 ms, then the ECG was categorized as "QRS prolongation" if the current QRS duration was longer than the previous QRS duration. In the scenario where the ECG reviewers disagreed on the rhythm, type of intraventricular conduction delay, or whether T waves were peaked or not, then we used the attending cardiologist reading.

Outcomes

We categorized ECGs as having "any abnormality suggestive of hyperkalemia" if one or more of the following were present: (1) peaked T waves; (2) PR prolongation; (3) QRS prolongation; (4) bradycardia (HR<50 bpm); (5) 2nd or 3rd degree heart block; (6) junctional rhythm; (7) ventricular escape rhythm; or (8) ventricular tachycardia.

The presence or absence of an adverse event within six hours of the laboratory measurement of a K^+ ≥6.5 mEq/L (regardless of treatment status) was determined. We defined an adverse event as symptomatic bradycardia, ventricular tachycardia, ventricular fibrillation, cardiopulmonary resuscitation (CPR) and/or death. Symptomatic bradycardia was defined as bradycardia

requiring treatment with calcium chloride, calcium gluconate, atropine, epinephrine, dopamine and/or pacing for symptoms of hypotension, syncope, chest pain, dyspnea and/or altered mental status. Calcium chloride or gluconate administered solely for asymptomatic bradycardia, an abnormal ECG or high potassium value was not recorded as an adverse event.

Data Analysis

For the association of short-term adverse events with specific ECG abnormalities, we used the Pearson chi-square statistic. Fisher's exact test was used for analysis involving less than five events. We analyzed each variable separately and calculated relative risk (RR). The relationship of the K^+ value to an ECG with "any abnormality suggestive of hyperkalemia" and to short-term adverse events was determined using binary logistic regression. We included K^+ as a continuous variable in this model. The kappa statistic was calculated to evaluate the level of agreement between ECG reviewers for ECG variables, as well as for the level of agreement between reviewers for adverse events. We ran tests with SPSS (version 22; IBM Corp, Armonk, NY).

RESULTS

The final study group included 188 episodes of severe hyperkalemia (Figure 1). The majority of episodes (n=176, 94%) occurred in the ED. Mean patient age was 68 years (range 21-94 years), 54% were male, and 94% were White (Table 1). All patients had abnormal kidney function. Half of the patients had an estimated glomerular filtration rate of less than 15 mL/min/1.73m^2. Established hemodialysis patients represented 32 (17%) of the 188 patients. Established hemodialysis patients and non-dialysis patients had no significant difference in the frequency of "any ECG abnormality suggestive of hyperkalemia" (RR 1.02, 95% CI [0.81-1.29]) or of short term adverse events ((RR 1.34, 95% CI [0.58-3.06]).

The mean serum K^+ level was 7.1 mEq/L (SD=0.6mEq/L). The distribution of K^+ values is presented in Figure 2. Potassium levels ranged from 6.5-9.3 mEq/L. A plasma K^+ level was obtained on the same laboratory draw as the serum K^+ level in 96 episodes (51%).

The ECG findings are characterized in Table 2. The mean time between the ECG and K^+ lab draw was 18 minutes (SD=14 minutes). Previous ECGs were available for comparison in 123 episodes (65%). There was no statistical difference between the frequency of "any ECG abnormality suggestive of hyperkalemia" in patients with previous ECG available and patients who did not have a previous ECG available (RR 0.92, 95% CI [0.74-1.10]). The RR for adverse events in patients with previous ECG available was comparable to those for the full study population (Appendix).

A total of 134 episodes (71%, 95% CI [64.4%-77.3%]) had "any ECG abnormality suggestive of hyperkalemia," with the two most common findings being QRS prolongation (43%, 95% CI [36.7%-50.8%]) and peaked T waves (30%, 95%

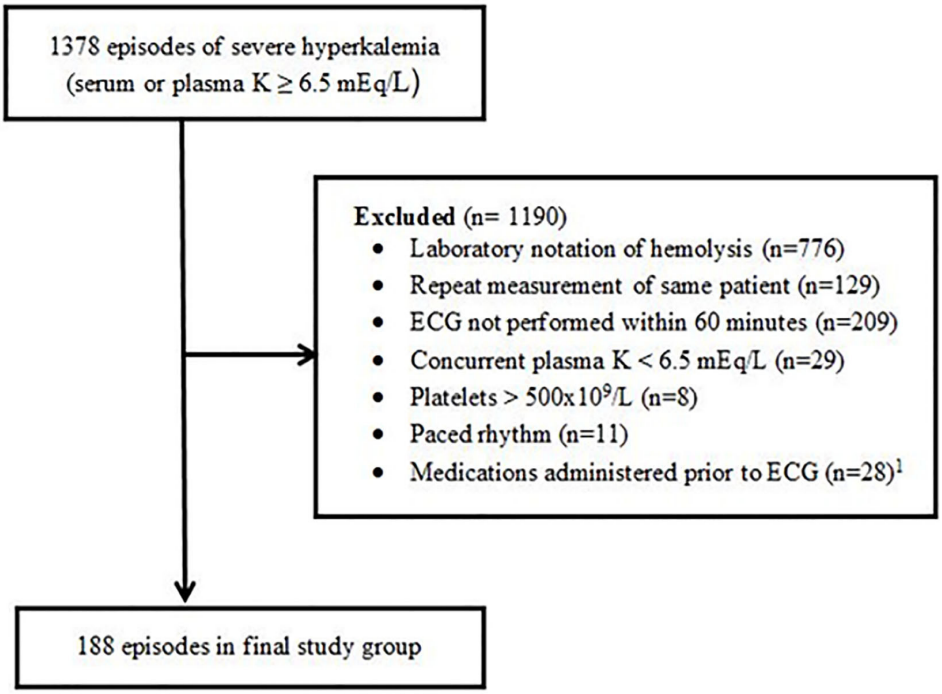

Figure 1. Flow diagram for inclusion in a study examining the association between electrocardiographic (ECG) abnormalities and short-term adverse events in patients with hyperkalemia.
[1] Atropine, dopamine, epinephrine, norepinephrine, vasopressin, calcium chloride, calcium gluconate, sodium bicarbonate, albuterol, insulin, and/or sodium polystyrene sulfonate.
[2] No patients received diuretics, dobutamine, isoproterenol or milrinone.

Table 1. Demographics and laboratory results of patients with severe hyperkalemia (K^+≥6.5 mEq/L).

Patient characteristic	N=188
Demographics	
Age, mean (SD), y	68 (16)
Gender, n (%) male	102 (54)
Race, n (%)	
White	177 (94)
Black	4 (2)
Hispanic	1 (0.5)
Other	6 (3)
Laboratory values, mean (SD)	
Potassium level, mEq/L	7.1 (0.6)
Sodium level, mEq/L	135 (6)
Calcium level, mg/dL*	9.0 (1.0)
Bicarbonate level, mEq/L	19 (9)
Estimated glomerular filtration rate, n, (%)†	
<15 mL/min/1.73m2	94 (50)
15-29 mL/min/1.73m2	64 (34)
30-59 mL/min/1.73m2	28 (15)
60-89 mL/min/1.73m2	2 (1)
≥90 mL/min/1.73m2	0 (0)
Established Hemodialysis	32 (17)

SD, standard deviation.
*Calcium level was not measured in 26 events (14%).
†Estimated glomerular filtration rate was calculated using the MDRD study equation.

CI [24.1%-37.2%]). More than half (n=77, 57%) had only a single hyperkalemic ECG abnormality. Multiple hyperkalemic ECG abnormalities were present in the other 57 episodes (43%), with the most frequent combination of findings being QRS prolongation with peaked T waves.

We identified 28 patients (15%, 95% CI [10.4%-20.7%]) as having had an adverse event within six hours of the measurement of hyperkalemia. The mean K^+ value in patients with an adverse event was 7.5 mEq/L (SD=0.7). Adverse events included symptomatic bradycardia (n=22, 12%), ventricular tachycardia (VT) (n=2, 1%), cardiopulmonary resuscitation (CPR) (n=2, 1%) and death (n=4, 2%). Two patients experienced more than one adverse event. One patient with VT survived after a brief period of CPR. Another patient died after CPR for pulseless electrical activity. Three deaths occurred in patients who did not receive CPR as they were "do not resuscitate." All patients with symptomatic bradycardia or VT improved after treatment with calcium.

The median time from the ECG to the adverse event was 47 minutes. Adverse events occurred either prior to the laboratory notification of hyperkalemia (n=16, 59%) or shortly after the laboratory notification of hyperkalemia (mean 36 min; SD 19 min). All adverse events occurred prior to treatment with calcium, and all but one occurred prior to K^+-lowering intervention. The majority of patients (n=177, 95%) received treatment within the six-hour period. The median time from ECG to treatment was 85 minutes. There was no significant difference in time to treatment between patients with or without adverse event, nor for each particular ECG finding. The rate of adverse events after treatment with calcium was 0% (95% CI [0-4.0%]) and after K^+-lowering intervention was 0.7% (95% CI [<0.01%-3.5%]).

All of the 28 patients with an adverse event within six hours had an ECG with evidence of at least one hyperkalemic abnormality (Table 2). QRS prolongation (n=22) and bradycardia of less than 50 bpm (n=17) were the most common ECG abnormalities identified. Of the patients with QRS prolongation, the average QRS duration was 152 msec (SD 35 msec, range 116-266 msec). The majority of the hyperkalemic patients with an adverse event had more than one hyperkalemic ECG abnormality (n=24, 86%). Two patients had isolated bradycardia (HR<50), one patient had isolated junctional rhythm, and one patient had isolated QRS prolongation. No short-term adverse events occurred among patients with isolated peaked T waves or isolated PR prolongation as their ECG manifestation of hyperkalemia.

QRS prolongation had a statistically significant association with short-term adverse events (RR 4.74, 95% CI [2.01-11.15]), as did the presence of junctional rhythm (RR 7.46, 95% CI [5.28-11.13]). Additionally, bradycardia (HR<50 bpm) had a strong positive association with short-term adverse event (RR 12.29, 95%CI [6.69-22.57]) All patients with a ventricular escape rhythm (n=4) developed a short-term adverse event. There was no statistically significant correlation between peaked T waves and short-term adverse events (RR 0.77, 95% CI [0.35-1.70]). Analysis of the association of PR prolongation and adverse events was limited because the majority of the patients who had a short-term adverse event were in a non-sinus rhythm (junctional rhythm n=11, ventricular escape rhythm n=4, atrial fibrillation n=6, 2nd degree heart block n=1). Of the six patients with short-term adverse events who could have a PR interval measured, three patients had PR prolongation.

We calculated the interrater reliability with a kappa value of 1.0 for PR prolongation and QRS prolongation; 0.662 for peaked T waves, 0.716 for rhythm analysis, 0.870 for type of block, and 0.822 for "any abnormality suggestive of hyperkalemia." The interrater reliability for the presence or absence of a short-term adverse event was strong (kappa 0.870).

DISCUSSION

This paper is the largest study to date to report the relationship of specific ECG abnormalities to short-term adverse events in patients with severe hyperkalemia

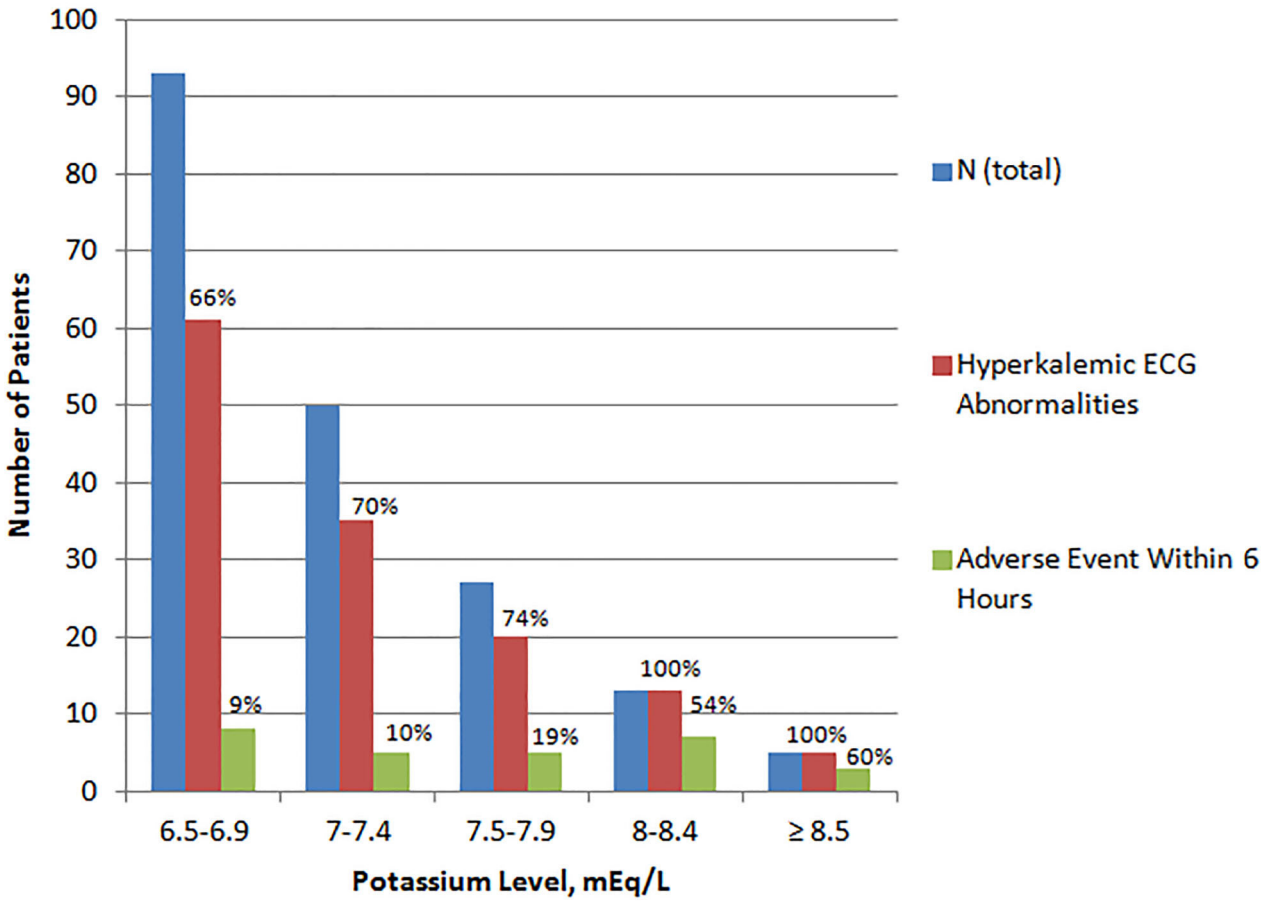

Figure 2. Hyperkalemic electrocardiographic (ECG) abnormalities and six-hour adverse events in patients with severe hyperkalemia (K^+≥6.5 mEq/L). Potassium level was predictive of having "any ECG abnormality suggestive of hyperkalemia" (OR 2.71, 95% CI [1.31-5.59]) and of adverse event within six hours (OR 3.35, 95% CI [1.72-6.53]). We have not adjusted for potentially relevant covariates.

(K^+≥6.5 mEq/L). Short-term adverse events occurred in 15% of patients (95% CI [10.4%-20.7%]). All patients who experienced a short-term adverse event had a preceding ECG that demonstrated at least one hyperkalemic abnormality. An increased likelihood of short-term adverse event was found for hyperkalemic patients whose ECG demonstrated QRS prolongation, bradycardia (HR<50), and/or junctional rhythm.

Previous research has demonstrated that ECG abnormalities and adverse events typically occur in hemodialysis patients at higher serum K^+ levels than those with preserved renal function.[9,19] In our study, there was no statistical difference between the frequency of hyperkalemic ECG abnormalities and adverse events in established hemodialysis patients and non-dialysis patients. We suggest that this lack of distinction between the two groups derives from the high rate of severe renal impairment (81%) in our study's non-dialysis patients.

To our knowledge, prior to our publication only two other studies have reported the relationship between ECG findings of hyperkalemia and the development of adverse events.[11,16] Our study methods were designed to minimize limitations in two similar designs.

In An's study of patients with K^+≥6.5 mEq/L, ECG findings were correlated with survival to hospital discharge.[16] In comparison with our study, An's study did not focus on the use of the ECG for risk stratification of hyperkalemic patients. The most common ECG finding of hyperkalemia was "asystole or pulseless electrical activity," a reflection of the fact that 20% of the hyperkalemic patients were diagnosed at time of cardiac arrest. In addition, the time from ECG to death was not reported. A significant lapse of time between the ECG and death is suggested by the report that almost half (47%) of patients were not hyperkalemic at the time of their death.

In Montague's study of 90 patients with K≥6.0 mEq/L, 14 patients experienced arrhythmia or cardiac arrest.[11] Fewer than half of the patients with arrhythmia or cardiac arrest were noted to have new T-wave peaking or symmetry. Montague's finding is consistent with our observation that only 25% of patients with short-term adverse events had peaked T waves. However, this study did not discuss the presence or absence of other hyperkalemic ECG manifestations (such as bradycardia, junctional rhythm, PR prolongation, QRS prolongation) in the study population.

Table 2. Electrocardiographic (ECG) findings in patients with severe hyperkalemia.

Characteristic	No adverse event (n=160,%)	Adverse event (n=28,%)	Total (n=188,%)	Relative risk for adverse event (95% CI)
Any ECG abnormality suggestive of hyperkalemia	106 (66)	28 (100)	134 (71)	‡
Peaked T waves	50 (31)	7 (25)	57 (30)	0.77 (0.35-1.70)
PR prolongation†	25 (18)	3 (50)	28 (20)	4.11 (0.88-19.28)
QRS prolongation	60 (38)	22 (79)	82 (43)	4.74 (2.01-11.15)*
Mild QRS prolongation (111-119 msec)	13 (8)	2 (7)	15 (8)	
Left bundle branch block	8 (5)	3 (11)	11 (6)	
Right bundle branch block	17 (11)	10 (36)	27 (14)	
Nonspecific intraventricular conduction delay	22 (14)	7 (25)	29 (15)	
Bradycardia (HR<50 bpm)	4 (3)	17 (61)	21 (11)	12.29(6.69-22.57)*
Junctional rhythm	4 (3)	11 (39)	15 (8)	7.46 (4.32-12.87)*
Ventricular escape rhythm	0 (0)	4 (14)	4 (2)	7.67 (5.28-11.13)*
Ventricular tachycardia	NA	2 (7)	2 (1)	NA
2nd Degree heart block	0 (0)	1 (4)	1 (0.5)	6.92 (4.88-9.82)
3rd Degree heart block	0 (0)	0 (0)	0 (0)	NA

Patients may have had more than one hyperkalemic ECG abnormality.
†PR interval measured in 143 episodes (137 episodes without adverse event and 6 episodes with adverse event). PR interval was unable to be measured in 45 episodes due to non-sinus rhythm.
‡ Relative risk unable to be calculated as no adverse events occurred in patients without ECG abnormality suggestive of hyperkalemia
* $p<0.05$

In contrast to An and Montague's methods, no patients in this study experienced a cardiac arrest prior to or during the performance of the ECG. We examined multiple ECG manifestations of hyperkalemia. All adverse events occurred within six hours of the ECG, with a median time from ECG to adverse event of 47 minutes.

In our study, all patients who experienced a short-term adverse event had a preceding ECG that demonstrated hyperkalemic abnormality (100%, 95% CI [85.7-100%]). In fact, the majority of the hyperkalemic patients with a short-term adverse event had more than one hyperkalemic ECG abnormality (86%). However, the small number of adverse events in our study resulted in CIs that were too broad to conclude that hyperkalemia patients without ECG abnormalities do not have short-term adverse events.

Three quarters of patients with short-term adverse events did not have peaked T waves, and there was no statistically significant correlation between the presence of peaked T waves and the development of a short-term adverse events. These findings contradict classic teaching. Texts and papers tend to emphasize peaked T waves as the ECG manifestation of hyperkalemia in their illustrations and research design.[11,17-19] In contrast, our study identified QRS prolongation (RR 4.74, 95% CI [2.01-11.15]), junctional rhythm (RR 7.46, 95% [5.28-11.13]), and bradycardia of less than 50 bpm (RR 12.29, 95% CI [6.69-22.57]) as the ECG manifestations of hyperkalemia associated with short-term adverse events.

Interestingly, all adverse events in our study occurred prior to treatment with calcium, and all but one occurred prior to K^+-lowering intervention. There was no significant difference in time to treatment between patients with or without adverse events. Rather, adverse events occurred either prior to the laboratory notification of hyperkalemia (n=16, 59%) or shortly after the laboratory notification of hyperkalemia (mean 36 min; SD 19 min). One potential application of our study results would be the use of the ECG for early identification of patients who are at higher risk of adverse events. These patients could then be prioritized to rapid treatment (either empirically if clinical suspicion for hyperkalemia is high or after laboratory notification if hyperkalemia was not clinically suspected).

Our findings suggest that the ECG is a useful tool in the stratification of hyperkalemic patients into higher and lower risk groups. This study is the first step in creating a predictive tool for the use of the ECG to identify which hyperkalemic patients are at risk for adverse events.

LIMITATIONS

The lack of racial/ethnic diversity in our study sample (94% White) may limit the applicability of our findings to more diverse populations.

Severely hyperkalemic patients frequently have additional metabolic abnormalities and these can also affect the ECG. Concurrent metabolic disturbances thought to worsen the ECG manifestations of hyperkalemia (hypocalcemia, hyponatremia, acidemia) were more common in our study than metabolic disturbances thought to lessen the ECG manifestations of hyperkalemia (hypercalcemia, hypernatremia, alkalemia).[2] These patients' ECGs can also be affected by underlying cardiac disease. We performed comparison to previous ECG to decrease the effect of baseline ECG abnormalities. Previous ECG was unavailable in 35% of patients. However, we observed no difference between the frequency of hyperkalemic ECG abnormality between patients with or without a previous ECG.

While the ECG readers were blinded to the study methods and objective, the high number of ECGs with hyperkalemic abnormalities, along with a lack of non-hyperkalemic controls, could have led the ECG readers to suspect that the study population contained patients with hyperkalemia.

Our definition of symptomatic bradycardia required both treatment and symptoms. Symptomatic bradycardia may have been underestimated because symptoms may have been present but not recorded in the medical record. All patients treated with atropine, epinephrine, dopamine and/or pacing had recorded symptoms and were classified as symptomatic bradycardia. Four patients were identified who were treated with calcium and had a documented HR of <50bpm within six hours, but were asymptomatic and therefore not classified as an adverse event. All four of these patients had an ECG with hyperkalemic abnormalities.

Patients may have had both severe hyperkalemia and additional acute medical illnesses. The influence of concurrent acute medical illness on the occurrence of adverse events in this study is unknown. However, the majority of patients who experienced an adverse event improved with calcium treatment, suggesting that hyperkalemia was the primary etiology.

Almost all patients (95%) received treatment and the timing and type of treatment was not standardized. Treatment differences had the potential to confound the associations between specific ECG abnormalities and adverse events. However, this was not observed. All adverse events occurred prior to treatment with calcium, and all but one occurred prior to K^+-lowering intervention. There was no significant difference in time to treatment between patients with or without adverse event, nor for each particular ECG finding. Time to treatment was consistent with previous study of hyperkalemia treatment practices.[8]

CONCLUSION

Our findings support the use of the ECG in the risk stratification of patients with severe hyperkalemia. All hyperkalemic patients in our sample who experienced a short-term adverse event had a preceding ECG that demonstrated at least one hyperkalemic abnormality. An increased likelihood of short-term adverse event was found for hyperkalemic patients whose ECG demonstrated QRS prolongation, bradycardia (HR<50), and/or junctional rhythm. These data could be used to create a predictive tool to identify which hyperkalemic patients are at risk for adverse events based on ECG findings.

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Duration of Mechanical Ventilation in the Emergency Department

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Introduction: Due to hospital crowding, mechanically ventilated patients are increasingly spending hours boarding in emergency departments (ED) before intensive care unit (ICU) admission. This study aims to evaluate the association between time ventilated in the ED and in-hospital mortality, duration of mechanical ventilation, ICU and hospital length of stay (LOS).

Methods: This was a multi-center, prospective, observational study of patients ventilated in the ED, conducted at three academic Level I Trauma Centers from July 2011 to March 2013. All consecutive adult patients on invasive mechanical ventilation were eligible for enrollment. We performed a Cox regression to assess for a mortality effect for mechanically ventilated patients with each hour of increasing LOS in the ED and multivariable regression analyses to assess for independently significant contributors to in-hospital mortality. Our primary outcome was in-hospital mortality, with secondary outcomes of ventilator days, ICU LOS and hospital LOS. We further commented on use of lung protective ventilation and frequency of ventilator changes made in this cohort.

Results: We enrolled 535 patients, of whom 525 met all inclusion criteria. Altered mental status without respiratory pathology was the most common reason for intubation, followed by trauma and respiratory failure. Using iterated Cox regression, a mortality effect occurred at ED time of mechanical ventilation > 7 hours, and the longer ED stay was also associated with a longer total duration of intubation. However, adjusted multivariable regression analysis demonstrated only older age and admission to the neurosciences ICU as independently associated with increased mortality. Of interest, only 23.8% of patients ventilated in the ED for over seven hours had changes made to their ventilator.

Conclusion: In a prospective observational study of patients mechanically ventilated in the ED, there was a significant mortality benefit to expedited transfer of patients into an appropriate ICU setting. [West J Emerg Med. 2017;18(5)972-979.]

INTRODUCTION

Hospital crowding, leading to boarding patients in the emergency department (ED), is a common problem nationwide with crowding reported in 90% of EDs, 40% of which report crowding on a daily basis.[1] Boarding is a particular problem for patients awaiting intensive care unit (ICU) beds; the American Hospital Association (AHA) reports an average ED boarding time of six hours for critically ill patients in crowded EDs.[2] Multiple studies worldwide have illuminated the detrimental effect of ED crowding on patient outcomes and mortality.[2-8] Delay in transfer of mechanically ventilated patients from the ED to the ICU has been associated with higher in-patient mortality and longer hospital length of stay (LOS).[2,8,9]

With the aging population and advances in care of chronic medical conditions, ED crowding and the need to manage critically ill patients in the ED will continue to increase. Previously, urban EDs have been shown to provide up to 150 days of critical care time per year, and this trend is increasing.[1,10] One prior retrospective review of a national database of ED visits found ED LOS for critically ill patients has been increasing by 7% per year.[11] ED staffing and organization are generally not conducive to delivering the personalized care critically ill patients require. Emergency physicians (EP) have limited time for ongoing management of critically ill patients, and ED nurses are rarely staffed at the 1:1 or 1:2 nurse-to-patient ratio common in most ICU settings. Additionally, the population of patients needing prolonged acute mechanical ventilation (defined as >96 hours) is projected to grow at a rate of 5.5% per year. [12]

Although the first hours of management in a critically ill patient can be pivotal in terms of outcome,[13-16] many patients in the ED, including those with acute respiratory distress syndrome (ARDS), are not ventilated with lung-protective ventilation,[17-19] and the majority of patients have no changes made to their ventilators while in the ED.[18,19] Every hour of additional mechanical ventilation in the ED has been associated with a 20% increased risk of developing pneumonia in blunt trauma patients.[20] Therefore, we performed a prospective, observational study of mechanically ventilated patients boarding in the ED, awaiting admission to an ICU bed. We hypothesized that those patients with a longer duration of mechanical ventilation in the ED would have increased in-hospital mortality, longer duration of mechanical ventilation, and longer ICU and hospital LOS.

Population Health Research Capsule

What do we already know about this issue?
Extended boarding in the emergency department (ED) has been associated with increased morbidity and mortality.

What was the research question?
Is there an association between duration of ventilation in mechanically ventilated patients boarding in the ED with mortality?

What was the major finding of the study?
Older patient age and intubation for neurologic issues were independently associated with increased mortality.

How does this improve population health?
Triaging high-risk patients for transfer to the ICU and increased attention to ventilator management in the ED may improve patient outcomes.

METHODS

This was a multi-center, prospective, observational cohort study of patients ventilated in the ED, conducted at three academic emergency departments in the United States from July 2011 to March 2013. All three EDs are Level I Trauma Centers with over 100,000 ED visits a year, staffed with board-certified EPs and emergency medicine residents. All consecutive adult patients on invasive mechanical ventilation via an endotracheal tube or tracheostomy tube were eligible for enrollment. Exclusion criteria included death upon arrival or during ED course, or direct transfer to the operating room (OR) from the ED. We also excluded patients who did not have complete documentation regarding the duration of time ventilated in the ED and ED LOS.

Patients were screened and enrolled upon presentation to the ED while receiving invasive mechanical ventilation or after intubation in the ED. Patients were prospectively screened by trained research assistants (RAs) seeking patients receiving invasive mechanical ventilation on presentation to the ED or after intubation in the ED at each of the three study sites. RAs then enrolled the patients presenting during the hours of RA presence in the ED, collecting all data regarding demographics, indication for intubation and ventilation, initial ventilator settings, any changes made to ventilator settings, and blood gas data. RAs also collected data from the remainder of the hospitalization for each enrolled patient, including ventilator days, ICU LOS, hospital LOS, and mortality. RAs worked closely with respiratory therapists at each center to collect all ventilator settings and changes. Data monitoring was performed by each site's local primary investigator. This study was funded in part by a university development grant, and the study duration and sample size was determined by convenience sampling during the grant funding period.

To assess the effects of duration of mechanical ventilation in the ED, rather than entire ED LOS, we defined the time ventilated in the ED as the time of presentation to the ED for those initiated on ventilation prior to arrival, or the time of intubation, for the remainder of patients, until the time of ICU admission. Patients were classified by the indication for intubation including altered mental status with no overt respiratory pathology, trauma, cardiac arrest, respiratory failure, neurologic events, and other causes. We defined subgroups of interest by the most common indications for intubation, including altered mental status, trauma, and respiratory failure. We included any recorded modification of ventilator settings as a change in settings, from changing the mode to decreasing the fraction of inspired oxygen. Lung protective ventilation was defined as a tidal volume of 8mL/kg or less of predicted body weight, with full details published previously.[19] (See Appendix A.)

The time of intubation, time of transfer to an ICU, admitting ICU, duration of mechanical ventilation, ICU LOS, hospital LOS, and in-hospital mortality were recorded. Our primary outcome was in-hospital mortality, with secondary outcomes of ventilator days, ICU and hospital LOS. To reduce the risk of survivor bias, we excluded patients who died from the secondary outcome analyses.

Institutional review boards for all participating institutions approved the study protocols with waiver for informed consent.

Data were input into Microsoft Excel (Microsoft Corp., Redmond, WA) and then transferred to SPSS (version 21.0, IBM Corp, Armonk, NY) for statistical analysis. We visually inspected data and excluded missing data on a case-by-case basis. The effect of duration of mechanical ventilation in the ED on in-hospital mortality was analyzed by univariate Cox regression analysis. Specifically, we assessed a significant effect of duration of mechanical ventilation in the ED on mortality via iterative analyses using hour-based time points, such as <4 hours, <5 hours, in a stepwise fashion.

We performed descriptive analyses of relevant clinical outcomes for the entire cohort, as well as for patients ventilated in the ED for less than and more than seven hours. Continuous variables are reported as means and standard deviations (SD), and categorical variables are reported as numbers and percentages. The frequency of ventilator changes made among subgroups classified by indication for intubation was compared by chi-squared analyses. We assessed differences between continuous variables using single-factor ANOVA, while categorical variables were determined by chi-square testing or two-sided Student's T test with unequal variance as appropriate. Two-tailed Pearson's correlations were performed to assess for simple associations between clinical parameters and outcomes of interest. We performed multivariable regression analyses to assess for independent associations between clinical and patient parameters and mortality. An alpha of less than 0.05 was considered statistically significant for all analyses.

RESULTS

We enrolled 535 patients. Ten were excluded as their times in the ED were not fully documented, leaving 525 patients for final analysis (n=525). Sixty percent of patients were male and the average age was 55.6 years (range 18 to 96 years) (Table 1). Sixty-one percent of patients were intubated in the ED, with the remaining 39% intubated prior to arrival. Altered mental status without respiratory pathology was the most common reason for intubation (38.3%), followed by trauma (23.2%) and respiratory failure (17.1%). The primary disposition for patients was a medical ICU (52.7%), with 23.7% being admitted to a surgical/trauma ICU (STICU), and 16.3% to a neurosciences ICU. The mean duration of mechanical ventilation in the ED in this cohort was 4 hours and 28 minutes, with SD of 4 hours and 18 minutes.

Univariate Cox regression analysis demonstrated a significant increase in mortality with duration of mechanical ventilation for all time points of more than seven hours of mechanical ventilation in the ED. The hazard ratio (HR) for mortality for >7 hours of mechanical ventilation in the ED was 1.31 (95% confidence intervals [CI] [1.03-1.70], $P < 0.001$), and the HR remained significant for all time points greater than seven hours (Figure).

Of the 525 patients enrolled, 461 were ventilated in the ED for less than seven hours, and 64 were ventilated in the ED for greater than seven hours (Table 1). The cohort of patients ventilated for less than seven hours was younger and more likely to be ventilated for cardiac arrest or airway edema, although the numbers of patients intubated for these indications were small, with 34 total for cardiac arrest and 12 with airway edema (Table 1).

Patients in the greater-than-seven-hour group were more likely to receive initial lung protective ventilation, yet they were less likely to have any changes made to their ventilator during their time in the ED. More patients in the less-than-seven-hour group were admitted to the STICU, and more patients in the greater-than-seven-hour group were admitted to the neuro ICU.

Patients who remained ventilated in the ED greater than seven hours had significantly higher in-hospital mortality at 45.9% versus 29.4% (p=0.018) for those who were ventilated in the ED for less than seven hours (Table 2).

The greater-than-seven-hour group also had a longer duration of mechanical ventilation, at 4.8 days compared to 2.5 days, (p=0.011). ICU LOS and hospital LOS did not differ significantly between the two groups.

The frequency of lung protective ventilation was not significantly different between any of the subgroups, including patients intubated for altered mental status vs. respiratory failure (P=0.22), trauma vs. respiratory failure (P=0.14), or altered mental status vs. trauma (P=0.66). Both the subgroups of patients intubated for altered mental status and those intubated for trauma had a higher rate of ventilator changes

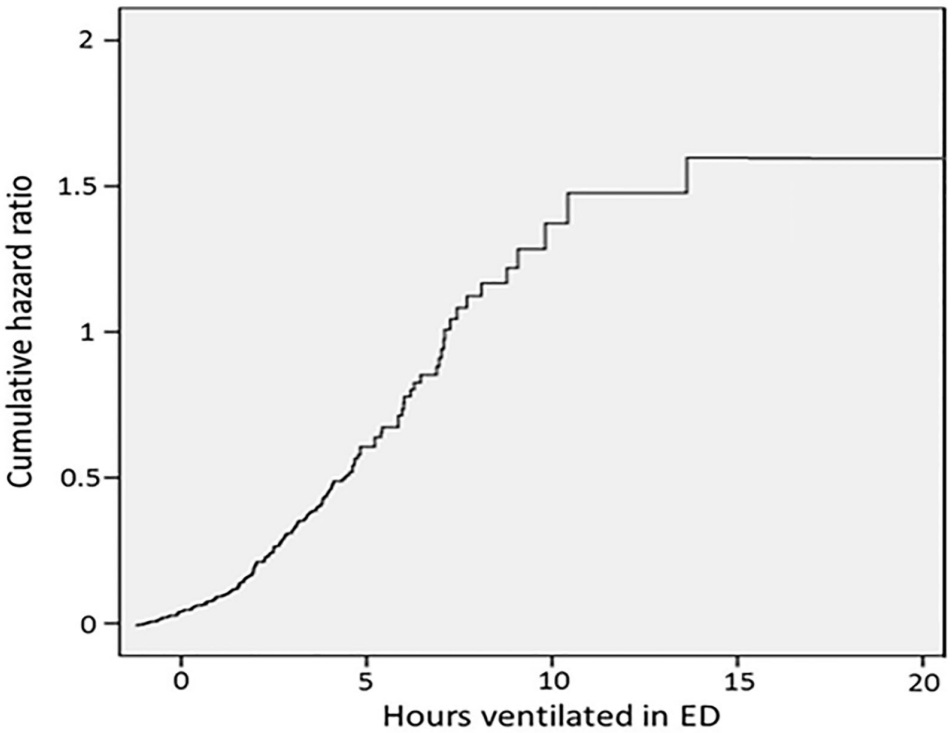

Figure. The study sample size and distribution of duration of mechanical ventilation in the ED were insufficiently powered to perform Cox regression for time points of less than four hours.

Table 1. Demographics of patients enrolled in a study of the association between duration of mechanical ventilation in the emergency department and in-hospital mortality.

Variable	Total (n=525)	Less than 7 hours (n=461)	More than 7 hours (n=64)	p value
Male patients n (%)	313 (59.6)	308 (66.9)	36 (56.3)	0.922
Mean age (years [IQR])	55.6 [41.7-69.2]	54.6 [41.5-67.8]	63.5 [50.2-78.4]	<0.001
Patients intubated in the ED n (%)	320 (60.9)	281 (61.0)	37 (57.8)	0.646
Indication for intubation n (%)				
AMS	201 (38.3)	179 (38.8)	22 (34.4)	0.480
Trauma	122 (23.2)	104 (22.6)	18 (28.1)	0.360
Respiratory failure	90 (17.1)	79 (17.1)	11 (17.2)	0.998
ICH or seizure	51 (9.7)	41 (8.9)	10 (15.6)	0.163
Cardiac arrest	34 (6.5)	33 (7.2)	1 (1.6)	0.005
Airway edema	12 (2.3)	12 (2.6)	0 (0)	<0.001
Other	15 (2.9)	13 (2.8)	2 (3.1)	0.824
Management of ventilation in the ED				
Lung protective ventilation n (%)	345(65.8)	296 (64.3)	49 (76.2)	0.047
Any ventilator changes while in ED n (%)	115 (21.9)	107 (23.2)	8 (12.5)	0.022
Disposition n (%)				
Medical ICU	277 (52.7)	245 (53.2)	31 (49.2)	0.559
Surgical trauma ICU	124 (23.7)	115 (24.9)	9 (14.3)	0.032
Neuro ICU	86 (16.3)	66 (14.4)	19 (30.2)	0.011
Cardiovascular ICU	38 (7.3)	34 (7.4)	4 (6.3)	0.744

ED, emergency department; *ICU*, intensive care unit; *IQR*, interquartile range; *AMS*, altered mental status; *ICH*, intracranial hemorrhage.

Table 2. Outcomes for patients mechanically ventilated in the ED for greater or less than seven hours.

Time ventilated in the ED	< 7 hours	> 7 hours	p value
Mortality (%)	29.4	45.9	0.018
Duration of mechanical ventilation (days)	2.5	4.8	0.011
ICU length of stay (days)	5.2	7.2	0.227
Hospital length of stay (days)	14.0	14.9	0.831

ED, emergency department; *ICU*, intensive care unit.

in the ED compared to those intubated for respiratory failure (28.4% versus 13.3%, P=0.002 and 25.4% versus 13.3%, P=0.03, respectively). There was no statistically significant difference between altered mental status and trauma patients (P=0.56).

For the subgroup of patients intubated for altered mental status, those patients ventilated in the ED > 7 hours were associated with an overall longer duration of ventilation, at 5.81 to 1.5 days, (p=0.05) (Table 3).

The extended duration of ventilation in the ED of over seven hours was also associated with significantly increased mortality in trauma patients (43.8% vs. 15.2%, P= 0.046) and patients with respiratory failure (72.7% vs. 32.9%, P=0.02).

Age, use of lung protective ventilation, changes made to ventilator settings in the ED, admission to the neurosciences ICU, admission to the STICU, and duration of mechanical ventilation were assessed as independent variables for their effect on in-hospital mortality. As the intubation for cardiac arrest group had only one patient in the greater-than-seven-hour cohort, and there were no patients who remained in the ED for greater than seven hours for airway edema, these factors were excluded from further analysis. Multivariate analysis demonstrated that age and admission to the neurosciences ICU, with an odds ratio of 2.210 (95% CI 1.286-3.800, P= 0.004) were independently associated with mortality (Table 4).

Bivariate two-tailed Pearson correlations demonstrated moderate positive correlation for death and age ($\rho = 0.33$, $P<0.001$) and weak correlation for death and admission to the neurosciences ICU ($\rho = 0.18$, $P<0.001$). Weak but significant negative correlations were determined for death and admission to the STICU ($\rho = -0.14$, $P = 0.002$) and mechanical ventilation of >7 hours in the ED ($\rho = -0.12$, $P = 0.009$). All other correlations were not significant.

Table 3. Outcome sub-group analyses.

Subgroup variables	< 7 hours	> 7 hours	p value
Altered mental status			
Lung protective ventilation (%)	62.6	90.9	<0.001
Any ventilator changes while in ED (%)	30.7	9.1	0.005
Mortality (%)	26.0	30.0	0.711
Mechanical ventilation duration (days)	1.5	5.81	0.050
ICU length of stay (days)	3.79	7.40	0.442
Hospital length of stay (days)	10.65	13.58	0.431
Trauma			
Lung protective ventilation (%)	68.3	66.7	0.898
Any ventilator changes while in ED (%)	26.0	22.2	0.736
Mortality (%)	15.2	43.8	0.046
Mechanical ventilation duration (days)	3.01	4.52	0.714
ICU length of stay (days)	6.98	6.77	0.972
Hospital length of stay (days)	16.0	8.7	0.039
Respiratory failure			
Lung protective ventilation (%)	55.8	72.7	0.286
Any ventilator changes while in ED (%)	13.9	9.1	0.633
Mortality (%)	32.9	72.7	0.020
Mechanical ventilation duration (days)	3.29	2.70	0.880
ICU length of stay (days)	5.22	11.1	0.104
Hospital length of stay (days)	15.5	26.8	0.305

ED, emergency department; *ICU*, intensive care unit.

Table 4. Multivariable regression analysis demonstrating association between age and admission to the neurosciences ICU.

Variable	Odds ratio for mortality (95% confidence intervals)	p value
Age	0.962 (0.950-0.974)	<0.001
Use of lung protective ventilation	0.860 (0.554-1.334)	0.500
Ventilator changes in the ED	1.036 (0.608-1.765)	0.896
Admission to Neuro ICU	2.210 (1.286-3.800)	0.004
Admission to the STICU	0.837 (0.475-1.476)	0.539
Duration of mechanical ventilation (>7 hours or <7 hours)	1.463 (0.796-2.690)	0.221

ED, emergency department; *ICU*, intensive care unit.

DISCUSSION

This study is the first prospective, multi-center, observational study assessing outcomes associated with duration of mechanical ventilation in the ED. The increased mortality correlated with a duration of mechanical ventilation in the ED of over seven hours in this cohort is consistent with prior retrospective studies[21] and recommended quality benchmarks,[8] including those focused on critically ill or ventilated patients, finding that an ED LOS over six hours is associated with worse outcomes. A retrospective cross-sectional analysis of the IMPACT database conducted by Chalfin et al., found both increased mortality and increased hospital LOS in critically ill ED patients whose transfer to the ICU was delayed over six hours.[2] Similarly, Hung and colleagues found that a greater-than-four-hour ED LOS for mechanically ventilated patients increased the 21-day mortality in their single center, retrospective cohort.[8] The importance of these findings is put into perspective when considering that the AHA reports a mean wait of six hours for an ICU bed in crowded EDs,[2] and this is supported by other studies.[22] The ED LOS in this study was similar to these reports, over five hours, with a mean duration of ventilation of over 4.5 hours. A minority of patients, approximately one in eight, were ventilated for over seven hours in the ED.

The two groups in this study were not equivalent, as patients waiting in the ED for over seven hours were older and were more likely to be admitted to the neurosciences ICU, while the less-than-seven-hour group included more patients admitted to the STICUs. In multivariate analysis, only older age and admission to the neurosciences ICU were independently associated with increased mortality. These results demonstrate that while increased ED boarding time is a confounder for mortality, boarding time was not independently significantly associated with mortality in this cohort. Increased ED boarding time may have effects in a broader population, however, and future studies assessing the role of boarding time as a contributor to or confounder of mortality are necessary.

However, the observation that patients with neurologic emergencies and those who were older were more likely to board in the ED while ventilated, while younger patients and those admitted to the STICU had shorter ED ventilation times, is an important finding. Patients with neurologic injuries require close monitoring of mechanical ventilation and hemodynamics, and multiple studies have shown that these patients have a significantly lower mortality rate when cared for in a dedicated neurocritical care unit.[23,24] Additionally, older age has been independently associated with increased mortality in the ICU.[25,26] Therefore, the findings of this investigation support the importance of transferring ventilated patients with neurologic injury and older patients to the ICU as soon as possible.

We previously reported that despite prolonged duration of ventilation in the ED, only 22.2% of patients in a subgroup of this cohort had any ventilator changes made in the ED, with the majority of those changes being adjustments to the respiratory rate and FiO2.[19] Of patients initially ventilated without lung protective ventilation, only 7% were changed to lung protective settings in the ED. These results, consistent with prior studies of ventilation in the ED,[18] suggest that once ventilator settings are selected in the ED, adjustments to the ventilator are infrequent and often trivial. One may anticipate that those patients who board the longest would be more likely to have changes made to their ventilator while waiting in the ED, but our findings were the converse. Twice as many patients in the less-than-seven-hour group had ventilator changes as compared to the greater-than-seven-hour group, despite the prolonged ED boarding time. Interestingly, the subgroups intubated for altered mental status and trauma were also more likely to have changes made to their ventilators as compared to those intubated for respiratory failure. Yet in our cohort, patients intubated with respiratory failure who ventilated in the ED for over seven hours had a mortality rate of approximately 73%, compared to 33% for those ventilated less than seven hours.

Emergency medicine residents[27] and EPs[28] have expressed relative discomfort with management of mechanical ventilation, and the majority surveyed cede responsibility for ventilator management to respiratory therapists.[27,28] Whether these factors, especially in patients with respiratory failure or neurocritical care patients who require close monitoring, account for the observed increase in mortality is unknown.

Numerous hospital and healthcare system factors may impact ED LOS,[29] and these factors may also impact the care provided to patients boarding in the ED. Although EDs have seen consistent increases in volume and patient acuity,[30-34] the number of ED beds and acute-care hospital beds have declined over the last two decades,[35,36] leading to more boarding of ever higher acuity patients. Intensivist and ICU nursing shortages hinder efficient transfer of patients to ICUs and prohibit early intensivist involvement in the care of critically ill patients. A recent study found that ICU crowding, with ICUs functioning at greater than 20% above the average annual census, was associated with an increased ED LOS.[29] With these dual factors of increasing acuity with worsening crowding, the incidence of mechanically ventilated patients in the ED is growing[37] and their LOS in the ED is increasing.[22] EPs, therefore, may be primarily responsible for prolonged management of mechanically ventilated patients.[22,32,33] Future efforts should jointly focus on increasing EPs' knowledge of and comfort with managing ventilated patients, while simultaneously working to remove barriers for expeditious ICU admission.

The creation of an ED-based ventilator care bundle, as proposed by Easter and colleagues,[9] may impact mortality and morbidity in this cohort with widespread implementation. A ventilator care bundle could be automated after intubation in the ED and could include such measures as elevation of head of bed, an arterial blood gas within 30 minutes of intubation and post-intubation chest radiography. A randomized trial comparing implementation of standardized post-intubation care to routine care in the ED would be of great interest. Notably, Fuller and colleagues recently published results of a quasi-experimental trial using an ED ventilator protocol for patients with ARDS finding their protocol to be feasible and associated with increased ventilator-free days and decreased mortality.[38]

LIMITATIONS

As an observational study, our findings have several limitations. Additionally, only correlative associations could be made while causal relationships could not be determined. Multiple confounding factors may have significantly impacted the results, and the effect of confounders could not be determined based on the available data. We did not have ASA scoring or APACHE scores for this cohort to compare severity of illness between the groups. Triage decisions may have impacted the outcomes, as patients with potentially reversible causes of critical illness may have been dispositioned more rapidly to receive definitive care. Our data reflect a greater proportion of patients with neurologic conditions in the > 7 hour group, possibly signifying a perceived unfavorable prognosis at the onset. Nearly 40% of our patients were intubated prior to ED arrival. Although ED transport time is minimal in urban settings,[39] this may have confounded our data set. Due to limitations in funding, these patients represent a convenience sample, and this sampling may have impacted the results.

CONCLUSION

In this cohort, there was a significant reduction in mortality and the total duration of mechanical ventilation associated with duration of mechanical ventilation in the ED of less than seven hours, although there were no differences in ICU or hospital LOS. Older age and admission to the neurosciences ICU were independently associated with increased mortality. Few patients had changes to their ventilator settings while boarding in the ED, and those who waited the longest were actually least likely to have any changes made. Although these patients may benefit most from prompt transfer to an ICU, crowding and limited resources currently limit this option. Therefore, the creation of a ventilator care bundle in the ED, with increased attention to ventilator management, may be a feasible way to impact patient outcomes.

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ADVANCED

WHEN	WHAT	WHERE
SATURDAY SEPTEMBER 23	CALIFORNIA ACEP'S ANNUAL ASSEMBLY	THE WESTIN PASADENA