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Western Journal *of* Emergency Medicine:
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Implementation of a Rapid, Protocol-based TIA Management Pathway

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Introduction: Our goal was to assess whether use of a standardized clinical protocol improves efficiency for patients who present to the emergency department (ED) with symptoms of transient ischemic attack (TIA).

Methods: We performed a structured, retrospective, cohort study at a large, urban, tertiary care academic center. In July 2012 this hospital implemented a standardized protocol for patients with suspected TIA. The protocol selected high-risk patients for admission and low/intermediate-risk patients to an ED observation unit for workup. Recommended workup included brain imaging, vascular imaging, cardiac monitoring, and observation. Patients were included if clinical providers determined the need for workup for TIA. We included consecutive patients presenting during a six-month period prior to protocol implementation, and those presenting between 6-12 months after implementation. Outcomes included ED length of stay (LOS), hospital LOS, use of neuroimaging, and 90-day risk of stroke or TIA.

Results: From 01/2012 to 06/2012, 130 patients were evaluated for TIA symptoms in the ED, and from 01/2013 to 06/2013, 150 patients. The final diagnosis was TIA or stroke in 45% before vs. 41% after (p=0.18). Following the intervention, the inpatient admission rate decreased from 62% to 24% (p<0.001), median ED LOS decreased by 1.2 hours (5.7 to 4.9 hours, p=0.027), and median total hospital LOS from 29.4 hours to 23.1 hours (p=0.019). The proportion of patients receiving head computed tomography (CT) went from 68% to 58% (p=0.087); brain magnetic resonance (MR) imaging from 83% to 88%, (p=0.44) neck CT angiography from 32% to 22% (p=0.039); and neck MR angiography from 61% to 72% (p=0.046). Ninety-day stroke or recurrent TIA among those with final diagnosis of TIA was 3% for both periods.

Conclusion: Implementation of a TIA protocol significantly reduced ED LOS and total hospital LOS. [West J Emerg Med. 2018;19(2)216-223.]

Population Health Research Capsule

What do we already know about this issue?
Patients with transient ischemic attack (TIA) are often admitted. Some studies have suggested that ED observation units can provide appropriate care more efficiently.

What was the research question?
What would be the impact on patients' length of stay and outcomes if we were to implement a TIA protocol incorporating an ED observation unit?

What was the major finding of the study?
Our protocol provided the same high-quality care with reduced length of stay, and no increased risk.

How does this improve population health?
TIA protocols using ED observation units can provide safe and efficient care, returning patients home more quickly, and freeing hospital capacity for patients with greater inpatient needs.

INTRODUCTION

Transient ischemic attack (TIA) affects 0.3% of the United States population annually and is associated with high risk for stroke or cerebrovascular accident.[1-3] The risk of subsequent ischemic stroke is up to 5% in the first 48 hours, and up to 12% within the first 30 days.[4-7]

Data has shown that urgent workup and treatment can minimize this risk.[5, 6, 8-10] Therefore, the early stages of TIA represent a tremendous opportunity for stroke prevention. Many TIA patients present to, or are referred to, the emergency department (ED), and for many healthcare systems the ED represents both the point of first healthcare contact and location for initial workup. However, it is unclear if the emergent workup is best performed in the ED, inpatient unit, or on an outpatient basis.[11-13] Some healthcare systems have developed rapid TIA outpatient clinics,[14-17] but these are not widely available in the U.S. As a result, many patients in U.S. systems receive inpatient hospitalization, and recent study results point to a significant increase in admit rates for TIA.[18,19]

In our hospital we noted substantial variability in workup, both in types of testing and in ED and in-patient length of stay (LOS). In addition, it appeared that there were opportunities to streamline care and improve our ability to risk-stratify patients. Therefore, to optimize quality and efficiency, in 2012 we developed a protocol-based pathway for acute TIA management (Figure). This pathway was based upon existing guidelines including those from the American Heart Association[20] (AHA) (published in 2009). These highlighted the value of clinical information in risk stratification; brain imaging (including magnetic resonance imaging), and cerebrovascular imaging. In particular, they included recommendations regarding the use of the ABCD2 score for risk stratification; therefore, these were included in our pathway.

Finally, other studies had suggested that an ED observation unit (EDOU) may provide an optimized pathway for TIA evaluation, and so we incorporated its use for selected patients.[17, 21, 22] While less common in other countries, EDOUs are increasingly used in the U.S. for patients who require more than a brief ED stay but less than 24 hours of observation or urgent diagnostics.[23] Our EDOU was managed by a nurse practitioner (NP) who was empowered to guide patients who would likely require more than 24 hours for their workup, based on availability of hospital resources at the time. In this analysis, we evaluated whether we could use this pathway to provide consistent streamlined care with shorter LOS without increasing 90-day stroke risk.

METHODS

Study Design

We performed a retrospective cohort analysis of patients presenting during the six-month time period before protocol implementation (see Figure for protocol), and then the same six-month time period the following year (six months after protocol implementation). The research protocol was approved by the institutional review board (IRB).

Study Setting

This study took place at a large, urban, tertiary, academic hospital with approximately 1,000 inpatient beds and approximately 100,000 ED visits per year.

Population

Patients with suspected TIA were eligible if they presented to our ED (either primarily or in transfer) and if clinical providers determined that a TIA workup was necessary. To capture all eligible patients, we used a number of overlapping methods. First, we queried a hospital-based centralized electronic data registry using the following *ICD-9* codes between January 1, 2011, and December 31,2013: Intracranial Hemorrhage (ICH): 430-432.9; Acute Ischemic Stroke 434.91; and Transient Ischemic Attack (TIA) 435.9. We included the diagnosis of ICH to capture the possibility that some patients may have presented with TIA symptoms but were ultimately diagnosed with ICH. Second, we queried our

TIA protocol

Patient admitted to EDOU for TIA workup if ALL of the following criteria are met:

1. EM attending determines patient requires TIA workup.
2. Neurologic symptoms have resolved.
3. Neurologic exam is at baseline.
4. Vital signs are stable (SBP<180).

TIA protocol:

1. Consult neurology resident, including the word "TIA" on text page
2. Labs per TIA protocol: Cardiac enzymes, CBC, coags, Chem10, lipid panel, HgbA1c
3. ECG
4. IV placement
5. Continuous cardiac monitoring for duration of ED visit (patients can travel off monitor)
6. Brain Imaging:
    a. MRI brain with DWI: first line
    b. CT head: second line UNLESS contraindication to MRI
7. Vascular Imaging:
    a. MRA head/neck: first line
    b. CTA head/neck: second line UNLESS contraindication to MRA
    c. Carotid duplex: third line UNLESS contraindication to MRA and CTA
8. Cardioembolic work-up: Neurology resident will recommend if high suspicion. Transthoracic ECHO (TTE) to be performed IF the OBS NP feels this can be accomplished in the remaining time in ED OBS. Results to be followed up by stroke service attending. Outpatient Holter monitor to be placed or ordered prior to discharge if suspicion of arrhythmia remains high despite negative telemetry recording.

Admission Criteria. The following types of patients will likely require admission and should not be discharged without the agreement of the stroke attending and the EM attending:

1. ≥ 50% stenosis of the blood vessel that might explain symptoms
2. Ischemic lesion on MRI or CT scan
3. More than one TIA in the past month
4. ABCD2 score = 6-7
5. Medical instability (e.g., new onset atrial fibrillation, uncontrolled hypertension)
6. Completion of the necessary workup as an outpatient cannot be easily or effectively arranged.

Following a negative workup:

1. Neurology resident will discuss all cases with Stroke Consult Service attending
2. Stroke attending will discuss all TIA patients with ED neurology resident and either see the patient in OBS or refer to TIA clinic within 7 days
    a. ABCD2 score 2-5: referral for TIA clinic within 4 days
    b. ABCD2 score 0-1: referral for TIA clinic within 7 days
    c. Migraine or other low probability spell: referral for non-urgent Neurology clinic or PCP follow-up
3. For patients, not currently on anti-thrombotic therapy, patients with suspicion of TIA and without contraindication to anti-thrombotic therapy will be started on ASA 81 mg per day.

Figure. Protocol for transient ischemic attack (TIA).

hospital's ongoing AHA Get-With-The-Guidelines® data collection, a prospectively collected cohort of all patients with stroke or TIA.[24] Third, we queried our ED electronic record for all patients with chief complaint or final diagnosis that included the term "TIA." Fourth, we queried our ED electronic record for all patients receiving neurology consultation. Most of the patients captured by this criterion did not actually present with TIA (as they included all

ABCD² Score		
Risk Factor	**Points**	**Score**
Age ≥ 60	**1**	
Blood Pressure at Time of First Evaluation **Systolic BP ≥ 140 mm Hg *OR* Diastolic BP ≥ 90 mm Hg**	**1**	
Clinical Features of TIA (choose one) **Unilateral weakness** **Speech impairment without weakness**	 **2** **1**	
Duration **TIA duration ≥ 60 minutes** **TIA duration 10-59 minutes**	 **2** **1**	
Diabetes by History or Labs	**1**	
Total ABCD2 Score (range 0-7)	**--**	

Figure. Continued.

neurology consultations), but this method provided a wide net (maximal sensitivity) for all those presenting with TIA symptoms, even if the workup ultimately yielded an alternate diagnosis (such as brain tumor or intracerebral hemorrhage).

A physician then reviewed each medical record to determine whether patients truly had TIA symptoms and whether symptoms had resolved at the time of evaluation. We included patients if clinical providers evaluated and worked up the patient for TIA. For patients with multiple visits, we collected data on the first visit only, and recorded the following visits as adverse events if within the given timeframe of data collection.

Study Protocol

We performed a structured chart review, collecting data on patient demographics, imaging, workup, ED LOS, and hospital LOS. Two physicians abstracted data. Demographics collected included age, sex, presenting features, and past medical history. We calculated the primary outcome LOS, based on times of registration and transfer – all abstracted electronically; therefore, no inter-rater agreement was calculated. Imaging data included all brain and vascular imaging. Data were collected on workup including any echocardiography or Holter monitoring. We captured final diagnoses of the clinical providers (after the ED workup). Neuroimaging was reviewed for clinically relevant findings (such as ischemic stroke, carotid artery stenosis, tumor, etc). In addition, the physician reviewer independently determined a likely final diagnosis. To evaluate outcome and adverse events, we reviewed the electronic record for followup outpatient visits and inpatient visits, up to 90 days after initial presentation. This electronic record review included data from our hospital as well as six other local hospitals covered by the same IRB.

Data Analysis

We performed statistical analysis using SAS version 9.4 (SAS Institute, Cary NC). Continuous variables were summarized using median with inter-quartiles and compared using Wilcoxon rank-sum tests. We summarized categorical data using frequency and percentage and compared them using Fisher's exact tests. A two-sided p-value 0.05 or less was considered statistically significant.

RESULTS

Our search strategy yielded 3,388 visits, of which 989 (29%) were overlapping. After removing these and repeat visits, 2,399 unique visits remained, of which 1,043 occurred during the time period of analysis. After chart review, 280 patients were found to have presented with transient neurologic symptoms that received evaluation for TIA; 130 patients were worked up for TIA before and 150 after protocol implementation. Table 1 shows the demographics of these two cohorts.

To determine whether our intervention was associated with any changes in processes of care, we examined admission patterns, workup, and outcomes (Table 2). We found that patients admitted to ED observation increased from 27% to 72% ($p<0.001$). This was associated with a decrease in inpatient admissions from 62% to 24% ($p<0.001$). Median total hospital LOS (including time in ED, observation, and inpatient) also decreased from 29.4 (interquartile ration [IQR]

Table 1. Demographics of study population presenting with transient neurologic symptoms.

Variable	Pre-intervention; n= 130	Post-intervention; n= 150	P value
Age, years; median (IQR)	70 (58-79)	68 (52- 79)	0.16
Sex, Male (%)	67 (52)	73 (49)	0.72
Diabetes (%)	29 (22)	20 (13)	0.059
Initial SBP, mmHg Median (IQR)	152 (134-172)	150 (129-172)	0.54
Initial DBP, mmHg Median (IQR)	81 (71-90)	80 (70-90)	0.81
ABCD2 score			0.43
0-1 (%)	2	3	
2-5 (%)	72	78	
6-7 (%)	26	19	

18.1-54.8) hours to 23.1 (IQR 15.9-35.7) hours (p=0.019).

To examine whether there was a change in type of patients chosen for TIA workup (for example, providers increasing sensitivity by including lower probability TIA patients for workup), we examined the frequency with which final diagnosis was in fact TIA. We found that the distribution of final diagnosis was quite similar (p=0.19) with 45% TIA diagnosis before and 41% after. Of those ultimately found not to have a TIA, similar frequencies of alternative diagnoses were found (Table 2).

We noted that the majority of patients, both pre and post intervention, received brain imaging (99%) and vascular imaging (92%). For brain imaging, 52% of patients received both head computed tomography (CT) and brain magnetic resonance imaging (MRI), while only 4% received both CT angiography (CTA) and MR angiography (MRA). As our observation protocol included preferential use of MRI over CT, we examined whether head CT use changed. Use of head CT decreased from 68% to 58% (p=0.11) and from 32% to 22% (p=0.078) for neck CTA. Yield of various modalities (frequency with which a clinically-relevant, positive finding was diagnosed) is shown in Table 3. Significant findings on head CT were typically findings suggestive of recent infarction. Significant findings on CTA and MRA were typically findings of vascular stenosis or occlusions.

To examine whether our intervention, and its associated shorter LOS, led to higher risk of adverse outcomes, we evaluated risk of TIA or stroke within 90 days of presentation. Table 4 shows that short-term stroke and recurrent TIA rates were approximately 3% both pre and post intervention.

DISCUSSION

Overall we found that implementation of a TIA clinical pathway, incorporating the use of an ED observation unit for selected patients, shortened hospital LOS, and we found no evidence for increased risk of followup stroke.

After this study was completed, the American College of Emergency Physicians (ACEP) published guidelines for TIA management.[25] These guidelines suggested not using the ABCD2 score to determine which patients could be discharged from the ED before a complete workup, instead highlighting the value of urgent imaging. As the American Heart Association suggests, there is substantial value in using a tissue-based definition of TIA rather than time-based, a definition requiring brain imaging to evaluate for signs of areas of infarct.[20] In addition, many authors have found that clinical prediction scores that do not use imaging (such as the ABCD2 scores) do not appear adequately sensitive to safely guide which patients can be discharged prior to urgent evaluation.[26]

We note that we did not (either before or after implementation of our clinical pathway) use the ABCD2 or another clinical score to discharge patients prior to urgent workup. Instead, our clinical pathway used this score to stratify which patients could receive their workup in an EDOU rather than as an inpatient. In fact, the ACEP guidelines included many elements that we had already included, such as "when feasible, physicians should obtain MRI with diffusion-weighted imaging (DWI) to identify patients at high short-term risk for stroke;" "When feasible, physicians should obtain cervical vascular imaging to identify patients at high short-term risk for stroke;" and "a rapid ED-based diagnostic protocol may be used to evaluate patients at short-term risk for stroke,"[25] As a result, our clinical pathway, although designed before these guidelines were published, remains concordant with them and remains in place today. It is also concordant with many suggested pathways in the literature.[26]

Many centers have studied the optimal location for TIA workup. These have included outpatient TIA clinics where assessment, workup, diagnosis and treatment can be efficiently performed. These may reduce unnecessary or avoidable hospital admissions.[14, 27] Such clinics may be less

Table 2. Processes of care.

	Pre-intervention; n= 130	Post-intervention; n= 150	P value
Disposition			<0.001
Discharged home from ED (%)	15 (11)	5 (3)	
Admit ED obs (%)	35 (27)	108 (72)	
Admit inpatient (%)	80 (62)	36 (24)	
Workup			
Head CT (%)	88 (68)	87 (58)	0.087
Neck CTA (%)	41 (32)	33 (22)	0.039
Brain MRI (%)	108 (83)	132 (88)	0.44
Neck MRA (%)	79 (61)	108 (72)	0.046
Carotid US (%)	14 (11)	15 (10)	0.99
Echocardiography (%)	50 (38)	52 (35)	0.36
Holter monitor while admitted	39 (30)	38 (25)	0.015
Holter planned after discharge	9 (7)	20 (13)	0.42
Length of stay			
ED LOS in hours; median (IQR)	5.7 (4.0-7.8)	4.9 (3.5-6.4)	0.027
ED OBS LOS in hours, of those admitted to obs; median (IQR)	10.7 (6.0-17.3) N=46	15.6 (8.8-20.5) N=124	0.034
Inpatient LOS in hours, of those admitted; median (IQR)	39.1 (20.3-84.3) N=84	61.8 (39.4-98.2) N=37	0.057
Total Hospital LOS in hours; median (IQR)	29.4 (18.1-54.8)	23.1 (15.9-35.7)	0.019
Final diagnosis (%)			0.18
TIA	59 (45)	61 (41)	
Stroke	19 (15)	15 (10)	
ICH	0 (0)	0 (0)	
Migraine	6 (5)	4 (3)	
Infection	0 (0)	0 (0)	
Tumor	0 (0)	3 (2)	

ED, emergency department; *OBS,* observation unit; *CT*, computed tomography, *CTA*, computed tomography angiography; *MRI*, magnetic resonance imaging; *MRA*, magnetic resonance angiography; *US*, ultrasound; *LOS*, length of stay; *IQR*, interquartile range; *ICH*, intracranial hemorrhage.

common in the U.S. than in countries with single-payer healthcare systems. Others have studied the use of EDOUs, typically structured as an ED or inpatient unit but designed for patients who need more than an initial ED workup, but less than 24 hours of observation or evaluation. These can be lower cost (to the healthcare system) than an inpatient admission, and are increasing in popularity in the U.S.[23] Some have found that these EDOUs can minimize inpatient admission for lower risk TIA patients in a safe manner.[19, 22] Our results are consistent with these findings. It appears that urgent workup of low- and intermediate-risk patients can be safely performed in an EDOU, reserving high-acuity, in-hospital beds for just the highest risk patients or those with clinically significant findings on workup. Such efforts successfully reduced not just hospital admissions, but total hospital LOS for all patients, while ensuring all necessary workup was performed in the acute setting.

One common limitation in TIA studies is that they often include only those patients with final diagnosis of TIA. However, many patients present with symptoms concerning for TIA, who are later determined to have an alternate diagnosis. The strength of this study is that we included all patients for whom ED providers suspected TIA. However, as a result only about half of patients finally did have TIA, similar to other findings.[28, 29] One interesting finding was that while use of head CT was reduced, approximately half of patients still received one. Many patients received brain imaging with both CT and MRI, which may expose patients to avoidable radiation risk, as CT did not appear to offer additional information beyond

Table 3. Yield of neuroimaging: For the purposes of this analysis, imaging was operationally defined as ”positive” if there were clinically relevant findings such as ischemic stroke, carotid artery stenosis, or tumor.

Imaging modality	Pre-intervention	Post-intervention	P value
Head CT positive	3/89 (3%)	4/89 (4%)	0.99
Brain MRI positive	33/109 (30%)	29/131 (22%)	0.18
Neck CTA positive	21/40 (53%)	10/33 (30%)	0.063
Neck MRA positive	12/79 (15%)	6/108 (6%)	0.042
Carotid US positive	7/15 (47%)	5/15 (33%)	0.71

CT, computed tomography, *CTA*, computed tomography angiography; *MRI*, magnetic resonance imaging; *MRA*, magnetic resonance angiography; *US*, ultrasound.

Table 4. Adverse events in those with final diagnosis of transient ischemic attack.

Variable	Pre-intervention; n= 59	Post-intervention; n= 61	P value
Followup at our hospital outpatient neuro clinic (%)	25 (42)	31 (51)	0.37
Recurrent TIA within 90 days (%)	2 (3)	0 (0)	0.24
Stroke within 90 days (%)	0 (0)	2 (3)	0.50

what MRI could provide. It may be that providers wished to obtain head CT to screen for an emergent process before initiating the observation protocol and awaiting MRI (which takes much longer).

LIMITATIONS

Our study had a number of limitations. First, it was limited to a single center, and our care pathways may not be the same as at other centers. Second, observational studies comparing before/after change implementation run the risk of other changes in clinical care happening at the same time. However, we are not aware of any changes in national or local recommendations for TIA workup during the time frame of this study. Third, adjudication of which patients truly had a TIA can be subject to inter-rater variability, which has been shown to be significant in several other studies.[30, 31] Fourth, as this was a retrospective study, our followup was limited to hospital records at our hospital and six other affiliates. We may have missed that some patients developed adverse events that were managed at other hospitals, or doctor offices. Fifth, we were unable to evaluate changes in cost, as cost data is typically not publicly available at our center.

CONCLUSION

In conclusion, we found that implementation of an ED observation-based TIA pathway led to shorter length of stay, with no evidence for increased risk of follow-up stroke.

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REFERENCES

1. Mozaffarian D, Benjamin EJ, Go AS, et al. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. *Circulation*. 2015;131(4):e29-322.
2. Fuentes B, Gallego J, Gil-Nunez A, Morales A, Purroy F, Roquer J, et al. Guidelines for the preventive treatment of ischaemic stroke and tia (ii). Recommendations according to aetiological sub-type. *Neurologia*. 2014;29(3):168-83.

3. Murphy SL, Xu J, Kochanek KD. Deaths: Final data for 2010. *Natl Vital Stat Rep*. 2013;61(4):1-117.
4. Giles MF, Rothwell PM. Risk of stroke early after transient ischaemic attack: a systematic review and meta-analysis. *Lancet Neurol*. 2007;6(12):1063-72.
5. Johnston SC, Gress DR, Browner WS, et al. Short-term prognosis after emergency department diagnosis of TIA. *JAMA*. 2000;284(22):2901-6.
6. Lovett JK, Rothwell PM. Site of carotid plaque ulceration in relation to direction of blood flow: an angiographic and pathological study. *Cerebrovasc Dis*. 2003;16(4):369-75.
7. Rothwell PM, Warlow CP. Timing of TIAs preceding stroke: time window for prevention is very short. *Neurology*. 2005;64(5):817-20.
8. Johnston SC, Rothwell PM, Nguyen-Huynh MN, et al. Validation and refinement of scores to predict very early stroke risk after transient ischaemic attack. *Lancet*. 2007;369(9558):283-92.
9. Kernan WN, Ovbiagele B, Black HR, et al. Guidelines for the prevention of stroke in patients with stroke and transient ischemic attack: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke*. 2014;45(7):2160-236.
10. Talwalkar A, Uddin S. Trends in emergency department visits for ischemic stroke and transient ischemic attack: United States, 2001-2011. *NCHS Data Brief*. 2015;(194):1-8.
11. Lindley RI. Patients with transient ischemic attack do not need to be admitted to hospital for urgent evaluation and treatment: Against. *Stroke*. 2006;37:1139-40.
12. Luengo-Fernandez R, Gray AM, Rothwell PM. Effect of urgent treatment for transient ischaemic attack and minor stroke on disability and hospital costs (express study): a prospective population-based sequential comparison. *Lancet Neurol*. 2009;8(3):235-43.
13. Siket MS, Edlow J. Transient ischemic attack: an evidence-based update. *Emerg Med Pract*. 2013;15(1):1-26.
,14. Horer S, Schulte-Altedorneburg G, Haberl RL. Management of patients with transient ischemic attack is safe in an outpatient clinic based on rapid diagnosis and risk stratification. *Cerebrovasc Dis*. 2011;32(5):504-10.
15. Joshi JK, Ouyang B, Prabhakaran S. Should TIA patients be hospitalized or referred to a same-day clinic?: A decision analysis. *Neurology*. 2011;77(24):2082-8.
16. Lavallee PC, Meseguer E, Abboud H, et al. A transient ischaemic attack clinic with round-the-clock access (SOS-TIA): Feasibility and effects. *Lancet Neurol*. 2007;6(11):953-60.
17. Merwick A, Kelly PJ. Transient ischaemic attack clinics and management of transient ischaemic attacks. *Curr Opin Neurol*. 2011;24(1):50-8.
18. Durrani-Tariq S, Eskin B, Allegra JR. Admission rates of ED patients with transient ischemic attack have increased since 2000. *Am J Emerg Med*. 2013;31(9):1349-51.
19. Stead LG, Bellolio MF, Suravaram S, et al. Evaluation of transient ischemic attack in an emergency department observation unit. *Neurocrit Care*. 2009;10(2):204-8.
20. Easton JD, Saver JL, Albers GW, et al. Definition and evaluation of transient ischemic attack: a scientific statement for healthcare professionals from the American Heart Association/American Stroke Association stroke council; Council on Cardiovascular Surgery and Anesthesia; Council on Cardiovascular Radiology and Intervention; Council on Cardiovascular Nursing; and the Interdisciplinary Council on Peripheral Vascular Disease. The American Academy of Neurology affirms the value of this statement as an educational tool for neurologists. *Stroke*. 2009;40(6):2276-93.
21. Nahab F, Leach G, Kingston C, et al. Impact of an emergency department observation unit transient ischemic attack protocol on length of stay and cost. *J Stroke Cerebrovasc Dis*. 2012;21(8):673-8.
22. Ross MA, Compton S, Medado P, et al. An emergency department diagnostic protocol for patients with transient ischemic attack: A randomized controlled trial. *Ann Emerg Med*. 2007;50(2):109-19.
23. Capp R, Sun B, Boatright D, et al. The impact of emergency department observation units on United States emergency department admission rates. *J Hosp Med*. 2015;10(11):738-42.
24. Ekundayo OJ, Saver JL, Fonarow GC, et al. Patterns of emergency medical services use and its association with timely stroke treatment: findings from Get with the Guidelines-stroke. *Circ Cardiovasc Qual Outcomes*. 2013;6(3):262-9.
25. American College of Emergency Physicians Clinical Policies Subcommittee (Writing Committee) on Suspected Transient Ischemic Attack:, Lo BM, Carpenter CR, Hatten BW, et al. Clinical policy: critical issues in the evaluation of adult patients with suspected transient ischemic attack in the emergency department. *Ann Emerg Med*. 2016;68(3):354-70.e29.
26. Long B, Koyfman A. Best clinical practice: Controversies in transient ischemic attack evaluation and disposition in the emergency department. *J Emerg Med*. 2017;52(3):299-310.
27. Birns J, Vilasuso M, Cohen DL. One-stop clinics are more effective than neurology clinics for TIA. *Age Ageing*. 2006;35(3):306-8.
28. Schrock JW, Glasenapp M, Victor A, et al. Variables associated with discordance between emergency physician and neurologist diagnoses of transient ischemic attacks in the emergency department. *Ann Emerg Med*. 2012;59(1):19-26.
29. Ghia D, Thomas PR, Cordato DJ, et al. Validation of emergency and final diagnosis coding in transient ischemic attack: South western sydney transient ischemic attack study. *Neuroepidemiology*. 2010;35(1):53-8.
30. Castle J, Mlynash M, Lee K, et al. Agreement regarding diagnosis of transient ischemic attack fairly low among stroke-trained neurologists. *Stroke*. 2010;41(7):1367-70.
31. Ishida K, Raser-Schramm JM, Wilson CA, et al. Convergent validity and interrater reliability of estimating the ABCD2 score from medical records. *Stroke*. 2013;44(3):803-5.

Prehospital Lactate Predicts Need for Resuscitative Care in Non-hypotensive Trauma Patients

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Introduction: The prehospital decision of whether to triage a patient to a trauma center can be difficult. Traditional decision rules are based heavily on vital sign abnormalities, which are insensitive in predicting severe injury. Prehospital lactate (PLac) measurement could better inform the triage decision. PLac's predictive value has previously been demonstrated in hypotensive trauma patients but not in a broader population of normotensive trauma patients transported by an advanced life support (ALS) unit.

Methods: This was a secondary analysis from a prospective cohort study of all trauma patients transported by ALS units over a 14-month period. We included patients who received intravenous access and were transported to a Level I trauma center. Patients with a prehospital systolic blood pressure ≤ 100 mmHg were excluded. We measured PLac's ability to predict the need for resuscitative care (RC) and compared it to that of the shock index (SI). The need for RC was defined as either death in the emergency department (ED), disposition to surgical intervention within six hours of ED arrival, or receipt of five units of blood within six hours. We calculated the risk associated with categories of PLac.

Results: Among 314 normotensive trauma patients, the area under the receiver operator characteristic curve for PLac predicting need for RC was 0.716, which did not differ from that for SI (0.631) (p=0.125). PLac ≥ 2.5 mmol/L had a sensitivity of 74.6% and a specificity of 53.4%. The odds ratio for need for RC associated with a 1-mmol/L increase in PLac was 1.29 (95% confidence interval [CI] [0.40 – 4.12]) for PLac < 2.5 mmol/L; 2.27 (1.10 – 4.68) for PLac from 2.5 to 4.0 mmol/L; and 1.26 (1.05 – 1.50) for PLac ≥ 4 mmol/L.

Conclusion: PLac was predictive of need for RC among normotensive trauma patients. It was no more predictive than SI, but it has certain advantages and disadvantages compared to SI and could still be useful. Prospective validation of existing triage decision rules augmented by PLac should be investigated. [West J Emerg Med. 2018;19(2)224-231.]

INTRODUCTION

The decision of whether to triage an injured patient to a trauma center can be difficult, and most emergency medical system (EMS) agencies rely on standardized decision-making systems.[1] Traditional trauma triage systems rely heavily on vital sign abnormalities to identify patients in need of a trauma center. Shock index (SI) is one vital-sign marker that has been identified as an early predictor of severe injury.[2] However, multiple studies have demonstrated that vital signs are limited in this role.[1,3-8]

Field measurement of serum lactate concentration could be of potential benefit in accurately identifying patients with more severe injury and need for resuscitative care (RC). Lactic acid is a byproduct of anaerobic metabolism and is a marker of inadequate tissue oxygenation or shock. Technological advancements have led to the development of rapid, portable, lactate assays, permitting lactate measurement in the prehospital and early clinical setting. Previous studies have demonstrated that elevated prehospital and emergency department (ED) lactate levels are predictive of poor outcomes in several populations: septic patients, cardiac arrest patients, and general medical patients.[9-15] Prehospital lactate has also been validated in two populations of patients selected for severe injury: those transported by helicopter and those with prehospital hypotension (systolic blood pressure ≤ 100 mmHg).[16-18]

However, the prognostic utility of a prehospital lactate level has not been studied systematically in a population of normotensive trauma patients encountered by ground advanced life support (ALS) crews. Of particular interest is the question of whether the test can risk-stratify normotensive trauma patients and retain specificity for the need for RC when applied to a much broader population with a lower overall prevalence of severe injury than those previously studied. (Note: For the purposes of this paper, the term "normotensive" should be taken to mean any patient with systolic blood pressure > 100 mmHg.) We sought to determine the test characteristics of prehospital lactate levels for predicting need for resuscitative care among a broad population of normotensive trauma patients being transported by ground ALS units.

Population Health Research Capsule

What do we already know about this issue?
Prehospital triage decisions for trauma patients are based on vital signs, but this misses some injuries. Prehospital lactate measurement could improve this process.

What was the research question?
How predictive is prehospital lactate in predicting severe injury in normotensive trauma patients?

What was the major finding of the study?
Prehospital lactate was predictive of severe injury with reasonable sensitivity and specificity.

How does this improve population health?
This will help inform EMS medical directors of the potential benefits and risks of incorporating prehospital lactate measurement into their trauma triage protocols.

METHODS

This study was approved by the University of Washington Institutional Review Board. It was a retrospective analysis of a prospective cohort study of all trauma patients transported by ground ALS units of the Seattle Fire Department between June 24, 2011, and August 21, 2012. In this two-tiered EMS system, ALS treatment and transport to a trauma center is triggered by a significant mechanism of injury, Glasgow Coma Scale ≤ 12, vital-sign abnormalities, neurovascular deficits, and injury pattern, in keeping with Washington State Department of Health Prehospital Trauma Guidelines.[19] Patients excluded from lactate measurement were those with age less than 15 years; obvious isolated, penetrating head trauma; drowning; asphyxia caused by hanging; burns greater than 20% body surface area; or known prisoner status. We also excluded patients with prehospital systolic blood pressure ≤ 100 mmHg because they had already been analyzed in a prior study with this population showing strong correlation between lactate and outcomes.[17] This allowed our study to determine the lactate test characteristics among a population that might not be preferentially transported to a high-level trauma center.

Serum lactate levels were drawn upon placement of an intravenous line. A drop of blood was placed on a test strip, which was inserted into a handheld measurement device (Lactate Pro, Arkray Inc., Kyoto, Japan). The Lactate Pro meter is similar in size and operation to the glucometers used by our EMS agencies and has a run time of 60 seconds.[20] EMS and hospital providers recorded the test result in the patient's chart but were instructed not to change care based on the number. Data were entered into a local database created specifically for study of prehospital lactate performance. All ALS patients in this catchment area were transported to a single Level I trauma center, Harborview Medical Center. Clinical variables from the time period after ED arrival through death or hospital discharge were obtained by review of electronic health records.

The primary clinical outcome of interest was need for RC. This was defined as death in the ED, disposition to operating room or interventional radiology within six hours, or transfusion of five units of any blood product within six hours of ED arrival. This outcome was used in the prior study of prehospital lactate in hypotensive trauma patients.[17] It is used here both for consistency to facilitate comparison of results to the prior study and because we believe it accurately defines a population of injured patients that requires high-level trauma care.

In the primary analysis, we defined the normal distribution of prehospital lactate. Subsequently, we evaluated its ability to predict the need for RC and compared it to the same predictive ability of shock index (SI = heart rate [HR] / systolic blood

pressure [SBP]) by calculating the area under the curve of the receiver operator characteristic (AUROC) for each. The AUROCs were compared using the DeLong-DeLong-Clarke-Pearson method.[21] We also calculated the sensitivity and specificity of a prehospital lactate level of 2.5 mmol/L or greater. This cutoff has been previously validated in trauma populations and was chosen to maximize the generalizability of our results.[16,22] The optimal cutoff point for the study population was also calculated by selecting the point visually determined to most closely represent an inflection point in the ROC curve that minimized loss of sensitivity but maximized specificity.

In planned secondary analyses, the AUROCs were calculated and compared in the predefined subpopulations of blunt and penetrating injury patients. We also calculated the AUROCs for prehospital lactate and SI for predicting the alternative outcomes of moderate and severe injury, as defined by injury severity score (ISS) > 9 and 15, respectively. These cutoffs were chosen because they have been used historically to represent moderate and severe injury and have been validated to be useful surrogates for patients who will benefit from triage to a trauma center.[23-28]

Finally, we did an exploratory analysis to further investigate the relationship between prehospital lactate and likelihood of need for RC. For this analysis, a multivariate logistic regression was performed that included need for RC as its outcome and a linear spline of lactate with knots at 2.5 and 4 mmol/L as the predictor of interest. We chose this model to allow for a possible non-linear relationship between lactate concentration and risk of need for RC. Cutpoints were previously validated in unrelated studies, indicating that they represent separation points of trauma patients with different outcomes.[29] We used Wald tests to determine significance.

RESULTS

We screened 371 patients for enrollment, and 314 were included in analysis. Of the 57 excluded patients, 50 were excluded for a missing prehospital lactate. The reason given for a missing lactate in those 50 patients was paramedic failure to run the test in 19 patients; ongoing cardiopulmonary resuscitation in 12 patients; unsecure scene in three patients; unstable vital signs in three patients; prolonged extrication in two patients; immediate adjacency to the trauma center in one patien;, and device malfunction in one patient. No reason was provided for eight patients. We also excluded seven patients who were missing a recorded initial HR or SBP necessary to calculate SI. Figure 1 summarizes inclusion/exclusion numbers. Demographic, injury, and hospital data for all included patients are summarized in the table.

The AUROC for prehospital lactate prediction of need for RC was 0.716 (95% confidence interval [CI] [0.632 – 0.800]) and for SI was 0.631 (95% CI [0.537 – 0.724]) (Figure 2). The AUROC for prehospital lactate did not differ from that for SI (p=0.125). Among normotensive patients, a prehospital lactate level of 2.5 mmol/L or greater had a sensitivity of 74.6% and specificity of 53.4% for predicting need for RC. Increasing the lactate cutoff level to 3.0, where there is an inflection point in the ROC curve, resulted in improvement in specificity (66.9%) with only modest change in sensitivity (70.9%). In this population, SI of 0.9 or greater (a commonly recognized marker for severe injury in trauma patients) had low sensitivity for predicting need for RC (30.8%) but high specificity (89.9%). Being positive for *either* prehospital lactate level of 2.5 mmol/L or greater *or* SI of 0.9 or greater had only slightly different sensitivity (77.6%) and specificity (49.8%) than with prehospital lactate prediction alone.

Looking at each of the individual outcomes defining need for RC, prehospital lactate had similar predictive power for each. The AUROC for predicting need for emergent surgery was 0.721 (95% CI [0.630 – 0.811]), for predicting transfusion of five units of blood products was 0.785 (95% CI [0.669 – 0.901]) and for predicting death in the ED was 0.863 (95% CI could not be calculated, because there was only one event).

Among the 260 blunt injury patients, the AUROC for prehospital lactate prediction of need for RC was 0.732 (95% CI [0.637 – 0.827]), which was not significantly different from that for SI at 0.657 (95% CI [0.545 – 0.769]) (p=0.121). Among the 54 penetrating injury patients, the AUROC for prehospital lactate was 0.636 (95% CI [0.473 – 0.798]) and for SI was 0.550 (95% CI [0.374 – 0.726]) (p=0.478). In predicting the secondary clinical outcome of moderate injury (ISS > 9), the AUROC for prehospital lactate was 0.592 (95% CI [0.528 – 0.655]) and for SI was 0.594 (95% CI [0.530 – 0.657]) (p=0.954). In predicting severe injury (ISS > 15), the AUROC for prehospital lactate was 0.648 (95% CI [0.580 – 0.716]) and for SI was 0.647 (95% CI [0.576 – 0.718]) (p=0.979).

In the exploratory analysis, the odds ratios for need for RC associated with a 1-mmol/L increase in prehospital lactate concentration was 1.29 (95% CI [0.40 – 4.12], p=0.666) for lactate levels less than 2.5 mmol/L, 2.27 (95% CI [1.10 – 4.68], p=0.027) for lactate levels between 2.5 and 4.0 mmol/L, and 1.26 (95% CI [1.05 – 1.50], p=0.011) for lactate levels greater than 4.0 mmol/L.

DISCUSSION

In this retrospective cross-sectional analysis of normotensive trauma patients who met criteria for ALS transport, prehospital lactate concentration as measured by a handheld, point-of-care (POC) assay was predictive of the need for RC. Lactate offered no significant performance benefit over shock index by AUROC. However, we propose that it has several advantages over SI. First, it is less prone to error and easier to calculate in real-time during a patient transport. Second, a PLac cutoff of 3.0 offered superior sensitivity (70.9%) over the commonly used SI cutoff of 0.9 (30.8%). Though this came at a modest cost in specificity (66.9 vs. 89.9%), the emphasis for a screening tool in this

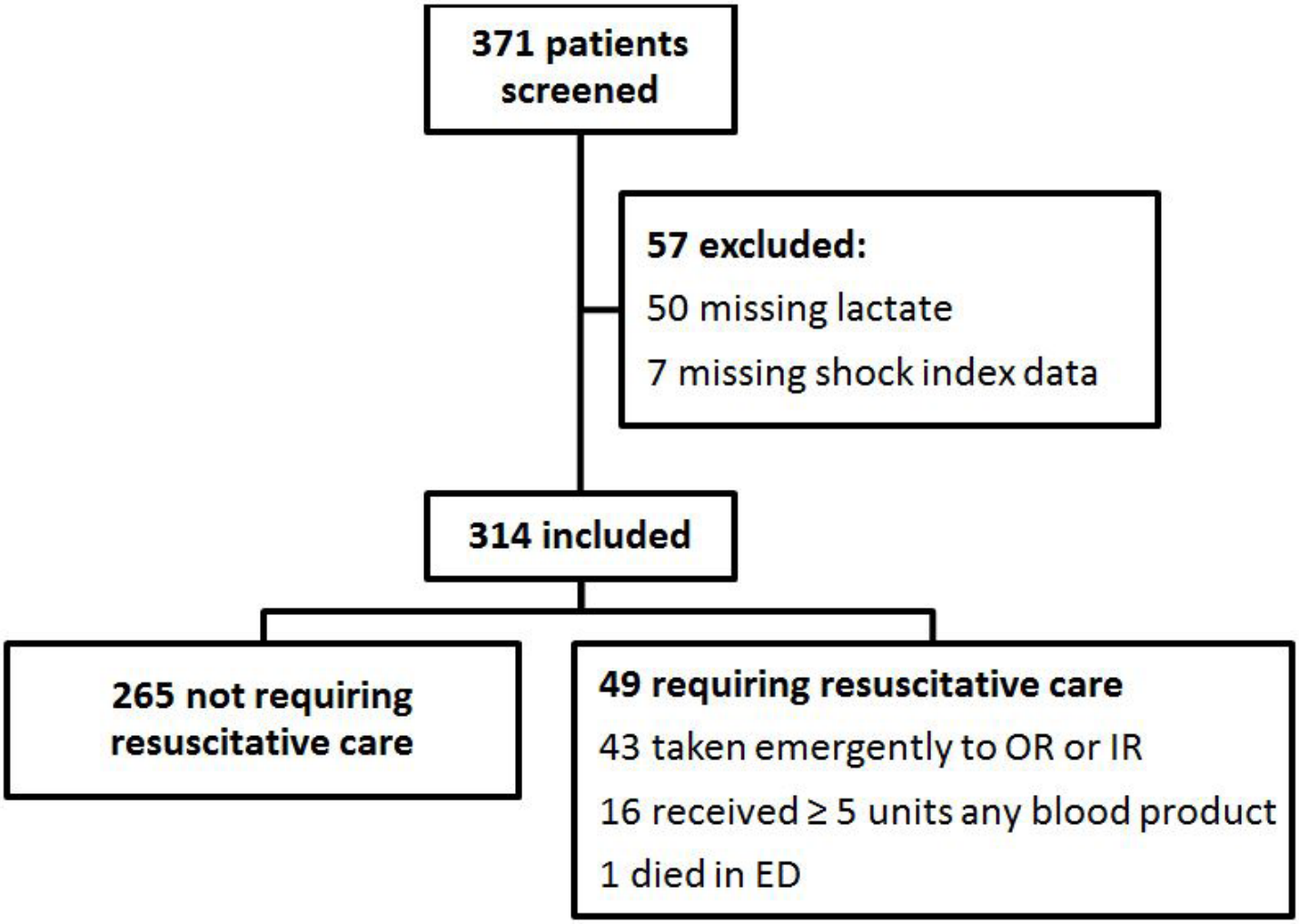

Figure 1. Cohort of patients enrolled in a study of the relationship between prehospital lactate levels and the need for resuscitative care. OR, operating room. IR, interventional radiology. ED, emergency department.

population is to avoid false-negatives. Third, because prehospital lactate has been demonstrated to be a useful adjunct in the triage of hypotensive ALS transports, its use in normotensive ALS transports could simplify protocols to include a prehospital lactate for any ALS transport. These advantages should be weighed against the disadvantages of cost of equipment and assay, requirement for training, additional time to run the assay, and potential distraction from directly caring for the patient.

The POC meter used in this study cost approximately $300 and required about $2 per use as a disposable cartridge. Our results are similar to those previously seen in hypotensive trauma patients, though each test (prehospital lactate and SI) had slightly lower AUROCs in this non-hypotensive population, likely owing to the rarer need for RC. This is the first prehospital study to examine the ability of prehospital lactate to risk-stratify normotensive trauma patients.

The lactate cutoff of 2.5 mmol/L that has been validated in other trauma populations had a high sensitivity at 75% and maintained specificity at 53%. This indicates that the test may have future value in decreasing undertriage without paying a heavy price in overtriage. One of the critical questions in extending the application of this test to a lower-acuity trauma population than previously studied is whether there would be a major decrease in specificity. Raising the cutoff level to 3.0 mmol/L led to a large increase in specificity with only a small cost paid in sensitivity in this population. However, it is important to note that the same is likely not true in the larger population that includes hypotensive patients. Prospective testing would be needed in the target population with specific comparison of a triage protocol incorporating the prehospital lactate to current triage guidelines.

In the subpopulation secondary analyses, prehospital lactate maintained a high AUROC for both blunt and

Table. Demographic, injury, and hospital data of included patients

Characteristic	Study population (n=314)
Age, years, median (IQR)	35.5 (25-51)
Male, n (%)	228 (72.6)
Race, n (%):	
White	181 (57.6)
Black	47 (15.0)
Hispanic	20 (6.4)
Asian	13 (4.1)
Pacific Islander	11 (3.5)
Native American	5 (1.6)
Other	1 (0.3)
Unknown	36 (11.5)
Mechanism of injury, n (%):	
Blunt	260 (82.8)
Fall	68 (21.7)
Motor vehicle collision	66 (21.0)
Pedestrian struck	38 (12.1)
Assault	28 (8.9)
Bicycle collision	23 (7.3)
Motorcycle collision	19 (6.1)
Other blunt injury	25 (8.0)
Penetrating	54 (17.2)
Gunshot wound	29 (9.2)
Stab wound	21 (6.7)
Other penetrating injury	4 (1.3)
Injury severity score, median (IQR)	9 (5-19)
Initial emergency department laboratory values:*	
Hematocrit, median (IQR)	40 (37-43)
International normalized ratio, median (IQR)	1.0 (1.0-1.1)
pH, median (IQR)	7.35 (7.30-7.41)
Hospital lactate concentration, mmol/L, median (IQR)	3.0 (2.2-4.7)
Emergency department care:	
Crystalloid volume infused in first 6 hours, mL, median (IQR)	1,500 (1,000-2,100)
Received pRBC transfusion in first 6 hours, n (%)	30 (9.6)
Outcomes	
Emergency department length of stay, minutes, median (IQR)	258 (184-391)
Death in emergency department, n (%)	1 (0.3)
Hospital length of stay, hours, median (IQR)	44.1 (7.1-155.5)
Intensive care unit days, median (IQR)	0 (0-2)
In-hospital mortality, n (%)	15 (4.8)
Hospital discharge location if alive, n (%):	
Home / self-care	236 (75.2)
Skilled nursing facility	26 (8.3)
Inpatient rehabilitation center	11 (3.5)
Other	12 (3.8)
Not documented	29 (9.2)

IQR, interquartile ratio, *pRBC,* packed red blood cells.
*Many laboratory values were not run in all patients, resulting in absence of reported values ranging from <1% (hematocrit) to 56% (hospital lactate concentration).

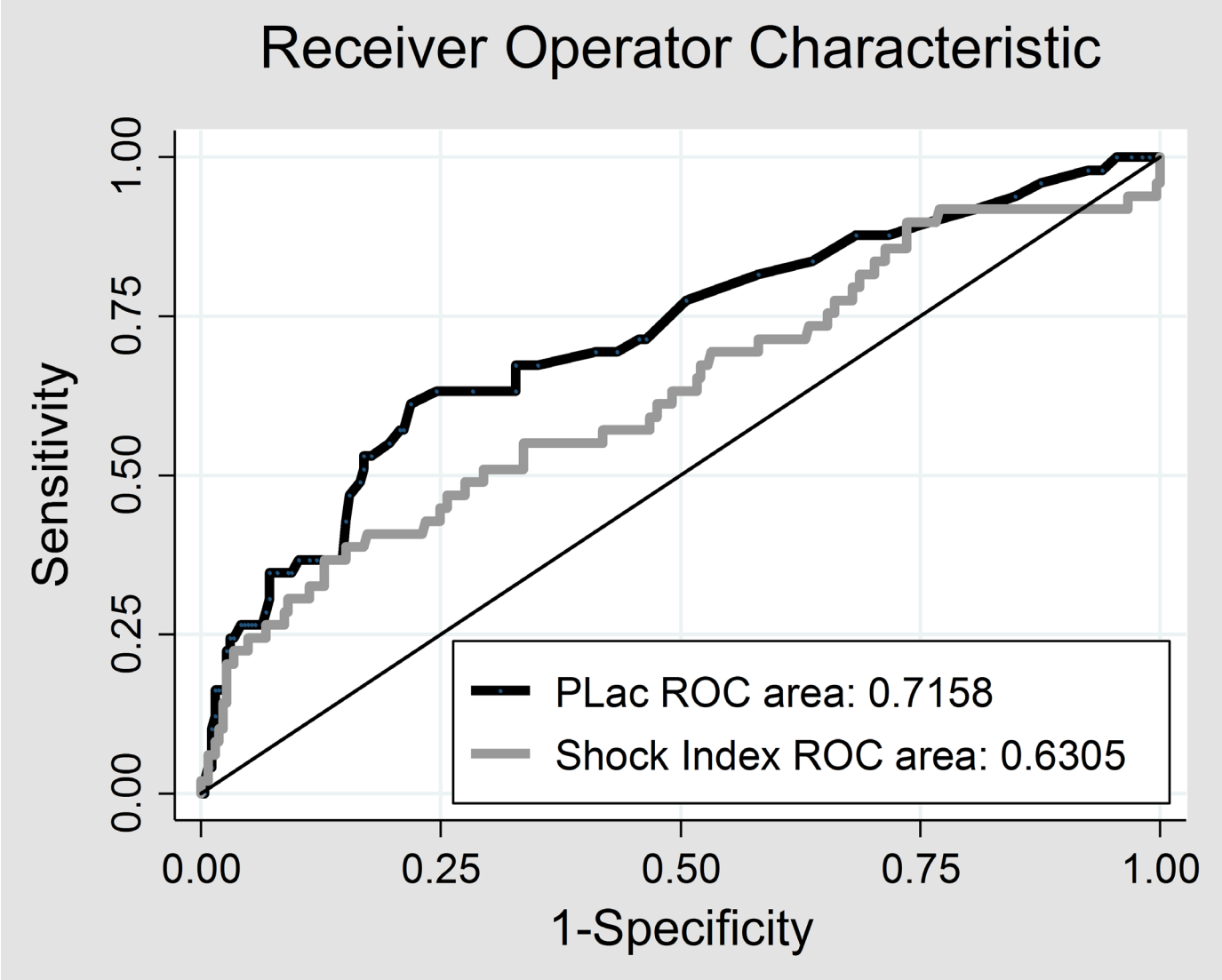

Figure 2. Receiver operator characteristic curves for the prediction of need for resuscitative care by prehospital lactate level and shock index.

penetrating patients. Prehospital lactate had no significant difference in performance compared to SI in the blunt or penetrating injury population, though there was a p-value of 0.121 trending toward superior performance in blunt injury. It is difficult to interpret these results in light of the smaller subgroup sample sizes and unknown power due to the lack of prior data in this population, particularly in the penetrating injury group. However, given that most triage criteria direct all penetrating injuries proximal to the knee or elbow to trauma centers already, the test performance comparison in this group might be less relevant.

When examining the prediction of the secondary clinical outcomes of moderate and severe injury (ISS > 9 and 15), prehospital lactate had markedly worse performance. The reasons for this are unclear but could include the fact that hypotensive patients were excluded, making a high ISS more likely representative of extremity and facial injuries less likely to cause shock and limiting the utility of lactate measurement. However, ultimately the high ISS outcome has been used in prior studies as a surrogate measurement predictive of need for RC; in our study, the lactate concentration was directly measured against clinical need for RC, making the primary analysis more impactful than this one.

The exploratory analysis showed that increases in prehospital lactate were associated with increased risk of need for RC only above lactate levels of 2.5 mmol/L. It also showed there is more risk associated with a 1-mmol/L increase in lactate concentration in the range of 2.5 to 4.0 mmol/L, and the increase in risk decreases in the higher lactate ranges. This is both logical, given the relatively high baseline risk associated with any lactate > 4.0, and in keeping with prior findings in a hypotensive trauma population.[17]

In conjunction with previous studies on prehospital lactate in trauma patients, these findings suggest that prehospital lactate could improve overall triage for ALS patients, and we suggest that it should be investigated prospectively as a rapid test in the field to identify occult shock. Among patients meeting local criteria for ALS transport, future investigation should test the integration of prehospital lactate into existing field triage decision rules to determine accuracy in the decision to transport to a trauma center. To account for the possible lack of improvement provided by prehospital lactate testing in the normotensive ALS transport population, future trials should include a planned subgroup analysis of normotensive patients. If found to be beneficial, testing could also be investigated for use by basic life support (BLS) providers to identify patients with occult shock requiring ALS transport, given that the tasks required for testing are within the BLS skillset. The role of the test should be further investigated primarily to prevent undertriage, as its test characteristics show that this would likely come at a relatively low cost of overtriage, even among normotensive trauma patients. A positive result could also hold promise for triggering more aggressive field treatment, including the earlier use of prehospital blood products in EMS systems with the capability to do so, though this would also require further study.

LIMITATIONS

This study has several limitations. First, although the data were collected prospectively, this is a retrospective analysis, which limits some of the granularity of the data. Second, because we lacked the ability to determine specific operative procedures being performed, we used disposition to OR within six hours as a surrogate for surgical hemorrhage control. This would inadvertently include the uncommon patient undergoing a non-emergent surgical procedure within six hours of ED arrival, such as open reduction internal fixation, but that would only bias the results towards a worse sensitivity for prehospital lactate. Third, the definitions for the composite outcome of need for RC were chosen subjectively. They were chosen both for ease of comparison to prior literature and because the authors felt they accurately represented a population requiring higher-level trauma care, but it could be argued that this is not an optimally targeted population.

Fourth, this study still only included patients meeting ALS criteria in a two-tiered system. It is important to note that, although this population includes normotensive trauma patients, the findings could not be extended to the population transported by BLS in our system. Furthermore, the impact of inclusion of prehospital lactate into any triage protocol would need to be investigated prospectively before it could be recommended for implementation. Fifth, while the lactate meter used in the study is Clinical Laboratory Improvement Amendment-waived, it is no longer commercially available. The Lactate Pro is operated identically to the POC glucose meter used on ambulances with minimal operational error. The devices are robust and reliable with a low failure rate.[20] During the study period, the meter did not require calibration. Future lactate meters available for prehospital use may be more complicated both in their operation and their administrative overhead.

Finally, we did not have access to all prehospital data, so we were unable to compare the performance of the current triage algorithm to what the performance would have been with a triage algorithm incorporating the prehospital lactate data. This study also has several important strengths, including prospective collection of the data and the single receiving center for patients, enhancing the collection of detailed in-hospital data.

CONCLUSION

In conclusion, this study suggests that prehospital lactate could be useful in risk-stratifying normotensive trauma patients. Prospective validation of existing triage decision rules augmented by prehospital lactate should be a focus of future investigation.

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REFERENCES

1. Sasser SM, Hunt RC, Faul M, et al. Guidelines for field triage of injured patients: recommendations of the National Expert Panel on Field Triage, 2011. *MMWR Recomm Rep.* 2012;61(Rr-1):1-20.
2. King RW, Plewa MC, Buderer NM, et al. Shock index as a marker for significant injury in trauma patients. *Acad Emerg Med.* 1996;3(11):1041-5.
3. McGee S, Abernethy WB 3rd, Simel DL. The rational clinical examination. Is this patient hypovolemic? *JAMA.* 1999;281(11):1022-9.
4. Brasel KJ, Guse C, Gentilello LM, et al. Heart rate: is it truly a vital sign? *J Trauma.* 2007;62(4):812-7.
5. Newgard CD, Rudser K, Hedges JR, et al. A critical assessment of

the out-of-hospital trauma triage guidelines for physiologic abnormality. *J Trauma.* 2010;68(2):452-62.
6. Lipsky AM, Gausche-Hill M, Henneman PL, et al. Prehospital hypotension is a predictor of the need for an emergent, therapeutic operation in trauma patients with normal systolic blood pressure in the emergency department. *J Trauma.* 2006;61(5):1228-33.
7. Eastridge BJ, Salinas J, McManus JG, et al. Hypotension begins at 110 mm Hg: redefining "hypotension" with data. *J Trauma.* 2007;63(2):291-7; discussion 297-9.
8. Henry MC, Hollander JE, Alicandro JM, et al. Incremental benefit of individual American College of Surgeons trauma triage criteria. *Acad Emerg Med.* 1996;3(11):992-1000.
9. Prause G, Ratzenhofer-Comenda B, Smolle-Juttner F, et al. Comparison of lactate or BE during out-of-hospital cardiac arrest to determine metabolic acidosis. *Resuscitation.* 2001;51(3):297-300.
10. Jansen TC, van Bommel J, Mulder PG, et al. The prognostic value of blood lactate levels relative to that of vital signs in the pre-hospital setting: a pilot study. *Crit Care.* 2008;12(6):R160.
11. Vandromme MJ, Griffin RL, Weinberg JA, et al. Lactate is a better predictor than systolic blood pressure for determining blood requirement and mortality: could prehospital measures improve trauma triage? *J Am Coll Surg.* 2010;210(5):861-7, 867-9.
12. Guerra WF, Mayfield TR, Meyers MS, et al. Early detection and treatment of patients with severe sepsis by prehospital personnel. *J Emerg Med.* 2013;44(6):1116-25.
13. van Beest PA, Mulder PJ, Oetomo SB, et al. Measurement of lactate in a prehospital setting is related to outcome. *Eur J Emerg Med.* 2009;16(6):318-22.
14. Tobias AZ, Guyette FX, Seymour CW, et al. Pre-resuscitation lactate and hospital mortality in prehospital patients. *Prehosp Emerg Care.* 2014;18(3):321-7.
15. Mullen M, Cerri G, Murray R, et al. Use of point-of-care lactate in the prehospital aeromedical environment. *Prehosp Disaster Med.* 2014;29(2):200-3.
16. Guyette F, Suffoletto B, Castillo JL, et al. Prehospital serum lactate as a predictor of outcomes in trauma patients: a retrospective observational study. *J Trauma.* 2011;70(4):782-6.
17. Guyette FX, Meier EN, Newgard C, et al. A comparison of prehospital lactate and systolic blood pressure for predicting the need for resuscitative care in trauma transported by ground. *J Trauma Acute Care Surg.* 2015;78(3):600-6.
18. Shah A, Guyette F, Suffoletto B, et al. Diagnostic accuracy of a single point-of-care prehospital serum lactate for predicting outcomes in pediatric trauma patients. *Pediatr Emerg Care.* 2013;29(6):715-9.
19. Health WSDo. State of Washington Prehospital Trauma Triage (Destination) Procedure. 2012. Available at: www.doh.wa.gov/portals/1/documents/pubs/530143.pdf.
20. Bonaventura JM, Sharpe K, Knight E, et al. Reliability and accuracy of six hand-held blood lactate analysers. *J Sports Sci Med.* 2015;14(1):203-14.
21. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics.* 1988;44(3):837-45.
22. Odom SR, Howell MD, Silva GS, et al. Lactate clearance as a predictor of mortality in trauma patients. *J Trauma Acute Care Surg.* 2013;74(4):999-1004.
23. American College of Surgeons (ACS) CoT. *Resources for Optimal Care of the Injured Patient* - Sixth Edition. 2014.
24. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med.* 2006;354(4):366-78.
25. Mullins RJ, Veum-Stone J, Hedges JR, et al. Influence of a statewide trauma system on location of hospitalization and outcome of injured patients. *J Trauma.* 1996;40(4):536-45; discussion 545-36.
26. Mullins RJ, Mann NC. Population-based research assessing the effectiveness of trauma systems. *J Trauma.* 1999;47(3 Suppl):S59-66.
27. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. *J Trauma.* 1999;47(3 Suppl):S46-55.
28. Hulka F, Mullins RJ, Mann NC, et al. Influence of a statewide trauma system on pediatric hospitalization and outcome. *J Trauma.* 1997;42(3):514-9.
29. Shapiro NI, Howell MD, Talmor D, et al. Serum lactate as a predictor of mortality in emergency department patients with infection. *Ann Emerg Med.* 2005;45(5):524-8.

Emergency Department Experience with Novel Electronic Medical Record Order for Referral to Food Resources

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Introduction: Food insecurity is a significant issue in the United States and is prevalent in emergency department (ED) patients. The purpose of this study was to report the novel use of an integrated electronic medical record (EMR) order for food resources, and to describe our initial institutional referral patterns after focused education and implementation of the order.

Methods: This was a retrospective, observational study, describing food-bank referral patterns before and after the implementation of dedicated ED education on the novel EMR order for food resources.

Results: In 2015, prior to formal education a total of 1,003 referrals were made to the regional food bank, Second Harvest Heartland. Five referrals were made from the ED. In 2016, after the educational interventions regarding the referral, there were 1,519 referrals hospital-wide, and 55 referrals were made from the ED. Of the 1,519 referrals 1,129 (74%) were successfully contacted by Second Harvest Heartland, and 954 (63%) accepted and received assistance.

Conclusion: Use of the EMR as a tool to refer patients to partner organizations for food resources is plausible and may result in an increase in ED referrals for food resources. Appropriate education is crucial for application of this novel ED process. [West J Emerg Med. 2018;19(2)232-237.]

INTRODUCTION

The United States Department of Agriculture (USDA) defines food insecurity as "limited or uncertain availability of nutritionally adequate and safe foods, or limited or uncertain ability to acquire acceptable foods in socially acceptable ways".[1] Food insecurity is prevalent in the U.S., affecting 12.7% of the population in 2016.[2] The impact of food insecurity can be pervasive and has been described by the World Health Organization as a key social determinant of health.[3]

The prevalence of hunger and the impact of food insecurity in the emergency department (ED) is clinically important and likely underestimated.[4–7] One study reported that 23.7% of ED patients reported hunger or food insecurity in the year prior, and nearly 18% of patients chose medicine over food during that same time period. Many of these patients reported the belief that this decision resulted in illness, ED visits, and hospitalization.[7]

To address such issues, healthcare institutions reportedly are partnering with food resources for their patients.[8] But if these services are to reach the patients, referrals must be initiated by staff or accessed directly by the patient/client. While our institution has partnered with the food bank Second Harvest Heartland since 2010, referrals from the ED were made infrequently. In 2015 a novel referral model was developed in the form of an electronic medical record (EMR) order by which ED providers could easily refer patients for food resources. Targeted education of the ED staff on food insecurity and instruction on the use of the EMR order was also performed.

The purpose of this study was to report the novel use of an integrated EMR order for food resources, and to describe our initial institutional referral patterns after focused education and implementation of the order.

Population Health Research Capsule

What do we already know about this issue?
The prevalence of hunger and the impact of food insecurity in the ED is a clinically important issue and likely underestimated. Food insecurity is prevalent in the U.S. and affected 12.7% of the population in 2016.

What was the research question?
The purpose of the study was to report the use of an integrated electronic medical record order for food resources and to describe our initial referral patterns.

What was the major finding of the study?
After focused education, ED referrals to the regional food bank increased from five in 2015 to 55 in 2016. Hospital-wide referrals increased from 1,003 in 2015 to 1,519 in 2016.

How does this improve population health?
The implementation of an integrated order in the electronic medical record for food resources is plausible and may increase ED use of food security resources.

METHODS

Study Setting and Population

This is a retrospective, observational study, describing food-bank referral patterns before (2015) and after (2016) the implementation of dedicated ED education on the novel EMR order for food resources. The study population was an urban, county ED with greater than 110,000 annual visits. This study was deemed exempt from review by our institutional review board.

Description of Food Services and Food Bank

Feeding America is a network of food banks, food pantries, and meal programs providing food and services in the U.S. It is the nation's largest organization to support hunger relief. Second Harvest Heartland, a midwestern member of Feeding America, is one of the nation's largest food banks, and supports over 1,000 food shelves and other partner programs that distribute food to over 532,000 individuals in Minnesota and western Wisconsin annually.

Our institution and Second Harvest Heartland have partnered to provide food assistance to our patients since 2010. As a result of this relationship, healthy food is available in our clinics in the form of bagged groceries, and on site through an institutional food shelf. Patients are able to receive food through clinics, at discharge from an inpatient stay, or delivered to their homes through a community paramedic program or visiting nurses.

The Institutional Referral Program

To determine eligibility for food services referrals in our institution, staff or providers screen patients for food insecurity with two questions. This two-question screening tool is a validated, abbreviated version of the 18-item U.S. Household Food Security Scale (HFSS), which is used to monitor national food security. [9] For purposes of our referral program, we modified the screening questions to be dichotomous yes/no responses from the validated responses: often, sometimes, or never. The questions included (1) "Within the past 12 months we worried whether our food would run out before we got money to buy more;" and (2) "Within the past 12 months the food we bought just didn't last and we didn't have money to get more." In its validation cohort, an affirmative response to either question yielded a sensitivity of 97% and specificity of 83%, compared to the gold-standard, full 18-item HFSS.

If deemed food insecure by this screening process, providers will then order a "referral for food" in the EMR to connect the patient to Second Harvest Heartland for support. The patient must consent to the referral and state what specific contact information they are comfortable sharing with the partner organization. This referral provides the patient's contact information to Second Harvest Heartland through an automated fax. The food bank staff will then assist the patient in enrolling in federal nutrition programs (see Table 1 for details), in addition to locating their neighborhood food shelves and meal programs, and arranging free produce distribution that they can access on a monthly basis.

Though initially intended for clinic and inpatient use, starting in 2015 this order became available for use in the ED (Figure). To advertise the referral program, focused information sessions were added to the emergency medicine resident educational conferences in late 2015, and to the new resident orientation, starting in 2016. In addition to this, semi-annual updates are integrated into the resident conferences, and the details of the referral patterns are distributed to faculty. Laminated placards were distributed in the ED to encourage discussions with patients about food security. All ED personnel were encouraged to use the referral order, including ED faculty physicians, residents, physician assistants, nursing staff, social workers, ED registration, and financial support staff. Institutional financial counselors were unforeseen allies with the program, as their workflow typically incorporated several questions that touched on financial and food security issues.

Table 1. Most frequent electronic medical record orders for food resources

	Food resource referrals - 2016
Pediatrics clinic	438
Internal medicine clinic	140
Family medicine clinic	246
Emergency department	55 (25 Attending Physicians, 22 Resident Physicians, 8 Physician Assistants)
Psychiatry clinic	52

Data Analysis

All data analysis was descriptive, using counts and proportion as appropriate. We described the frequency of food resource referrals before and after the implementation of an ED EMR order for food resources.

RESULTS

From January through December 2015 (preceding ED education on the EMR referral order), a total of 1,003 referrals were made to Second Harvest Heartland; only five were made from the ED. From January 2016 through December 2016 (after education regarding the EMR referral), there were 1,519 referrals hospital-wide, and 55 referrals were made from the ED. Table 2 outlines details of the frequency of EMR order use from all clinical sites. Of the 1,519 referrals, 1,129 (74%) were successfully contacted by Second Harvest Heartland, and 954 (63%) accepted and received assistance. Of the referred and successfully contacted households, 92% were connected with at least one new form of food assistance. This assistance included new information about geographically individualized food shelves, meal sites, and produce distribution. Of households eligible for the Supplemental Nutrition Assistance Program, 76% completed applications to the federal entitlement program. Additional details of the type of assistance patients received is detailed in Table 3.

DISCUSSION

This study sought to determine whether ED referrals for food resources for patients with food insecurity would increase after the implementation of an EMR referral order, as well as to introduce provider education about this referral program. To our knowledge, we report the first experience

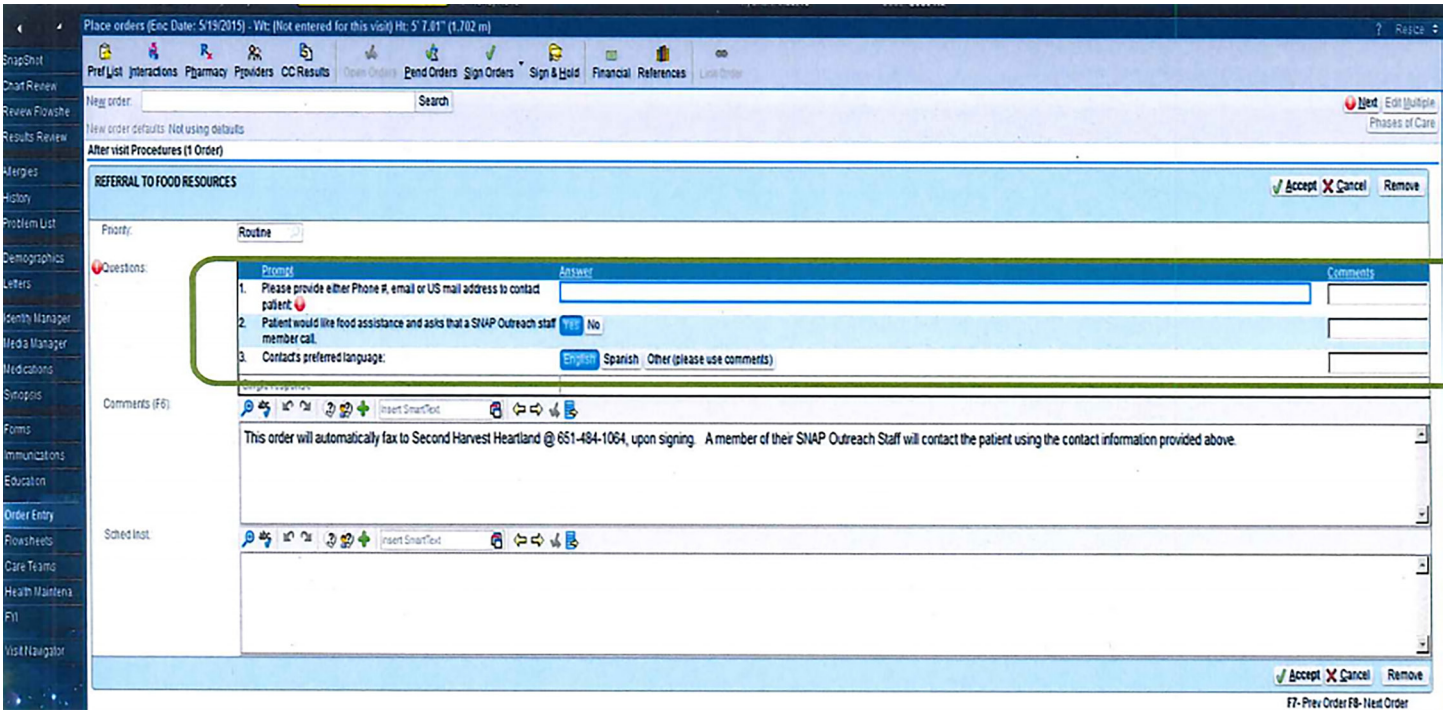

Figure. Emergency department "Order for Food Resources".

Table 2. List of food programs and whom they support

Name (acronym)	Description	Mothers & children	Seniors	Nutrition support	Foodbanks
Supplemental Nutrition Assistance Program (SNAP)	Formerly known as food stamps; now benefits are provided through an electronic card. SNAP can be used to purchase food at grocery stores.	X	X	X	
The Emergency Food Assistance Program (TEFAP)	The USDA buys food and distributes to individual states through food banks.	X	X	X	X
The Commodity Supplemental Food Program (CSFP)	Nutritious USDA foods are distributed to low-income seniors to supplement their diets.		X	X	X
The Child and Adult Care Food Program (CACFP)	Provides aid to child- and adult-care institutions with nutritious foods	X	X	X	X
The National School Lunch Program (NSLP)	Federally-assisted meal program providing nutritionally balanced, low-cost or free lunches to children in public and nonprofit private schools	X		X	
The School Breakfast Program (SBP)	Federally-assisted meal program providing nutritionally balanced, low cost or free lunches to children in public and nonprofit private schools. Some states have provided additional funding to provide universal, free breakfast for children.	X		X	
The Summer Food Service Program (SFSP)	A program that reimburses community organizations for hosting free meals for children under age 18 when they no longer have access to free and reduced-cost school lunch during the summer.	X		X	
Women, Infants, and Children (WIC)	Provides support for low-income, pregnant, breastfeeding and postpartum women and children up to age 5. This program is more nutrition-centered than SNAP as it includes check-ups, nutrition education, and supplemental foods.	X		X	

with such an institutional EMR order for food resources in the ED. While previous studies have documented the prevalence and ramifications of food insecurity in the ED,[4–7] the availability of a provider-driven order to improve this condition has not been previously documented.

Although food resources are available through a variety of federal and state programs, healthcare providers may be unaware of how to successfully connect patients with these programs.[10,11] Additionally, the details of the different programs, and understanding which programs apply to whom, can be unclear to patients and healthcare providers alike. Therefore, we believe that referring those patients in need to partners such as Second Harvest Heartland will likely be of greatest benefit to the patients, as these partners focus on one-on-one application assistance and navigation of programs, rather than simply handing out brochures or blank applications in the ED.

It is not surprising that using an EMR referral tool improved access to food services in our patient population; the benefit of EMR communication for connecting patients to numerous types of medical and social services has been well documented in the literature.[12–14] We did, however, identify certain issues with this referral process that are unique to food referrals and unique to the ED. For example, in contrast to the clinic setting where demographics and contact information is updated prior to patient evaluation, in the ED this information is frequently incomplete early in the patient's visit. If the EMR order was placed without accurate contact information, the information provided to Second Harvest Heartland was also incomplete. In the early stages of the ED referral, this led to a disproportionate number of ED referrals lacking the necessary contact information and thus these patients could not be reached. After identifying this problem, the EMR order was changed, requiring the provider to enter an address, phone number, mobile number, or email address, ensuring proper communication to the food bank for follow-up. Ongoing, focused education was valuable in ensuring this aspect of the order was completed for successful referrals.

Another important consideration identified during the implementation of this process was realizing the knowledge gaps regarding food insecurity in our ED. Screening for food insecurity is not standardized at intake, nor is it part of the registration/rooming process. As such, in faculty and resident discussions surrounding use of the order, failure to consider

Table 3. Types of assistance received as a result of the EMR food referral order

Assistance type*	Number of eligible referrals	% Eligible referrals
Community based referrals		
Food shelf	829	88%
Fare for all	825	88%
SFSP / community meals	742	79%
NAPS	96	10%
WIC	45	4%
SNAP screenings		
Already on SNAP	508	54%
SNAP application assistance		% of 446 patients not previously enrolled
Completed applications	338	76%
Ineligible	99	22%
Not interested in applying	9	2%

EMR, electronic medical record; *SFSP*, Summer Food Service Program; *NAPS*, Nutritional Assistance Program for Seniors; *WIC*, Women, Infants and Children; *SNAP*, Supplemental Nutritional Assistance Program.
*May be eligible for one or more.

food security as part of the ED assessment of patients was perceived to be a key limiting factor in making the food referral. Second Harvest Heartland began systematically visiting clinics and educating staff directly regarding the EMR order; while this helped increase referral volume in the clinics, the ED was targeted later in the rollout. We believe that this highlights the importance of provider education in the ED, as this patient population is at great risk for food insecurity and their needs may not be identified if they are not screened or if they do not use the clinic system. Even with education, concerted efforts and ongoing education are necessary.

LIMITATIONS

This study was subject to certain limitations, as it was only intended to describe referral patterns before and after implementing an institutional EMR order for food resources. We do not have patient data, such as demographics, as the data we present was provided from the food bank and thus protected. We also cannot account for whether referral increases were due to secular trends, rather than the provider education and the EMR order, though this is unlikely given the magnitude of the increase seen. We also acknowledge that 55 referrals in 12 months is not a substantial number given the prevalence of food insecurity;[5,6] we do believe, however, that our findings are still notable, demonstrating that a 10-fold increase in referrals out of the ED was possible with just a simple provider-driven process change. Finally, we cannot speak to long-term outcomes and whether the referrals lead to meaningful use of food resources over time. We were able to report the frequency at which services were initiated from the referral, but not if the patients maintained those services successfully.

CONCLUSIONS

This study suggests that using the EMR as a tool to refer patients to partner organizations for food resources is feasible, and may increase the frequency of referrals for food resources made from the ED. Such food-resource referrals are potentially an important initial step in addressing food insecurity in patients seen in the ED.

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REFERENCES

1. Measurement. USDA Economic Research Service. Available at:

https://www.ers.usda.gov/topics/food-nutrition-assistance/food-security-in-the-us/measurement/. Accessed on June 5, 2017.

2. Coleman-Jensen A, Rabbitt MP, Gregory CA, Singh A. Household Food Security in the United States in 2015 - USDA ERS. *US Department of Agriculture, Economic Research Service*. 2016. Available at: https://www.ers.usda.gov/webdocs/publications/79761/err-215.pdf?v=42636.
3. Closing the gap in a generation - World Health Organization. Available at: http://www.who.int/social_determinants/final_report/csdh_finalreport_2008.pdf. Accessed on June 2017.
4. Nelson K, Brown ME, Lurie N. Hunger in an adult patient population. *JAMA*. 1998;279(15):1211-4.
5. Kersey MA, Beran MS, McGovern PG, et al. The prevalence and effects of hunger in an emergency department patient population. *Acad Emerg Med*. 1999;6(11):1109-14.
6. Miner JR, Westgard B, Olives TD, et al. Hunger and food insecurity among patients in an urban emergency department. *West J Emerg Med*. 2013;14(3):253-62.
7. Biros MH, Hoffman PL, Resch K. The prevalence and perceived health consequences of hunger in emergency department patient populations. *Acad Emerg Med*. 2005;12(4):310-7.
8. Going Beyond Clinical Walls: Solving Complex Problems. Available at: https://www.icsi.org/solvingproblems/. Accessed on June 2017.
9. Hager ER, Quigg AM, Black MM, et al. Development and validity of a 2-item screen to identify families at risk for food insecurity. *Pediatrics*. 2010;126(1):e26-32.
10. Hoisington AT, Braverman MT, Hargunani DE, et al. Health care providers' attention to food insecurity in households with children. *Prev Med*. 2012;55(3):219-22.
11. Tscholl E, Holben DH. Knowledge and practices of Ohio nurse practitioners regarding food access of patients. *J Am Acad Nurse Pract*. 2006;18(7):335-42.
12. Esquivel A, Sittig DF, Murphy DR, et al. Improving the effectiveness of electronic health record-based referral processes. *BMC Med Inform Decis Mak*. 2012;12:107.
13. Burton LC, Anderson GF, Kues IW. Using electronic health records to help coordinate care. *Milbank Q*. 2004;82(3):457-81, table of contents.
14. Gandhi TK, Keating NL, Ditmore M, et al. Improving Referral Communication Using a Referral Tool Within an Electronic Medical Record. In: Henriksen K, Battles JB, Keyes MA, Grady ML, eds. *Advances in Patient Safety: New Directions and Alternative Approaches (Vol. 3: Performance and Tools)*. Rockville (MD): Agency for Healthcare Research and Quality (US); 2011.

Case Management Reduces Length of Stay, Charges, and Testing in Emergency Department Frequent Users

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Introduction: Case management is an effective, short-term means to reduce emergency department (ED) visits in frequent users of the ED. This study sought to determine the effectiveness of case management on frequent ED users, in terms of reducing ED and hospital length of stay (LOS), accrued costs, and utilization of diagnostic tests.

Methods: The study consisted of a retrospective chart review of ED and inpatient visits in our hospital's ED case management program, comparing patient visits made in the one year prior to enrollment in the program, to the visits made in the one year after enrollment in the program. We examined the LOS, use of diagnostic testing, and monetary charges incurred by these patients one year prior and one year after enrollment into case management.

Results: The study consisted of 158 patients in case management. Comparing the one year prior to enrollment to the one year after enrollment, ED visits decreased by 49%, inpatient admissions decreased by 39%, the use of computed tomography imaging decreased 41%, the use of ultrasound imaging decreased 52%, and the use of radiographs decreased 38%. LOS in the ED and for inpatient admissions decreased by 39%, reducing total LOS for these patients by 178 days. ED and hospital charges incurred by these patients decreased by 5.8 million dollars, a 41% reduction. All differences were statistically significant.

Conclusion: Case management for frequent users of the ED is an effective method to reduce patient visits, the use of diagnostic testing, length of stay, and cost within our institution. [West J Emerg Med. 2018;19(2)238-244.]

INTRODUCTION

Frequent users of the emergency department (ED) represent a complex group of patients who overuse ED resources. This group accounts for as many as 28% of all ED visits, with the number of annual visits by this group continuing to rise.[1-4] Frequent users of the ED are defined as patients making four or more ED visits per year; however, some "ultra"-frequent users may make 20 or more visits per year.[2-8] It has been well established that ED frequent users increase healthcare costs and contribute to ED and hospital crowding.

While the reasons underlying frequent ED visits are often complex and may represent failure of the healthcare system to

provide for patients with complex needs, ED frequent users incur significant charges and time for treatment and testing as a part of their evaluation and treatment. Additionally, as a part of each ED visit, evaluation, and treatment, patients spend time occupying EDs bed and using hospital services such as phlebotomy and radiology.[5,7,9-14] ED bed time and hospital resources are a valuable commodity, particularly as ED visits continue to rise nationwide, making the reduction of such resources by ED frequent users a desirable goal.

Case management, as defined by the Case Management Society of America, is a "collaborative process of assessment, planning, facilitation, care coordination, evaluation, and advocacy for options and services to meet an individual's and family's comprehensive health needs through communication and available resources to promote quality, cost-effective outcomes."[15] Given the complex medical and social needs of ED frequent users, case management has been extensively used in this group of patients, with multiple studies showing successful reducing in the use of ED services and cost of care in the ED.[5,9,13,16-23] A 2017 systematic review identified 31 different studies of interventions to decrease ED visits by frequent users.[19] However, despite the large number of studies published, there has been little research on the effect of ED case management for frequent users on length of stay (LOS), either in the ED or in the inpatient setting. To the best of our knowledge, this is the first study to evaluate the effect of case management on ED, inpatient, and total hospital LOS for all types of visits by ED frequent users.

The goal of this investigation was to explore the effect of ED case management in frequent users of the ED on LOS, both in the ED and the inpatient setting. To better understand the impact of case management in this population, we also chose to look at the effect of this intervention on ED and hospital charges as well as utilization of hospital services. We hypothesized that ED case management would reduce ED visits, admissions, ED LOS, inpatient LOS, charges, and diagnostic studies.

Population Health Research Capsule

What do we already know about this issue?
Frequent users of the emergency department (ED) are high utilizers of healthcare resources. Case management has been proven to reduce the number of ED visits by frequent users of the ED.

What was the research question?
How does case management for ED frequent users affect ED and inpatient length of stay? Is the use of healthcare resources affected?

What was the major finding of the study?
Case management in this group reduced ED and inpatient length of stay. Admissions, testing, and hospital charges also decreased.

How does this improve population health?
Case management for ED frequent users can reduce over-utilization of healthcare resources by ED frequent users, allowing EDs to provide faster care to ED patients with normal ED use.

METHODS

We conducted this study at a 225-bed hospital in a suburban area, with approximately 56,000 ED visits per year. The surrounding healthcare community consists of a variable mix of county-run primary care clinics and private practice physicians – in both primary care and specialty care. There are few free clinics in the surrounding area. Two other hospitals are within 30 miles of our institution, one of which is a county hospital.

The study consisted of a retrospective chart review of ED and inpatients visits by patients in our hospital's Emergency Department Recurrent Visitor Program (EDRVP), comparing the visits made in the one year prior to enrollment in the program, to the visits made in the one year after enrollment in the program. This study was considered exempt by our hospital's institutional review board.

The EDRVP is run by an ED social worker or registered nurse (RN), with emergency physicians, social workers, ED RNs, chemical dependency providers, behavioral health RNs, case managers, and representatives from local insurance providers. At monthly meetings, members of the EDRVP discuss approximately 10 patients who have been referred to the program. If a care plan does not appear to be working to address frequent ED visits or a new issue has come up for the patient causing recurrence of heavy ED use, the patient's case and care plan is re-visited at the next meeting. If a truly urgent or emergent issue arises, the staff will correspond via secure email or in person to address it and develop new care plans or revisions to existing care plans. The program was developed initially in 2006 by ED staff at our hospital to address increasing visits by frequent users. As the program has grown, additional hospital staff and services have been recruited to assist us with the growing number of patients requiring case management, and to meet newly identified needs of patients in the program.

For inclusion criteria, patients are referred to the program for any of the following reasons: concerning ED use (as identified by an ED staff member); 10 or more ED visits in 12 months; six or more ED visits in six months; four or more ED visits in one month; or activity by a patient that demonstrates a propensity for future problematic ED encounters – such as violence in the ED or

prescription forgery. Patients exhibiting such high-risk activity were believed to be potentially problematic patients, and therefore a plan was developed to preempt frequent, potentially dangerous, recurrent, and problematic visits. There are no exclusion criteria, and patients of any age may be referred. Once a patient has been referred for enrollment in the program, his or her visits are reviewed to determine the underlying medical, psychiatric, and social issues causing the multiple ED visits. A plan of care for the patient is then developed, with the intent to address these issues in the outpatient setting. Care plans may include referring the patient for a case manager, referring the patient to a needed specialist, assisting the patient with unstable housing, or requiring that patients only receive medications from their primary doctor – rather than coming to the ED for refills.

We studied all patients enrolled in the EDRVP between October 2013 and June 2015. For each patient, we reviewed all ED and inpatient visits for the one-year time period before they were enrolled as well as the one- year time period after they were enrolled. Visits were reviewed using the hospital's electronic medical records system, Sunrise Clinical Manager (Version 14.3; Allscripts Healthcare Solutions. Chicago, IL). We recorded the number of each of the following parameters for the year before and year after enrollment: number of ED visits; number of inpatient admissions; ED LOS; inpatient LOS; ED charges; inpatient charges; number of computed tomography (CT) scans; number of ultrasounds; number of radiographs, and number of ED visits at which blood work was performed.

Additionally, we noted six main reasons why patients were referred to the program: needing pain management; complex psychosocial issues; complex medical conditions; psychiatric illness; substance abuse; and needing resources or referrals. We recorded the reason for referral for each of our patients. Six chart reviewers reviewed all of the visits and recorded the data using a standardized data collection spreadsheet in Microsoft Excel (Excel 2013; Microsoft Corporation. Redmond, WA). The lead author supervised the chart reviewers to ensure that data collection was standardized and accurate between them.

After data collection was complete, we proceeded with data analysis. As we wanted to determine the effect of ED case management on the study parameters listed above, we compared each of the parameters for each patient from the one-year time period before enrollment in the program to the one-year time period after enrollment in the program. To evaluate for statistical significance, we then used a paired Wilcoxon signed-rank test, comparing the year before enrollment to the year after enrollment. Statistical analysis was performed with Microsoft Excel and Max Stat (Version 3.60; MaxStat. Jever, Germany).

RESULTS

Between October 2013 and June 2015, we enrolled 158 patients into the EDRVP program, which reflects our process of enrolling approximately 10 patients per month over this 19-month period. For administrative reasons, enrollment was significantly less than 10 patients per month on a few occasions. Demographic information of the patients can be found in Table 1. The oldest patient enrolled during this time period was 75 years old at the time of enrollment, with the youngest being nine months old at the time of enrollment.

In the one year prior to enrollment, patients in the program made 1,685 ED visits with 159 inpatient admissions, as compared to 855 ED visits with 97 inpatient admissions after enrollment. The number of CTs, ultrasounds, radiographs, and ED visits during which blood testing was done all decreased as well from the year prior to enrollment to the year after enrollment. All differences were statistically significant with a p-value of <0.05. The complete data on utilization of services is displayed in Table 2.

In the one year prior to enrollment, patients in the program occupied 125 days (a full 24-hour period) of ED bed time, along with 334 days of inpatient bed time, for a total of 459 days of ED and inpatient bed time. After enrollment in the program, this decreased to 83 days of ED bed time, 198 days of inpatient bed time, for a total of 281 days of ED and inpatient bed time. All differences were statistically significant with a p-value of <0.05. The complete data on LOS are displayed in Table 3.

In the one year prior to enrollment, charges incurred by ED visits by patients in the program were $5,827,162, with charges incurred during inpatient stays totaling $8,453,761, for a grand total of $14,280,923. In the one year after enrollment in the program, charges incurred by ED visits by patients in the program were $3,041,473, with charges incurred during inpatient stays totaling $5,405,175, for a grand total of $8,446,648. All differences were statistically significant with a p-value of <0.05. The complete data on charges are displayed in Table 4.

Table 1. Population in a study examining the effects of case management on frequent users of the emergency department. n = 158

	Total	Percent of total group
Homeless	12	7.6
Male	71	44.9
Female	87	55.1
Insurance		
Medicaid	90	57.0
Medicare	32	20.3
Tricare	3	1.9
Commercial	23	14.6
None	6	3.8
Other	4	2.5

Age at enrollment (mean) = 42.4 years

Table 2. Utilization of testing and services before and after enrollment of frequent ED users in a case management program.

	Pre-intervention	Post-intervention	Absolute change	Percent change	P-value
ED visits (1 year)	1685	855	-830	-49.26	<0.0001
Inpatient admissions (1 year)	159	97	-62	-38.99	0.002
Computed tomography	201	119	-82	-40.80	0.0001
Ultrasounds	71	34	-37	-52.11	0.01
Radiographs	384	239	-145	-37.76	<0.0001
ED visits during which blood testing was done	724	386	-338	-46.69	<0.0001

ED, emergency deparment.

Finally, we reviewed the reasons that patients were referred to the program. The greatest number were referred for issues regarding substance abuse, and the need for improved pain management. Additionally, the majority of patients had more than one issue for which they were identified as needing assistance, with the average number of reasons for referral being two per patient. The complete data are displayed in Table 5.

DISCUSSION

Our study clearly demonstrates that ED case management reduces utilization of services, LOS, and cost in a population of ED frequent users. Clearly in the current U.S. healthcare environment, which is characterized by expensive care and crowded hospitals and EDs, this is critical information and may provide some ideas to develop solutions to the problems of high cost and crowding. In reviewing the data on the reason for referrals to the program, it is apparent that this group of patients has complex needs, with less than a third of the group being referred to the program to address only one issue. This supports the need for a comprehensive case management program like the one we have instituted, as we believe that addressing only a single issue underlying recurrent ED use may not decrease ED utilization.

From an ED administration standpoint, the most compelling piece of data appears to be the effect of ED case management on LOS. EDs across the U.S. struggle with crowding, often with critically ill or injured patients being forced to wait in waiting rooms when no beds are available. Our study showed that ED case management for ED frequent users helps this problem in two ways. First, by reducing ED visits and ED LOS, the program directly decreases the amount of ED bed time occupied by these repeat visitors, freeing up beds for patients in the waiting room. Second, by reducing inpatient LOS, ED patients are more likely to have inpatient beds available when needed, reducing the frequency of ED boarding. With less ED boarding, there is more available bed time in the ED for new patients from the waiting room. This increased ability to place new patients from the waiting room allows for new patients to be roomed much more quickly, allowing for critically ill and injured patients to receive time-sensitive treatment more quickly and reducing the door-to-doctor time for all patients in the department.

In looking at the cost implications of our analysis, we must consider the payer mix when considering the implication of reducing ED and inpatient charges in such a drastic fashion, as insurance plans reimburse at variable rates. A 2016 Texas study found that for every $1.00 paid by Medicare to reimburse medical services, private insurance paid between

Table 3. Length of stay (LOS).

	Pre-intervention	Post-intervention	Absolute change	Percent change	P-value
Length of stay (LOS) in minutes					
ED LOS	450041	299514	-150527	-33.45	<0.0001
Inpatient LOS	1204099	711671	-492428	-40.90	0.001
Total LOS	1654140	1011185	-642955	-38.87	<0.0001
Length of stay (LOS) in days					
ED LOS	125.01	83.20	-41.81	-33.45	<0.0001
Inpatient LOS	334.47	197.69	-136.79	-40.90	0.001
Total LOS	459.48	280.88	-178.60	-38.87	<0.0001

ED, emergency deparment.

Table 4. The change in charges (in U.S. dollars) before and after frequent users were enrolled in care management program.

	Pre-intervention	Post-intervention	Absolute change	Percent change	P-value
ED charges	5,827,162	3,041,473	-2,785,690	-47.81	<0.0001
Inpatient charges	8,453,761	5,405,175	-3,048,586	-36.06	0.003
Total charges	14,280,923	8,446,648	-5,834,275	-40.85	<0.0001

ED, emergency deparment.

$1.15 and $2.35, while Medicaid paid between $0.61 and $0.85.[23] When looking at charges for services on the order of several million dollars, as in our study, the difference between reimbursement by private insurance and public insurance is enormous, also on the order of millions of dollars.

In our study, the majority of patients (57%) had Medicaid insurance, which (as demonstrated by the study above) results in lower reimbursements to the hospital as compared to other insurance programs. While we were unable to perform a formal cost analysis of the charges and reimbursements to the hospital due to limitations in access to the data, the fact that our intervention reduced visits predominantly by patients with Medicaid insurance is not likely to be financially harmful to the hospital. Furthermore, in reducing charges by the patients in our program, our intervention was able to save significant monies for all insurance programs in our healthcare system, which could be used for other health improvements and interventions, such as prevention and education.

Finally, it is clear that our intervention – case management for ED frequent users – decreased ED visits, with the results evident from our study, as well as multiple previous studies cited above. In our study, we noted a decrease in inpatient admissions, ED and inpatient LOS, charges, and the use of testing. The question arises as to whether case management reduces these metrics simply by keeping people out of the ED, or whether case management has some additional effect on utilization of services. In looking at Table 2, it becomes clear that ED visits decreased by 49%, with admissions and utilization of testing decreasing by about the same percentage, or slightly less. Continuing with Tables 3 and 4, LOS and charges decreased by less than 49%. This would suggest (although a formal analysis was not performed) that the most effective aspect of ED case management for frequent users is the ability to decrease ED visits, with all other decreased metrics the result of the patient not being in the ED (and therefore subjected to testing, charges, and possible admission).

LIMITATIONS

Our study had several limitations. First, because we looked at ED and hospital visits at just one institution our study includes a relatively small number of patients. It is possible that patients in the program simply chose to seek care at other hospitals and EDs. Thus, while we were able to significantly reduce cost, LOS, and utilization at our hospital, similar parameters may have increased at neighboring hospitals due to patients avoiding our institution. A study of the effect of ED case management on multiple hospitals within a geographic

Table 5. Reasons for referrals to Emergency Department Recurrent Visitor Program. n = 158

Reason for referral	Number of patients	% of total patients
Substance use	101	63.5
Need pain management	96	60.4
Psychiatric illness	46	28.9
Complex psychosocial issues	26	16.4
Needing resources/referrals	21	13.2
Complex medical conditions	20	12.6
Average number of reasons for referrals per patient		2
Number of reasons for referral		
Referred for 1 reason	47	29.7
Referred for 2 reasons	79	50.0
Referred for 3 reasons	23	14.6
Referred for 4 reasons	9	5.7

region would provide valuable information on this issue.

Second, our study consisted of a retrospective chart review of a program in existence at our hospital, with no control group for comparison. While case management likely accounted for the significant changes in the parameters studied, it is possible that other factors, or simply regression towards the mean, accounted for part or all of our significant decreases.

Another limitation was that we did not look at testing utilization over the long term, but rather only compared the year prior to the intervention to the year after the intervention. For patients with recurrent complaints, physicians may not choose to perform imaging if imaging has recently been done. So, it is possible that robust imaging done on our patients in the year prior to enrollment decreased physician ordering of imaging studies in the year after enrollment. To be certain that our intervention decreased imaging study utilization, we would have needed to compare imaging in several years prior to enrollment to the year after enrollment.

Finally, as previously mentioned we did not conduct a formal cost analysis of charges and reimbursements to our institution to determine the impact of the significant reduction in ED charges. While again we speculated that with the majority of enrolled patients having Medicaid, the reduced charges represented savings to the hospital, it is possible that the program may have reduced reimbursements to the hospital in an unfavorable way.

CONCLUSION

Case management is an effective means for reducing recurrent ED visits by frequent users. As a result of decreased ED visits, case management also was shown to reduce cost, length of stay, and utilization of testing – both in the ED and the inpatient setting.

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REFERENCES

1. Martin GB, Stokes-Buzzelli SA, Peltzer-Jones JM, et al. Ten years of frequent users in an urban emergency department. *West J Emerg Med*. 2013;14(3):243-6.
2. Ruger JP, Richter CJ, Spitznagel EL, et al. Analysis of costs, length of stay, and utilization of emergency department services by frequent users: implications for health policy. *Acad Emerg Med*. 2004;11(12):1311-7.
3. Doupe MB, Palatnick W, Day S, et al. Frequent users of emergency departments: developing standard definitions and defining prominent risk factors. *Ann Emerg Med*. 2012; 60(1):24-32.
4. LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the policy implications. *Ann Emerg Med*. 2010;56(1): 42-8.
5. Murphy SM, Neven D. Cost effective: emergency department care coordination with a regional hospital information system. *J Emerg Med*. 2014;47(2):223-31.
6. Liu SW, Nagurney JT, Chang Y, et al. Frequent ED users: are most visits for mental health, alcohol, and drug-related complaints? *Am J Emerg Med*. 2013;31(10):1512-5.
7. Vinton DT, Capp R, Rooks SP, et al. Frequent users of US emergency departments: characteristics and opportunities for intervention. *Emerg Med J*. 2014;31(70):526-32.
8. LaCalle EJ, Rabin EJ, Genes NG. High-frequency users of emergency department care. *J Emerg Med*. 2013;44(6):1167-73.
9. Weiss A, Schechter M, Chang G. Case management for frequent emergency department users. *Psychiatr Serv*. 2013;64(7):715-6.
10. Castillo EM, Brennan JJ, Killeen JP, et al. Identifying frequent users of emergency department resources. *J Emerg Med*. 2014;47(3):343-7.
11. Scott J, Strickland AP, Warner K, et al. Frequent callers to and users of emergency medical systems: a systematic review. *Emerg Med J*. 2014;31(8):684-91.
12. Shapiro JS, Johnson SA, Angiollilo J, et al. Health information exchange improves identification of frequent emergency department users. *Health Aff (Millwood)*. 2013;32(12):2193-8.
13. McCormack RP, Hoffman LF, Wall SP, et al. Resource-limited, collaborative pilot intervention for chronically homeless, alcohol-dependence frequent emergency department users. *Am J Public Health*. 2013;103 Suppl 2:S221-4.
14. Fertel BS, Hart KW, Lindsell CJ, et al. Patients who use multiple EDs: Quantifying the degree of overlap between ED populations. *West J Emerg Med*. 2015;16(2):229-233.
15. Case Management Society of America. Definition of Case Management. Available at: http://www.cmsa.org/Home/CMSA/WhatisaCaseManager/tabid/224/Default.aspx. Accessed on August 9, 2017.
16. Crane S, Collins L, Hall J, et al. Reducing utilization by uninsured frequent users of the emergency department: combining case management and drop-in group medical appointments. *J Am Board Fam Med*. 2012;25(2):184-91.
17. Kumar GS, Klein R. Effectiveness of case management strategies in reducing emergency department visits in frequent user patient

populations: a systematic review. *J Emerg Med*. 2013;44(3):717-29.
18. Hudon C, Chouinard MC, Lambert M, et al. Effectiveness of case management interventions for frequent users of healthcare services: a scoping review. *BMJ Open*. 2016;6(9):e012353.
19. Moe J, Kirkland SW, Rawe E, et al. Effectiveness of interventions to decrease emergency department visits by adult frequent users: a systematic review. *Acad Emerg Med*. 2017;24(1):40-52.
20. Soril LJ, Leggett LE, Lorenzetti DL, et al. Reducing frequent visits to the emergency department: a systematic review of interventions. *PLoS One*. 2015;10(4):e0123660.
21. [No authors listed]. ED case managers save $4.5 million. *Hosp Case Manag*. 2011;19(8): 117, 122-3.
22. Shumway M, Boccellari A, O'Brien K, et al. Cost-effectiveness of clinical case management for ED frequent users: results of a randomized trial. *Am J Emerg Med*. 2008;26(2):155-64.
23. Grover CA, Close RJ, Villarreal K, et al. Emergency department frequent user: a pilot study of intensive case management to reduce visits and computed tomography. *West J Emerg Med*. 2010;11(4):336-43.
24. Krause TM, Ukhanova M, Revere FL. Private carriers' physician payment rates compared with Medicare and Medicaid. *Tex Med*. 2016;112(6):e1.

Transition of Care from the Emergency Department to the Outpatient Setting: A Mixed-Methods Analysis

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Introduction: The goal of this study was to characterize current practices in the transition of care between the emergency department and primary care setting, with an emphasis on the use of the electronic medical record (EMR).

Methods: Using literature review and modified Delphi technique, we created and tested a pilot survey to evaluate for face and content validity. The final survey was then administered face-to-face at eight different clinical sites across the country. A total of 52 emergency physicians (EP) and 49 primary care physicians (PCP) were surveyed and analyzed. We performed quantitative analysis using chi-square test. Two independent coders performed a qualitative analysis, classifying answers by pre-defined themes (inter-rater reliability > 80%). Participants' answers could cross several pre-defined themes within a given question.

Results: EPs were more likely to prefer telephone communication compared with PCPs (30/52 [57.7%] vs. 3/49 [6.1%] P < 0.0001), whereas PCPs were more likely to prefer using the EMR for discharge communication compared with EPs (33/49 [67.4%] vs. 13/52 [25%] p < 0.0001). EPs were more likely to report not needing to communicate with a PCP when a patient had a benign condition (23/52 [44.2%] vs. 2/49 [4.1%] p < 0.0001), but were more likely to communicate if the patient required urgent follow-up prior to discharge from the ED (33/52 [63.5%] vs. 20/49 [40.8%] p = 0.029). When discussing barriers to effective communication, 51/98 (52%) stated communication logistics, followed by 49/98 (50%) who reported setting/environmental constraints and 32/98 (32%) who stated EMR access was a significant barrier.

Conclusion: Significant differences exist between EPs and PCPs in the transition of care process. EPs preferred telephone contact synchronous to the encounter whereas PCPs preferred using the EMR asynchronous to the encounter. Providers believe EP-to-PCP contact is important for improving patient care, but report varied expectations and multiple barriers to effective communication. This study highlights the need to optimize technology for an effective transition of care from the ED to the outpatient setting. [West J Emerg Med. 2018;19(2)245-253.]

INTRODUCTION

The vast majority of patients presenting to the emergency department (ED) are evaluated and subsequently discharged.[1] Many of these visits will require a follow-up plan of care with a primary care physician (PCP). An appropriate transfer of information, within a reasonable time frame, must occur during this hand-off to ensure high-quality patient care and continuity of disease management.

Background

Patient care transitions directly impact quality and patient safety. The discharge of a patient from the ED is a time of high vulnerability. Given the increasing complexity of medical care and the limitations that some patients may have due to language fluency or health literacy, the expectation of high-fidelity information transfer through discharge instructions alone is unrealistic in many cases.[2] Prior studies have looked at handoffs between emergency physicians (EP) at shift change, between EPs and hospitalists, and between EPs and nursing homes.[3-6] Common themes that arise from the literature regarding transitions of patient care from one healthcare provider to another are the need for bidirectional communication and a balance between standardization and flexibility.[2]

Both EPs and PCPs believe that coordination of care between the two settings is an important transition in healthcare.[7] Communication between the EPs and PCPs has been regarded as unsatisfactory, if performed at all.[8] Poor communication results in provider confusion regarding follow-up needs, which may predispose patients to error or adverse events.[9-10] The process of hospital discharge to outpatient care currently has multiple barriers that contribute to poor transitions of care. These include unstructured communication systems, such as the electronic medical record (EMR), lack of longitudinal care and absence of follow-up standards.[11] To begin to address barriers to effective transitions of care, it is necessary to investigate current systems of communication, with a focus on provider expectations and use of the EMR.

Goals of this Investigation

The goal of this study was twofold. First, we aimed to characterize the current practices in the transition of care from the ED to the outpatient setting. Second, we sought to clarify providers' preferences and use of EMR technology in managing that transition.

Population Health Research Capsule

What do we already know about this issue?
Transitions of care directly impact patient safety and healthcare quality. Discharge from the ED is a time of high vulnerability, yet there are few standards of communication in place.

What was the research question?
What are the current practices and preferences in the transition of care from the ED to the outpatient setting?

What was the major finding of the study?
Discrepancies exist between EP and PCP expectations and handoff preferences, and there are numerous barriers to communication.

How does this improve population health?
Standardized systems of communication should be the focus of improvements in the transition of care to the outpatient setting, with a specific focus on electronic medical record tools and technology.

METHODS

Study Design

This was a prospective study using semi-structured interviews. We developed a mixed-methods survey based on literature review and modified Delphi technique.[12] The survey was designed in two phases (Figure 1). In the first phase, the authors created the survey tool, which consisted of a set of general questions in regard to professional setting. The remainder of the survey was divided into questions specific for either EPs or PCPs. We included both multiple-choice questions and free-response questions to ensure capture of individual practices (Appendix). The survey was piloted via email to a group of 16 EPs and PCPs.

After the initial pilot test, we reviewed and modified the survey for usability and redundancy. Additionally, we changed the format to an in-person interview. Four external reviewers were consulted and the survey was further refined for the in-person interview. Content validity and face validity were assessed by a process of multiple revisions based on pilot-test results, expert analysis, and triangulation.[13] The survey was re-piloted in an in-person interview format with three EPs and three PCPs to obtain feedback on structure. We surveyed participants at eight different institutions. Participant anonymity was maintained by collection of data without identifying information.[14, 15]

Setting

The survey tool was developed by members of the American College of Emergency Physicians (ACEP) Academic Affairs Committee. Academic and community physicians at eight different sites across the country participated in the study. We selected institutions based on author affiliation; these

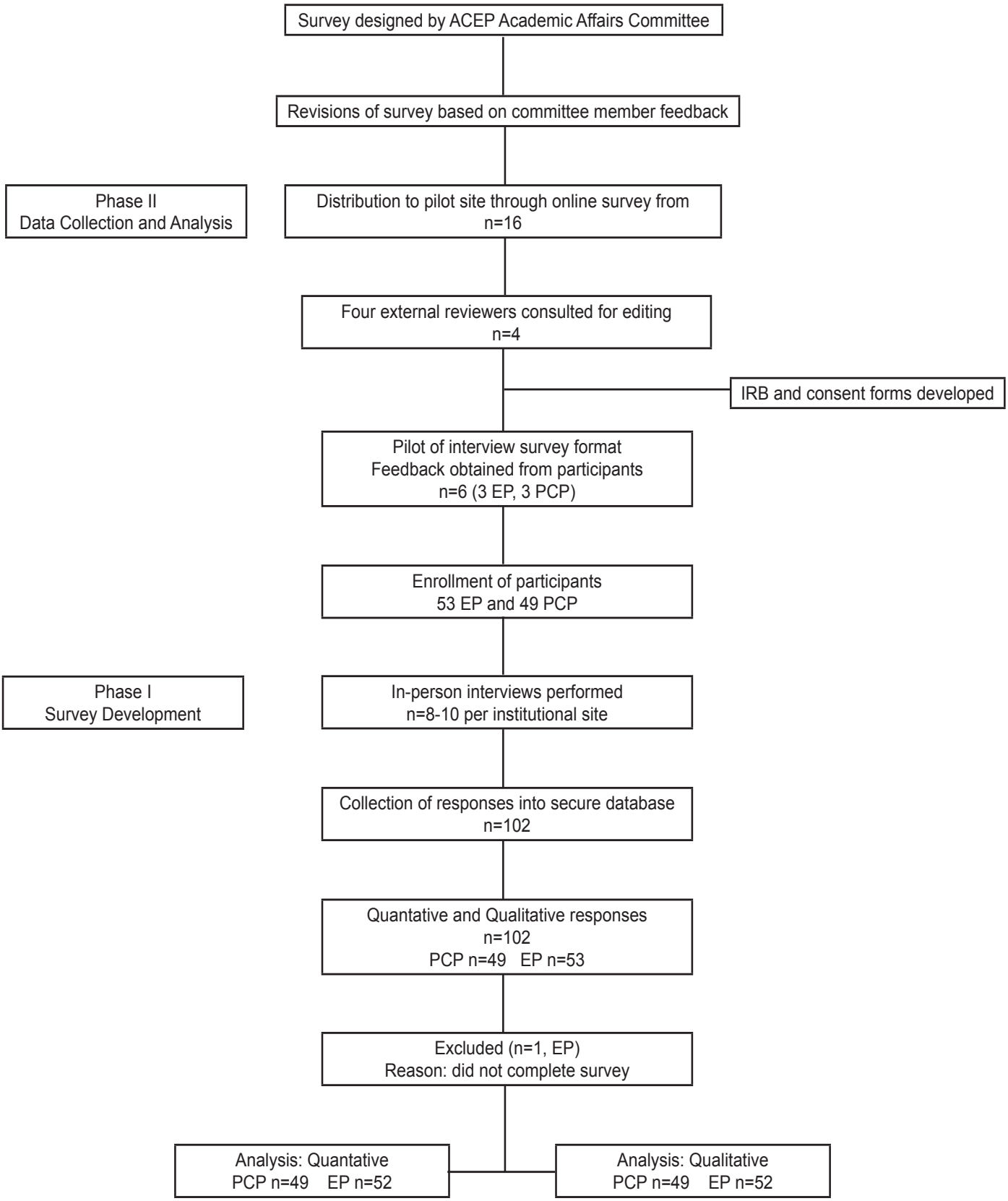

Figure 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram of responses to transition-of-care survey. *ACEP*, American College of Emergency Physicians; *EP*, emergency physician; *PCP*, primary care physician.

included University of California Davis, Eastern Virginia Medical School, Baylor College of Medicine, University of Nebraska, MetroHealth Medical Center, University of Iowa, Loyola University, and University of Texas San Antonio.

Selection of Participants

We obtained institutional review board approval at each site. These institutions were primarily urban-based academic centers. Each author selected a convenience sample of EPs and PCPs. Only attending- level physicians were enrolled.

Methods and Measurement

All participants underwent a verbal, informed consent prior to completing the survey. Interviews took place in person and lasted 15-20 minutes. We de-identified all data upon response submission. Data responses were collected electronically into a single electronic database at each site, and subsequently combined into a master database.

Analyses

Quantitative data was extracted and entered into a processing program. We examined five demographic questions for all participants. The PCP survey contained 12 additional multiple-choice questions about transitions of care, and the EP survey contained eight additional questions. Data analysis was performed in SAS (version 9.2; SAS Institute, Inc. Cary, NC) using Fisher's exact test. We performed qualitative data analysis for responses to the open-ended questions.

Themes were developed based on a grounded theory approach.[16,17] Two independent coders used the constant comparative method to identify themes in the data collected from the interviews. If a discrepancy occurred, the reviewers discussed to achieve consensus. Themes were standardized for each question, and data were independently coded according to established themes. We assigned responses to one or more themes for each question. In an effort to minimize rater subjectivity regarding identified themes, we measured inter-rater reliability for each question with the goal of > 80% agreement.[18] Percent agreement was based on the alignment of all selected themes for each question. We analyzed qualitative data for percent representation of individual themes. The number of responses for each theme was calculated and averaged between the coders for a percent representation of each theme.

RESULTS

Characteristics of Study Subjects

Between November 2014 and February 2015, 102 interviews were attempted. Forty-nine respondents were PCPs and 53 were EPs. Of these respondents, one EP participant did not complete the survey in its entirety. This respondent was omitted from the analysis, resulting in 101 responses analyzed.

PCPs were divided between family medicine, internal medicine, and pediatrics. All of the EPs were trained in emergency medicine, with one individual also trained in pediatrics. Both EPs and PCPs share similar demographic trends with the majority of the sites categorized as urban academic settings. The remainder of the demographic information is shown in Table 1.

Quantitative Analysis

PCPs reported receiving communication about an ED visit much more frequently than EPs reported communicating back to the PCPs. Forty percent of PCPs reported actually receiving follow-up on their patients "most" of the time (81-100%), but a greater proportion (61.2%) felt that they should be contacted at this frequency. EPs preferred telephone communication to EMR and reported greater use of this modality, whereas PCPs preferred discharge communication through the EMR.

EPs were more likely to report no PCP communication for a patient with a benign and stable condition.

For patients requiring urgent follow-up, EPs were more likely to report the need for verbal communication prior to the patient's discharge from the ED than PCPs. Both groups thought that a patient with an urgent condition required direct discharge communication with the PCP (Table 2).

Regarding perceptions of EMR use, EPs believe that the majority of PCPs (53.8%) use the same EMR and view the patient's records directly. A minority of EPs believed that PCPs receive EMR notifications of a patient visit, whereas many PCPs reported receiving a notification.

Qualitative analysis

Analysis of the 101 responses to qualitative-response questions identified thematic concepts for each question. The first question, "Under what circumstance is it important that the emergency physician communicate with a patient's primary care physician?" demonstrated that follow-up needs were the most important reason to communicate with PCPs. Figure 2 demonstrates physician response.

Physicians also responded to the question, "How should EMR be used as a tool in the transition of care?" More PCPs reported EMR notification/alert systems as a valuable use of EMR, compared to EPs who cited the EMR's ability to aid in follow-up and continuity of care. Figure 3 demonstrates physician response.

Finally, providers were asked, "What are major barriers to efficient communication with EP/PCPs?" Themes included setting/environmental constraints, communication logistics, and EMR barriers. Patient constraints were reported to a lesser extent by both groups. Poor documentation was mentioned among the PCP group. Figure 4 demonstrates physician response.

DISCUSSION

Our multi-center prospective study examines and highlights the current practices and preferences for handoffs between EPs and PCPs and highlights quality gaps in the

Table 1. Demographic information of survey participants.

	PCP (N=49)	EP (N=52)
Specialty type		
Emergency medicine		51
Family medicine	25	
Internal medicine	15	
Pediatrics	8	
Combined emergency medicine/pediatrics		1
Combined internal medicine/pediatrics	1	
Years In practice		
Range	1-56	1-33
Average	15.3	10.4
Median	14	9.5
Type of practice		
Academic	34	36
Community	10	10
Both academic/community	4	5
No response	1	1
Setting		
Urban	21	27
Suburban	15	22
Rural	0	0
No response	13	3
Use of electronic medical record		
Yes	48	51
No	1	0
No response	0	1
Type of electronic medical record		
Epic	28	47
NextGen EHR	3	0
Allscripts	7	3
Sunrise	10	0
Azyxil	0	1
None	1	0
No response	0	1

EP, emergency physician; *PCP*, primary care physician.

transition of the discharged ED patient back to the community. The study results suggest there is a discrepancy in provider expectations regarding best method of communication, and a disconnect between perception and reality of frequency of contact between ED and PCP providers. EPs preferred direct phone contact and communication synchronous to the encounter on patients needing urgent follow-up. In addition, EPs treated the communication of benign conditions differently that those with an urgent need. PCPs, on the other hand, preferred gathering information from the EMR and communication asynchronous to the encounter and wanted communication about non-urgent patients more often than EPs.

EPs may prefer to communicate by telephone because perhaps they are not aware of the extent to which PCPs automatically receive updates through the EMR. Less than half of EPs perceived that PCPs receive an EMR notification, while a majority of PCPs reported receiving an alert through

Table 2. Results of quantitative analysis comparing primary care physician and emergency physicians responses to questions regarding direct discharge communication.

	PCP (N = 49)	EP (N = 52)	P value
PCP receives follow up after an ED visit "most of the time" (81-100%)	20 (40.8%)	0 (0%)	P<0.001
How ED visits are typically communicated to PCP			
EMR	36 (73.5%)	17 (32.7%)	P<0.001
Telephone	4 (9.2%)	36 (69.2%)	P<0.001
Preferred method of communication			
EMR	33 (67.4%)	13 (25%)	P<0.001
Telephone	3 (6.1%)	30 (57.7%)	P<0.001
Time frame for communication, benign condition prior to discharge			
Within 6 hours	2 (4.1%)	2 (3.8%)	P = 1
Within 24 hours	2 (4.1%)	3 (5.8%)	P = 1
Within 2 days	17 (34.7%)	12 (23.1%)	P = 0.271
Within 1 week	14 (28.6%)	6 (11.5%)	P = 0.045
Does not need	12 (24.5%)	7 (13.4%)	P = 0.205
Communication	2 (4.1%)	23 (44.2%)	P<0.001
Time frame for communication, urgent condition prior to discharge			
Within 6 hours	20 (40.8%)	33 (63.5%)	P = 0.029
Within 24 hours	10 (20.4%)	8 (15.4%)	P = 0.606
Within 2 days	15 (30.6%)	10 (19.2%)	P = 0.249
Within 1 week	2 (4.1%)	1 (1.9%)	P = 0.610
Does not need	0	0	
Communication	0	0	
PCP receives EMR notifications of ED visit	28 (57.1%)	11 (21.2%)	P<0.001

EP, emergency physician; *PCP*, primary care physician; *ED*, emergency department; *EMR*, electronic medical record

the EMR. Since EMR notification was the preferred PCP method of communication, EPs might in future be more cognizant of the role of EMR notification to the PCP as a key component of transition of care for ED discharge.

There are also existing, under-used tools for communicating discharge information that are highly regarded and improve provider satisfaction.[19] Limpahan et al. developed a set of best practices for patient discharge, including sending a summary to the PCP, performing medication reconciliation, and providing patient education.[20] The authors suggest using the EMR as a potential avenue for automated inclusion of the described practices. Separate EMR systems have been identified as a challenge in the transition of care, while an interface for a shared EMR has been cited as a way to minimize transitions-of-care losses.[7] Furthermore, the ability of EPs to provide an alert to the PCPs through flagging or email notification has been described as a potential tool for communication.

In the present study providers reported setting and environmental constraints including a high patient volume, coordinating time to call, and communication during non-business hours. A standard EMR notification system may alleviate some of these constraints; however, EMR barriers to effective transitions were also noted, including lack of EMR access or shared EMR, uncertain receipt of information, and limited EMR literacy. Other logistical barriers to communication included inability to identify the PCP, difficulty getting in touch with the appropriate provider, and lack of resources. These are systems issues that could be addressed with increased emphasis on the ED-to-outpatient communication. Specific strategies might include readily available electronic documentation of a patient's PCP, shared EMR access among hospitals and clinics, and professional coordinators to relay information during the discharge process.

Healthcare providers believe that both technology and standardization should be the focus for future improvements in the transition of care.[8, 21] Shared EMR access and EMR notifications are potential areas for development. There are also new tools of clinical communication that may bridge the gap between the synchronous phone communication preferred by EPs and

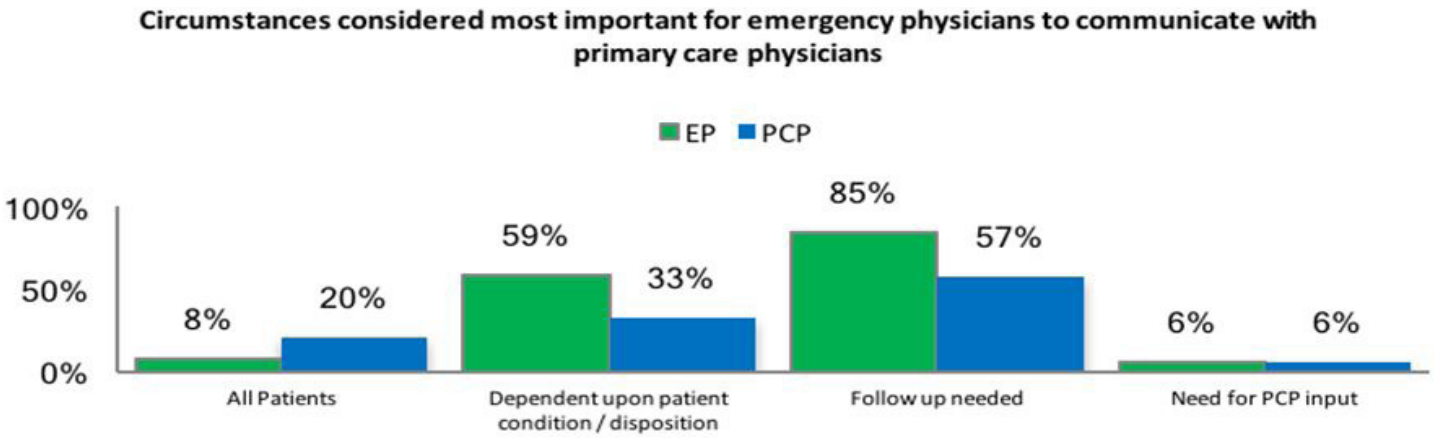

Figure 2. First qualitative question examining circumstances important for communication.
EP, emergency physician; *PCP*, primary care physician.

the asynchronous EMR communication preferred by PCPs. Mobile health platforms that use HIPAA-compliant, secure text messaging can serve as an intermediate solution between phone message and EMR message, as these texts can satisfy the need for EPs to confirm delivery of an urgent message to a PCP, while allowing a small amount of asynchrony that does not disrupt the PCP's workflow during a busy clinic day and is less intrusive than a phone call after hours. Further study is necessary to characterize the best structure and content of EMR notifications, in order to facilitate the transition of care from the ED to the outpatient setting.

LIMITATIONS

There are several limitations to this study. Most notably, the participants comprised a convenience sample of physicians from eight academic institutions. All community physicians worked at a community site affiliated with one of the primary academic sites. The present study lacks representation from community sites without academic affiliation, military, and rural institutions. Our responses may not reflect practice patterns in these settings. This study also lacks input from mid-level providers and residents who are also involved in the hand-off process. Interviews were performed in-person and therefore may have led to reporting bias on the part of the participant.

Furthermore, this data is based on perception rather than objective measure of phone calls and EMR notifications, which is subject to recall bias. The qualitative questions served as a strategy to recruit more diverse responses. The process of coding synthesizes information, thus losing the context of specific statements in favor of categorizing data into themes. Finally, the majority of subjects in this study reported using EPIC EMR software. Other interfaces may allow for varying degrees of electronic communication between the ED and PCP, thus altering one's perception of EMR utility.

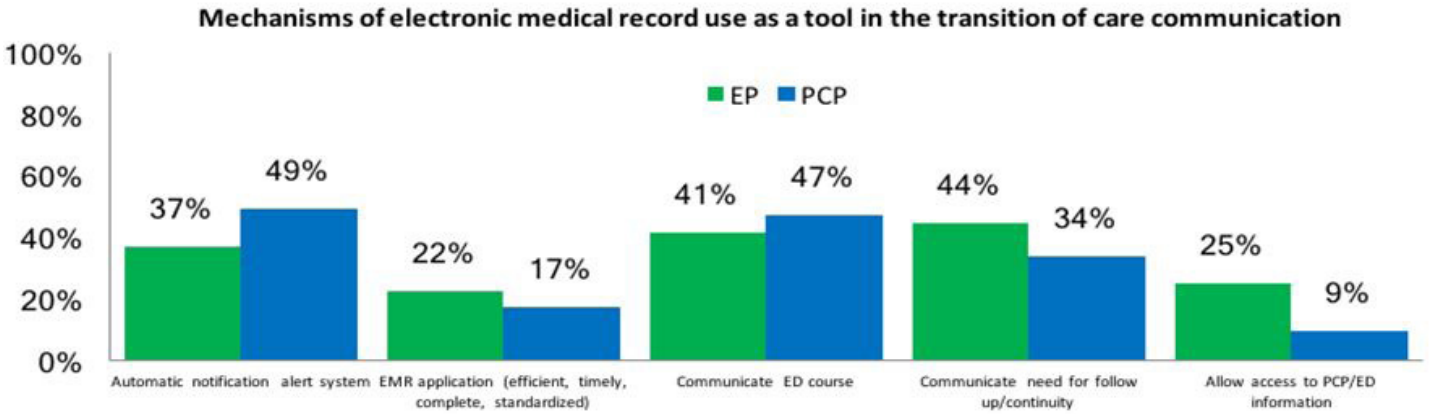

Figure 3. Second qualitative question regarding the use of the electronic medical record in the transition of care.
EMR, electronic medical record; *EP*, emergency physician; *PCP*, primary care physician; *ED*, emergency department.

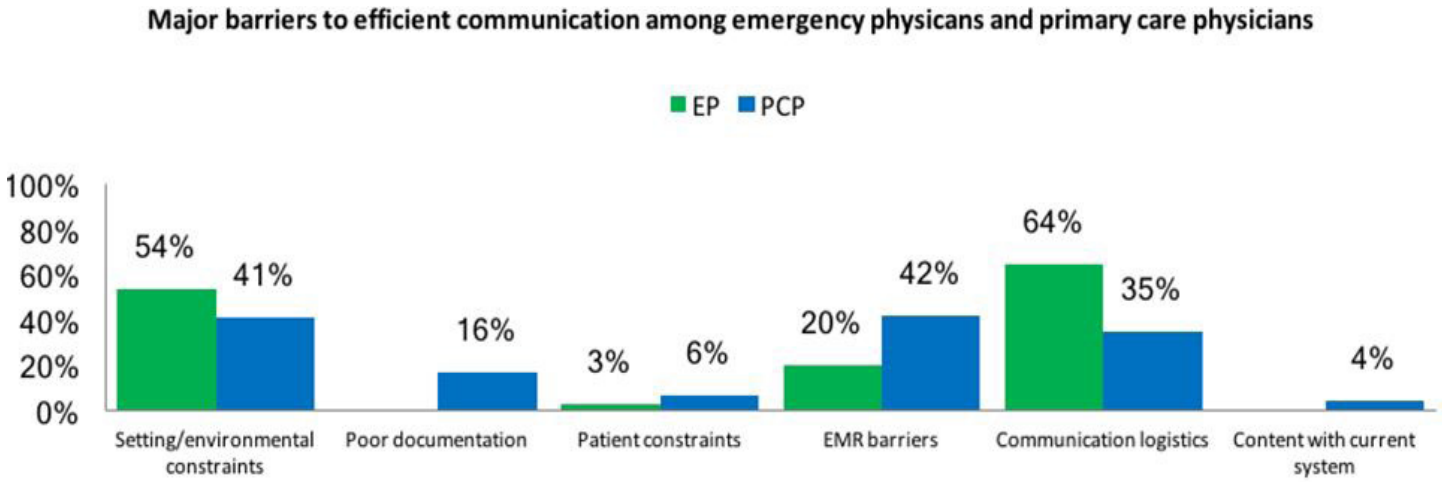

Figure 4. Qualitative question identifying major barriers to efficient communication.
EP, emergency physician; *PCP*, primary care physician; *EMR*, electronic medical record
Category descriptions: Setting and environmental constraints: high patient volume; coordinating time to call; and communication during non-business hours. EMR barriers: lack of EMR access or shared EMR; uncertain receipt of information; and limited EMR literacy. Barriers to communication: inability to identify the PCP; difficulty getting in touch with the appropriate provider; and lack of resources.

CONCLUSION

Our results highlight the need for a consistent system of communication, while also emphasizing the need for flexibility as EPs and PCPs work in distinct environments with different needs and expectations. Identifying these discrepancies is the first step in moving toward addressing them. EPs and PCPs should focus on working synergistically and view each other as partners working toward improved patient care. Future research should focus on new clinical communication tools for use between EPs and PCPs. Mobile health platforms or standardized, collaborative EMR tools have the potential to provide safer transitions back to the community.

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REFERENCES

1. CDC/NCHS, National Hospital Ambulatory Medical Care Survey: 2011 Emergency Department Summary Tables, page 32. Available at: http://www.cdc.gov/nchs/data/ahcd/nhamcs_emergency/2011_ed_web_tables.pdf. Accessed on September 14, 2017.
2. Samuels-Kalow ME, Stack AM, Porter SC. Effective discharge communication in the emergency department. *Ann Emerg Med*. 2012;60(2):152-9.
3. Kessler C, Scott NL, Siedsma M, et al. Interunit handoffs of patients and transfers of information: a survey of current practices. *Ann Emerg Med*. 2014;64(4):343-9.
4. Maughan BC, Lei L, Cydulka RK. ED handoffs: observed practices and communication errors. *Am J Emerg Med*. 2011;29(5):502-11.
5. Peterson SM, Gurses AP, Regan L. Resident to resident handoffs in the emergency department: an observational study. *J Emerg Med*. 2014;47(5):573-9.
6. Terrell KM, Miller DK. Strategies to improve care transitions between nursing homes and emergency departments. *J Am Med Dir Assoc*. 2011;12(8):602-5.
7. Carrier E, Yee T, Holzwart RA. Coordination Between Emergency and Primary Care Physicians. National Institute for Health Care Reform, Research Brief No 3. 2011. Available at: http://nihcr.org/analysis/improving-care-delivery/prevention-improving-health/ed-coordination/ . Accessed on September 14, 2017.
8. Dunnion ME, Kelly B. From the emergency department to home. *J Clin Nurs.* 2005;14(6):776–85.
9. Kripalani S, Jackson AT, Schnipper JL, et al. Promoting effective transitions of care at hospital discharge: a review of key issues for hospitalists. *J Hosp Med.* 2007;2(5):314-23.
10. Villanueva T. Transitioning the patient with acute coronary

syndrome from inpatient to primary care. *J Hosp Med*. 2010;Suppl 4:S8-14.

11. Arora VM, Farnan JM. Care transitions for hospitalized patients. *Med Clin North Am.* 2008;92(2):315-24.
12. Linstone HA, Turoff, M. *The Delphi Method: Techniques and Applications.* Reading, Mass: Addison-Wesley Pub. Co., Advanced Book Program; 1975.
13. Rothbauer P. Triangulation. In Given, Lisa (Ed.), *The SAGE Encyclopedia of Qualitative Research Methods.* Los Angeles: SAGE Publications; 2008.
14. Kessler, CS, Dharmapuri S, Marcolini, EG. Qualitative analysis of effective lecture strategies in emergency medicine. *Ann Emerg Med*. 2011;58(5):482-9.
15. Kessler, CS , Kutka BM, Badillo C. Consultation in the emergency department: a qualitative analysis and review. *J Emerg Med*. 2012;42(6):704–11.
16. Glaser, BG. *Basics of Grounded Theory Analysis: Emergence V Forcing*. Mill Valley, CA: Sociology Press; 1992.
17. Bradley EH, Curry LA, Devers KJ. Qualitative data analysis for health services research: developing taxonomy, themes, and theory. *Health Serv Res*. 2007;42(4):1758-72.
18. Miles MB, Huberman M. *Qualitative Data Analysis: A Sourcebook of New Methods. 2d Ed.* Beverly Hills, CA: Sage Publications; 1994.
19. Kelly NA, Mahoney DF, Bonner A, et al. Use of a transitional minimum data set (TMDS) to improve communication between nursing home and emergency department providers. *J Am Med Dir Assoc*. 2012;13(1):9-15.
20. Limpahan LP, Baier RR, Gravenstein S, et al. Closing the loop: best practices for cross-setting communication at ED discharge. *Am J Emerg Med.* 2013;31(9):1297–301.
21. Johnson JK, Farnan JM, Barach P, et al.; HANDOVER research collaborative. Searching for the missing pieces between the hospital and primary care: mapping the patient process during care transitions. *BMJ Qual Saf.* 2012;21 Suppl 1:i97-105.

A Novel Approach to Addressing an Unintended Consequence of Direct to Room: The Delay of Initial Vital Signs

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Introduction: The concept of "direct to room" (DTR) and "immediate bedding" has been described in the literature as a mechanism to improve front-end, emergency department (ED) processing. The process allows for an expedited clinician-patient encounter. An unintended consequence of DTR was a time delay in obtaining the initial set of vital signs upon patient arrival.

Methods: This retrospective cohort study was conducted at a single, academic, tertiary-care facility with an annual census of 94,000 patient visits. Inclusion criteria were all patients who entered the ED from 11/1/15 to 5/1/16 and between the hours of 7 am to 11 pm. During the implementation period, a vital signs station was created and a personal care assistant was assigned to the waiting area with the designated job of obtaining vital signs on all patients upon arrival to the ED and prior to leaving the waiting area. Time to first vital sign documented (TTVS) was defined as the time from quick registration to first vital sign documented.

Results: The pre-implementation period, mean TTVS was 15.3 minutes (N= 37,900). The post-implementation period, mean TTVS was 9.8 minutes (N= 39,392). The implementation yielded a 35% decrease and an absolute reduction in the average TTVS of 5.5 minutes (p<0.0001).

Conclusion: This study demonstrated that the coupling of registration and a vital signs station was successful at overcoming delays in obtaining the time to initial vital signs. [West J Emerg Med. 2018;19(2)254-258.]

INTRODUCTION

The concept of "direct to room" (DTR), also known as "immediate bedding," has been reported in the literature as a mechanism to improve front-end emergency department (ED) processing.[1] At one institution DTR was referred to as "closing" the waiting room, since patients were taken directly to a bed, when available, without undergoing formal triage and registration in the waiting room.[2] Reducing wait times has been linked to patient perceptions of superior service and increased trust, especially in private hospitals.[3] Although every ED may have individual front-end processes, most ED visits include patient presentation, registration, triage, bed assignment, and medical evaluation.[4]

Various models have been implemented in an attempt to reduce ED wait times and overall length of stay (LOS), from split flows to rapid triage.[5,6,7] DTR uses the design of parallel processing, as opposed to serial processing, which allows patients to bypass many preliminary steps between arrival to

the ED and placement in a bed. The goal is to decrease the backlog of waiting room patients waiting for less-critical tasks and allow registration, nursing evaluation, and medical provider evaluation to occur simultaneously at the bedside.[4,8] More importantly, this facilitates an expedited clinician and patient interaction.

The literature suggests that DTR can decrease waiting times, ED LOS, and left without being seen (LWBS) rates, while simultaneously improving patient satisfaction.[4] Bertoty et. al. reported that the LOS for admitted patients decreased by 7.7%, and the LOS for discharged patients also decreased after DTR was implemented.[1] Similarly, there was an improvement in patient satisfaction, which was hypothesized to occur since patients prefer to wait in a treatment area rather than a waiting room. Patients also perceived their treatment as beginning from the moment they were brought into the treatment area.

At our institution, we implemented a DTR policy, which improved our front-end process dramatically. The Staten Island University Hospital ED has seen an improvement in metrics, similar to those cited in the literature, since implementing a DTR process. This includes decreased physician turn-around time, a decrease in LWBS, and a marked increase in patient satisfaction. Unfortunately, such improvements were accompanied by unforeseen consequences. In a traditional system, all patients undergo a formal triage process by a dedicated nurse, during which vital signs are obtained. In the DTR process, this step may be bypassed. Consequently, we noticed a delay from the time of presentation to the first recorded set of vital signs. In some circumstances, patients were unwittingly treated and released before obtaining a single set of vital signs. To address this issue, we developed a vital signs station within the waiting area. Our goal was to determine the feasibility and effectiveness of obtaining and recording vital signs within 10 minutes of every patient's arrival to the ED after initiation of a DTR process.

Population Health Research Capsule

What do we already know about this issue?
The direct-to-room (DTR) concept uses parallel processing to decrease ED wait times, length of stay, and left without being seen rates, but may result in vital sign delays.

What was the research question?
Does a vital signs station in the waiting room reduce the time to first vital signs to under 10 minutes?

What was the major finding of the study?
A vital signs station in the waiting room reduced the mean time to first vital signs by 5.5 minutes, a 35% reduction.

How does this improve population health?
This improves front-end ED processing by maintaining all of the advantages of DTR without delaying initial vital signs, which improves patient safety.

METHODS

This retrospective, cohort study took place at a single, academic, tertiary-care, Level I trauma center with an annual census of approximately 94,000 visits. Inclusion criteria were all patients who entered the ED between the hours of 7 am to 11pm. We excluded from the study all patients who entered the ED between 11 pm and 7 am. due to inability to staff the vital signs station during these hours of the pilot phase of the program. The pre-implementation time period used for comparison was November 1, 2014, to May 1, 2015. The post-implementation time period was November 1, 2015, to May 1, 2016. We defined TTVS documented as the time from quick registration to first vital sign documented in the electronic medical record (EMR). The pilot phase was initiated in May 2014 for eight hours/day, five days/week, excluding weekends. This was extended to 16 hours/day, seven days/week in November 2014, which was the study period.

During the implementation period, a vital signs station was created and a personal care assistant (PCA) was assigned to the waiting area with the designated job of obtaining vital signs on all patients upon arrival to the ED and prior to leaving the waiting area. PCAs are part of the ED team and perform duties under the supervision of doctors and nurses. They assist with numerous tasks. This vital sign station was directly adjacent to the quick registration desk. After patient arrival and sign-in, a quick registration including name, date of birth, and chief complaint was completed. Subsequently, patients were directed to a PCA with a portable vital signs machine and a computer on wheels with access to the EMR. The PCA's sole task was to obtain vital signs on all patients before they left the waiting area and then enter this information in the EMR. Patients who arrived via EMS had vital signs entered by the ED triage nurse and were also included in this analysis. PCAs were also empowered to obtain vital signs on patients who were waiting in line for registration.

STATISTICAL ANALYSIS

We reported summary statistics as mean ± standard deviation and median (first quartile, third quartile) for the continuous variable TTVS. We compared the difference

between pre-implementation and post-implementation periods in the primary outcome variable of TTVS with the Wilcoxon two-sample test. All statistical tests are two-sided, and a p-value of <0.05 was considered to indicate statistical significance. We performed all statistical analyses using the SAS software, Version 9.3 (SAS Inc., Cary, NC, USA).

RESULTS

The total census between November 1, 2014, and May 1, 2015, was 44,177 patients. The total census between November 1, 2015, and May 1, 2016, was 45,807 patients. During the study period, 37,900 subjects were enrolled in the control group (pre-implementation group) and 39,392 subjects were enrolled in the intervention group (post-implementation group). The pre-implementation period mean TTVS was 15.3 minutes (N= 37,900) with a median of 9.0 minutes and a range of 0 to 846 minutes. The post-implementation period mean TTVS was 9.8 minutes (N= 39,392) with a median of 5.0 minutes and a range of 0 to 479 minutes. The implementation yielded an average TVVS reduction of 5.5 minutes (p<0.0001), a 35% reduction.

DISCUSSION

The implementation of DTR has had countless benefits, including faster turnaround times, improved door-to- doctor times, and decreased LWBS rates.[3] By reducing ED crowding, decision-making time can be reduced as well as reducing over-use of the laboratory and computed tomography.[9] However, our experience has shown that an unintended consequence of DTR is both a delay and inconsistency in obtaining initial vital signs. In this study, we demonstrated that the implementation of a vital sign station at ambulatory registration reduced the TTVS, an unintended consequence of DTR, by a mean time of nearly six minutes.

Table. Characteristics of patients whose initial vital signs were obtained in the waiting room as part of an existing quick-registration process.

	Pre-intervention	Post-intervention
Age	41.9 (25.3)	41.6 (25.1)
Males (%)	47.4%	47.1%
ESI		
1	0.2%	0.6%
2	1.4%	2.9%
3	40.9%	47.4%
4	52.6%	46.1%
5	4.2%	2.4%
unassigned	0.8%	0.6%

ESI, Emergency Severity Index.

When we coupled a vital signs station with our already-existing quick registration process, the department experienced no delays in overall throughput. Although this now adds a few minutes to the quick registration, we found that the overall benefits far outweigh this short delay. For EDs that have some form of quick registration and DTR process and experience similar delays in obtaining vital signs, we believe that creating a vital sign station in the waiting room is a feasible and effective solution that could be implemented by any ED.

Our ED has two portals of entry: an ambulance entrance, where the patient is immediately triaged and has his vital signs obtained by a nurse who then enters them in the patient chart; and a quick registration desk in the waiting room where all ambulatory patients must sign in prior to being brought to the treatment area. At the quick registration desk, brief demographic information and chief complaint is obtained, which allows the patient to be entered into the EMR and receive a medical record number. After undergoing a quick registration, there are three subsequent pathways for the patient: 1) taken directly into the treatment area by a nurse, PCA, or pavilion coordinator (our DTR process); 2) taken to a triage station for formal nursing triage, 3) queued in the waiting room for either the next available DTR or formal triage availability.

At our institution the pavilion coordinator is an ED greeter who helps the nursing staff facilitate our DTR process. Quick registration with chief complaint and vital sign assessment is markedly different from formal triage, in that formal triage requires nursing resources and a significant amount of time. Quick registration only requires patient demographics and chief complaint, whereas traditional formal triage includes expanded history-taking and a medical assessment including allergies, medications, surgical history, etc. which can lead to a delay in initial clinical assessment in treatment areas.

There are many potential benefits to this new process besides the decrease in TTVS. Obtaining earlier vital signs enhances patient safety since it allows for earlier recognition of potentially abnormal vital signs and therefore prompt treatment and intervention. This is especially true in the patient who may appear stable. Second, patient satisfaction is improved since they recognize that they are being taken care of from the moment they walk into the ED. Implementation may be limited due to PCA competing priorities and unanticipated staffing needs within the department. While there were no extra personnel costs as staffing did not increase to fill the vital signs station, we did decrease the availability of existing PCAs in the clinical arena.

LIMITATIONS

This study has several limitations. Because it was performed at a single ED, the results may not be duplicated or applicable at another ED. In addition, the study was

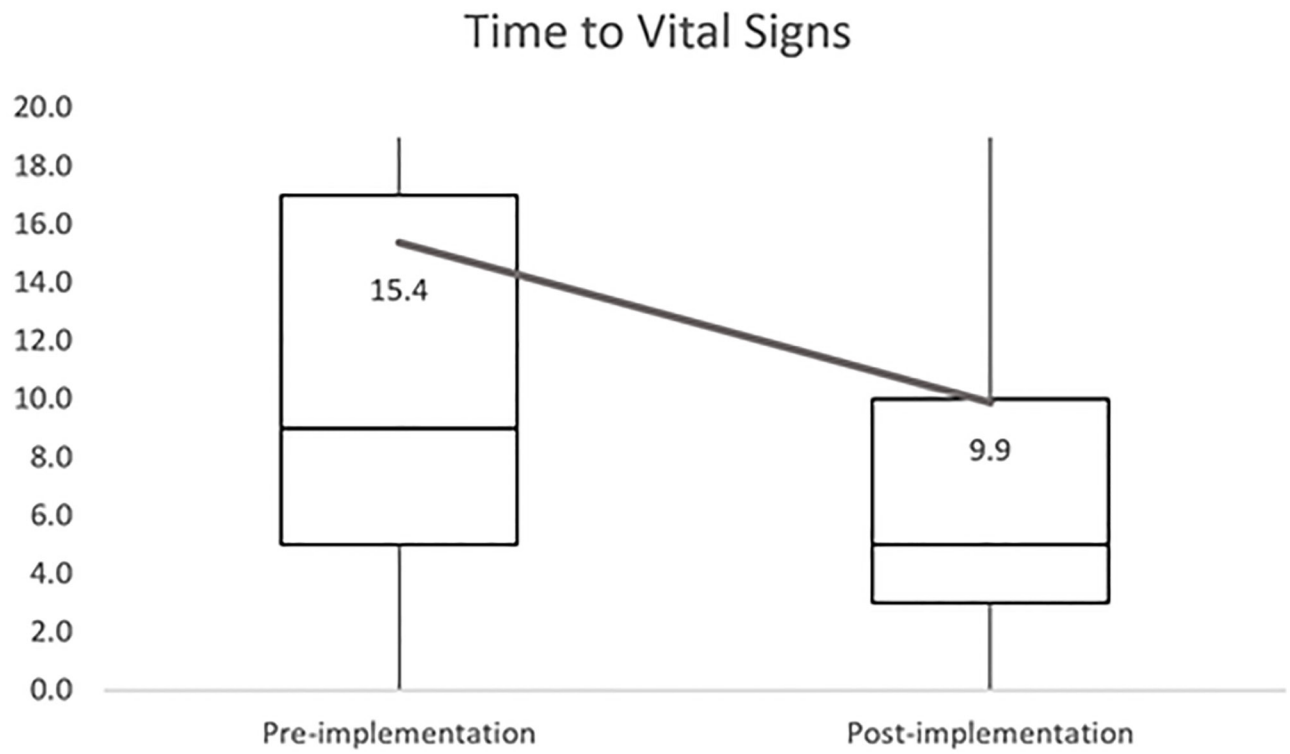

Figure. Time (minutes) to vital signs first recorded demonstrated as box-and-whisker plot, modified with maximum values shown at tops of curtailed whiskers. Mean values are demonstrated with trendline.

retrospective, and therefore results are subject to the biases associated with a retrospective study. Also, enrollment in the study was limited to 7 am – 11 pm due to limitations in staffing outside of this time frame.

We included in the analysis patients who arrived via EMS during the study period. The electronic report generated for this project does not have a mechanism to separate EMS from non-EMS patient arrivals. This report identifies all ED patients and generates a time from arrival to first vital sign. Our EMS process did not change in the study periods and we have no reason to believe that this would have had any impact on our results. Of note, between 2014-2016 our annual EMS arrivals have been consistently 20% of our overall volume. Given that our study period included a seasonal comparative as a control and there were no changes in the departmental management of EMS triage, we do not believe that this would have had an effect on our results.

Outliers were noted in both groups. We can only hypothesize that these delays were likely secondary to poor provider documentation. The report generated notes the first time vital signs were documented in the EMR. This is not an absolute reflection of what may have taken place. For example, if vital signs were obtained earlier on in a visit and noted by a provider but inadvertently were not placed into the chart in a timely manner, it's easy to see how any outlier could occur.

CONCLUSION

This study found that coupling quick registration to a vital signs station in the waiting room is both a feasible and effective method to overcome delays in obtaining initial vital signs in a "direct-to-room" ED process.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

REFERENCES

1. Bertoty DA, Kuszajewski ML, Marsh EE. Direct-to-room: one department's approach to improving ED throughput. *J Emerg Nurs*. 2007;33(1):26-30.
2. Tanabe P, Gisondi MA, Medendorp S, et al. Should you close your waiting room? Addressing ED overcrowding through education and staff-based participatory research. *J Emerg Nurs*. 2008;34(4):285-9.
3. Wiler JL, Gentle C, Halfpenny JM, et al. Optimizing emergency department front-end operations. *Ann Emerg Med*. 2010;55(2):142-60.
4. Ward PR, Rokkas P, Cenko C, et al. "Waiting for" and "waiting in" public and private hospitals: a qualitative study of patient trust in South Australia. *BMC Health Serv Res*. 2017;17(1):333.
5. Al-Onazi M, Al Hajri A, Caswell A, et al. Reducing patient waiting time and length of stay in an Acute Care Pediatric Emergency Department. *BMJ Qual Improv Report*. 2017;6:epub.
6. Chartier LB, Simoes L, Kuipers M, et al. Improving emergency department flow through optimized bed utilization. *BMJ Qual Improv Rep*. 2016;5(1). Pii:u206156.w2532.
7. Chartier L, Josephson T, Bates K, et al. Improving emergency department flow through Rapid Medical Evaluation unit. *BMJ Qual Improv Rep*. 2015;4(1):epub.
8. Rutman LE, Migita R, Woodward GA, et al. Creating a leaner pediatric emergency department: how rapid design and testing of a front-end model led to decreased wait time. *Pediatr Emerg Care*. 2015;31(6):395-8.
9. Chiu IM, Lin YR, Syue YJ, et al. The influence of crowding on clinical practice in the emergency department. *Am J Emerg Med.* 2017;17:epub.

Variations in Cardiac Arrest Regionalization in California

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Introduction: The development of cardiac arrest centers and regionalization of systems of care may improve survival of patients with out-of-hospital cardiac arrest (OHCA). This survey of the local EMS agencies (LEMSA) in California was intended to determine current practices regarding the treatment and routing of OHCA patients and the extent to which EMS systems have regionalized OHCA care across California.

Methods: We surveyed all of the 33 LEMSA in California regarding the treatment and routing of OHCA patients according to the current recommendations for OHCA management.

Results: Two counties, representing 29% of the California population, have formally regionalized cardiac arrest care. Twenty of the remaining LEMSA have specific regionalization protocols to direct all OHCA patients with return of spontaneous circulation to designated percutaneous coronary intervention (PCI)-capable hospitals, representing another 36% of the population. There is large variation in LEMSA ability to influence inhospital care. Only 14 agencies (36%), representing 44% of the population, have access to hospital outcome data, including survival to hospital discharge and cerebral performance category scores.

Conclusion: Regionalized care of OHCA is established in two of 33 California LEMSA, providing access to approximately one-third of California residents. Many other LEMSA direct OHCA patients to PCI-capable hospitals for primary PCI and targeted temperature management, but there is limited regional coordination and system quality improvement. Only one-third of LEMSA have access to hospital data for patient outcomes. [West J Emerg Med. 2018;19(2)259-265.]

INTRODUCTION

Annually over 400,000 people suffer non-traumatic out-of-hospital cardiac arrest (OHCA) in the United States.[1,2] This represents the third leading cause of death in industrial nations and accounts for eight times as many deaths as motor vehicle collisions.[3,4] There have been steady, albeit modest, improvements in the survival of patients with OHCA over the past decade.[5] With recent advances in post cardiac arrest care, the proportion of patients who survive to hospital discharge after cardiopulmonary resuscitation (CPR) and return of spontaneous circulation (ROSC) has increased from one-third to one-half.[6] Other improvements including higher rates of bystander CPR, dispatch-directed CPR, deployment of automatic external defibrillators in the community, and improved CPR quality have also contributed to increasing survival rates.[5,7]

Recently the American Heart Association (AHA) and other subject matter experts have advocated for the development of regional systems of cardiac arrest care with designation of cardiac arrest centers.[3,8-10] A cardiac arrest center is a hospital that provides evidence-based practice in resuscitation and post-

resuscitation care, including 24/7 percutaneous coronary intervention (PCI) capability and targeted temperature management (TTM), as well as an adequate annual volume of OHCA cases and a commitment to performance improvement and benchmarking. There is a similar precedent in the establishment of ST-segment elevation myocardial infarction (STEMI) centers over the past decade to improve outcomes in that time-dependent disease.[11,12]

Observational studies suggest a benefit of regionalization; therefore, the establishment of regional care systems may optimize access to and delivery of care for patients with OHCA. A prospective study demonstrated improved outcomes in patients with OHCA transported to a cardiac arrest center compared to non-cardiac arrest centers.[13] There have been numerous observational studies with differing hospital characteristics[14-26] as well as a number of studies that compared outcomes before and after the implementation of regionalized systems of care,[27-32] all suggesting an association between improved survival and routing of select patients to cardiac arrest centers.

A regionalized cardiac arrest system involves a systematic approach to the care of the OHCA patients across a geographic area. This would include consistency in prehospital care, selective transport to designated cardiac arrest centers, consistent policies on the post-resuscitation care, and participation in a regional performance improvement process to address any potential disparities in care. Currently, most cardiac arrest centers in the U.S. are self-designated academic centers.[9] The extent to which regionalization of cardiac arrest care has been established is not well quantified. Two studies describing established regional cardiac arrest care systems demonstrated improved patient outcomes with regionalization.[27,31]

This survey of local EMS agencies (LEMSA) in California was intended to determine the current practices regarding the treatment and routing of OHCA patients and the extent to which EMS systems have regionalized care across California.

Population Health Research Capsule

What do we already know about this issue?
Out-of-hospital cardiac arrest (OHCA) patients have better outcomes at cardiac arrest centers, and some emergency medical service (EMS) systems direct OHCA patients to such centers.

What was the research question?
How do EMS agencies in California route OHCA patients? What quality improvement metrics do they track?

What was the major finding of the study?
There is wide variation in the treatment and routing of OHCA patients in California. Only two of 33 EMS agencies have formal regionalized systems.

How does this improve population health?
This study suggests that EMS agencies in California can expand regionalized care for OHCA patients and increase quality improvement around OHCA systems.

METHODS

The State of California has a population of 39 million, and EMS care is regulated by the California EMS Authority. Oversight of local care is provided by 33 LEMSA. These government agencies establish uniform policies and procedures for a countywide or region-wide (comprising multiple counties) system of first responders and EMS providers. While all LEMSA must have an EMS plan that conforms to California EMS Authority mandates, policies and protocols vary among them.[33,34]

We surveyed all 33 California LEMSA on three topics: 1) local policy regarding routing of OHCA patients to designated cardiac arrest centers; 2) specific interventions for post-resuscitation care available in those centers; and 3) access to data on OHCA treatment and outcome measures. We also requested system metrics on frequency of OHCA and patient outcomes. Of note, our survey inquired about the policies and protocols pertaining to all OHCA patients, not only those who achieved ROSC. We developed a 37-question survey (Appendix) in three sections: field treatment and routing policies (multiple choice); specialty centers (multiple choice); and system data (free response). Prior to dissemination, the survey was reviewed by several LEMSA administrators and subsequently edited for clarity. The survey was distributed by email to the California LEMSA administrators and medical directors in August 2016, available online via Qualtrics software. Reminders were sent until all LEMSA completed the survey. We clarified incomplete or inconsistent survey responses by email and/or phone.

The primary objective was to describe management of OHCA throughout California in terms of current treatment guidelines and specifically to determine the extent to which systems have regionalized care. Responses were submitted by either the LEMSA director or representative and downloaded or input into Excel (Microsoft Corporation, Redmond WA) for analysis. The findings of this study will be shared with the EMS Medical Directors Association of California (EMDAC),

an advisory body to the California EMS Authority comprised of all EMS medical directors of the 33 LEMSAs, who meet quarterly to advise the state on issues pertaining to prehospital scope of practice and quality of care.

This study was submitted to the Institutional Review Board (IRB) at the University of California at San Francisco and was deemed to not involve human subjects as to require continuous IRB review.

RESULTS

All 33 California LEMSA participated in the survey for a response rate of 100%. Table 1 provides a summary of LEMSA routing policies. Two LEMSA reported a fully developed regional cardiac arrest care system with specific clinical protocols to direct patients to cardiac arrest centers, a role in influencing hospital policies about post-cardiac arrest care, and participate in a regional performance-improvement process. The Los Angeles (LA) regional cardiac arrest system (population 10 million) has been described previously.[27] In LA, all OHCA with ROSC and those transported with presumed cardiac etiology are routed to designated centers, which double as STEMI and cardiac arrest centers. All have 24/7 PCI capability, written internal protocols for TTM, and take part in a regional performance-improvement process. Alameda County (population 1.5 million) operates a similar system, routing all OHCA patients with ROSC at any time to cardiac arrest centers.

A large number of LEMSA (20/33), comprising a population of 14 million, have specific protocols to direct all OHCA patients with ROSC to designated PCI-capable hospitals. They have a limited role or no role in influencing hospital policies about post cardiac arrest care and do not have a regional performance-improvement process. There was inconsistency among agencies regarding the protocols and reporting required from these hospitals. Nearly all LEMSA (31/33) have a termination of resuscitation protocol for OHCA.

Eight LEMSA have policies and protocols that direct the use of TTM during post-resuscitation care, requiring hospitals to have a written TTM protocol, and five have a memorandum of understanding to enforce the requirement and allow them a role in determining the inclusion and exclusion criteria. Six LEMSA have protocols for the prehospital administration of therapeutic hypothermia.

Seven LEMSA have policies that require receiving hospitals to have a written protocol for emergent PCI after OHCA. Of these, four have memoranda of understanding with the hospitals and three have a role in determining inclusion and exclusion criteria. The use of PCI for patients with persistent cardiac arrest was rare. Fifteen agencies reported that this occurred in their system, but none reported more than 3-5 patients. Eleven LEMSA have hospitals with extracorporeal membrane oxygenation (ECMO) capability, but it was rarely used for this indication and there were no LEMSA with specific

Table 1. Summary of the routing and treatment policies for out-of-hospital cardiac arrest (OHCA) among the 33 local EMS agencies (LEMSA) in California.

	Number of LEMSAs in CA
Field treatment and routing policies	
Allow for the routing of OHCA to specific hospitals	23 (70%)
Require the routing of all OHCA to specific hospitals	5 (15%)
Have a Termination of Resuscitation policy for OHCA	31 (94%)
Route all persistent Vfib to specific hospitals	10 (30%)
Have a policy for pre-hospital initiation of Targeted Temperature Management (TTM)	6 (18%)
Require the use of mechanical CPR devices during transport	2 (6%)
Specialty centers	
Require that a written TTM policy exist at the receiving hospital	8 (24%)
Require that a written policy for emergent coronary angiography exist at the receiving hospital	8 (24%)
Require the transport of OHCA to a hospital with 24 hour capability for percutaneous coronary intervention	18 (55%)
Require the use of mechanical CPR devices in hospitals receiving OHCA	1 (3%)
Have hospitals that perform PCI for patients in persistent cardiac arrest	15 (45%)
Have hospitals that initiate ECMO for patients in persistent cardiac arrest	11 (33%)
Outcomes data	
Collect outcomes data on OHCA	26 (79%)

CPR, cardiopulmonary resuscitation; *PCI,* percutaneous coronary intervention; *ECMO,* extracorporeal membrane oxygenation; *Vfib,* ventricular fibrillation.

routing or regional policies for its use. Mechanical CPR devices were optional for 18 local EMS agencies. One agency required the use of mechanical CPR devices during transport and another required them for all OHCA patients.

The majority of LEMSA report collecting process measures for system quality improvement, with EMS response time the most commonly measured (30/33), followed by the time to CPR (24/33), the time to defibrillation (25/33), and the rate of dispatcher-assisted CPR (18/33). However, the measurements of in-hospital outcomes were significantly lower (14/33) with survival to hospital discharge the most commonly measured. The frequency of reported treatment and outcome measures are listed in Table 2.

DISCUSSION

We present the current policies for treatment and routing of all OHCA patients throughout California with a 100% survey response rate. While the majority of LEMSA route cardiac arrest patients to specific specialty centers (PCI-capable hospitals), only two have formally regionalized cardiac arrest care systems, covering 39% of the California population. A surprising finding of our survey was the larger number of more informal designation of cardiac arrest centers without regionalization. A total of 20 out of 33 LEMSA (representing a population of 14 million or 36% of the population) had specific protocols to direct OCHA patients to STEMI- designated hospitals. A regionalized cardiac arrest system not only directs OHCA patients to designated hospitals, but also establishes a systemwide approach to cardiac arrest management and quality improvement to optimize resuscitation and post-resuscitation care. This is a multi-disciplinary approach that involves prehospital and inhospital care, including the appropriate and timely use of TTM and PCI, as well as consistent intensive care unit care and uniform prognostication.

Designated cardiac arrest centers that operate within a regionalized system with a robust performance-improvement process are likely to decrease the variability in care and improve outcomes. Several studies have demonstrated that survival after ROSC from an OHCA can vary considerably depending on the hospital and its clinical characteristics.[14,16,18,35] In one Swedish study, the survival of OHCA patients with ROSC ranged from 14% to 42%.[20] In 2008, Arizona designated 31 cardiac arrest centers and routed all OHCA patients to these centers. Before and after analyses of the Arizona Department of Health Services statewide, EMS cardiac-arrest database demonstrated increased neurologically intact survival with regionalization, as well as improved adherence to post-resuscitation care guidelines at designated centers.

However, routing of patients alone, even without the regionalized system infrastructure, may improve outcomes. As demonstrated in other complicated medical conditions, a number of studies have suggested that increasing the volume of OHCA patients receiving care at a particular hospital is associated with improved outcomes. Hospitals with high volumes of CPR cases demonstrate better outcomes for OHCA patients than those with lower volume, despite longer transport times to these cardiac arrest centers.[10,13,16,17,36-39] Using California statewide data from 2011, we found that 10% of hospitals are defined as AHA Level I cardiac receiving centers, capable of providing 24-hour PCI and TTM, and meet a minimum volume of OHCA patients.[40] As of 2011, these hospitals treated approximately 25% of the OHCA patients in California. The designation of cardiac arrest centers may be associated with an increased use of TTM and PCI and the rate of their use correlates with their survival rate with neurologically favorable outcome.[41] While this is of particular interest to rural communities, where it may be advantageous for the OHCA patient to bypass the closest hospital or use air transportation to reach a cardiac arrest center, further work is necessary to determine what length-of-transport time and characteristics of cardiac arrest have maximal benefit in transport to a specialized center.

Still, quality improvement is essential to continue to improve system outcomes. A concerning finding of the survey was that only 14 LEMSA (42%) have access to the hospital

Table 2. Number of California local EMS Agencies (LEMSA) that track and maintain quality improvement processes and outcomes in cardiac-arrest care metrics.

	Pre-hospital outcomes				In hospital outcomes				
	EMS response time	Time to CPR	Time to defibrillation	Rate of dispatcher assisted CPR	Survival to hospital discharge	CPC or mRS scores at discharge	Risk-adjusted mortality	Frequency of TTM	Frequency of emergent coronary angiography
Yes	30 (91%)	24 (73%)	25 (76%)	18 (55%)	14 (42%)	10 (30%)	1 (3%)	3 (9%)	9 (27%)
Partially					4 (12%)	5 (15%)	1 (3%)	3 (9%)	5 (15%)
No	3 (9%)	9 (27%)	8 (24%)	15 (45%)	15 (45%)	18 (55%)	31 (94%)	27 (82%)	19 (58%)

EMS, emergency medical services; *CPR,* cardiopulmonary resuscitation; *CPC*, cerebral performance category; *mRS*, modified Rankin score; *TTM*, targeted temperature management; *PCI*, percutaneous coronary angiography

outcomes. All successful systems that have improved their cardiac arrest survival required measuring different components of their system, with hospital outcomes one of the most important.[2,5,42,43]

These survey results provide an important foundation from which to move forward. There are a number of future opportunities for inquiry and improvement of cardiac arrest systems in California. As discussed above, the availability of hospital outcomes is essential for system quality improvement. The use of consistent definitions and inclusion/exclusion criteria developed by national or international organizations is also important to effectively benchmark. Given the low usage of ECMO or PCI during cardiac arrest, there may be opportunities to standardize their use across each region.[44] The development of regional systems of care with designated cardiac arrest centers may allow for more rapid adoption of current and future evidence-based advances in care. There may also be a role for secondary transfer of OHCA patients with sustained ROSC who present to a non-cardiac arrest center, but this has yet to be established.[45]

LIMITATIONS

Given the survey design, the study results are limited by self-reporting bias and potential misclassification bias by the survey participants. Question misinterpretation is possible; however, we attempted to mitigate this by careful review and follow-up with individual respondents for any discrepancies in responses. The survey only included California LEMSA; therefore, results may not be generalizable to other U.S. regions. Additionally, the survey did not ask explicitly about LEMSA participation in national, cardiac-arrest registry reporting, or collect numbers regarding OHCA patients and outcomes across all LEMSA. This study did not evaluate specific quality indicators or system performance in the individual EMS systems or differentiate between rural and urban LEMSA.

CONCLUSION

Regionalized care of OHCA is established in two of 33 California LEMSA, providing access to approximately one-third of California residents. Many other LEMSA direct OHCA patients to PCI-capable hospitals for primary PCI and targeted temperature management, but there is limited regional coordination and system quality improvement. Only one-third of LEMSA have access to hospital data for patient outcomes.

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REFERENCES

1. Sasson C, Rogers MA, Dahl J, et al. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Circ Cardiovas Qual Outcomes.* 2010;3(1):63-81.
2. McNally B, Stokes A, Crouch A, et al. CARES: Cardiac arrest registry to enhance survival. *Ann Emerg Med* 2009;54(5):674-83.e2.
3. Nichol G, Aufderheide TP, Eigel B, et al. Regional systems of care for out-of-hospital cardiac arrest: a policy statement from the American Heart Association. *Circulation*. 2010;121(5):709-29.
4. Georgiou M. Restart a Heart Day: a strategy by the European Resuscitation Council to raise cardiac arrest awareness. *Resuscitation*. 2013;84(9):1157-8.
5. Chan PS, McNally B, Tang F, et al. Recent trends in survival from out-of-hospital cardiac arrest in the United States. *Circulation*. 2014;130(21):1876-82.
6. Rittenberger JC, Callaway CW. Temperature management and modern post-cardiac arrest care. *N Engl J Med*. 2013;369(23):2262-3.
7. Jentzer JC, Clements CM, Wright RS, et al. Improving survival from cardiac arrest: a review of contemporary practice and challenges. *Ann Emerg Med*. 2016;68(6):678-89.
8. Soar J, Packham S. Cardiac arrest centres make sense. *Resuscitation*. 2010;81(5):507-8.
9. Donnino MW, Rittenberger JC, Gaieski D, et al. The development and implementation of cardiac arrest centers. *Resuscitation.* 2011;82(8):974-8.
10. Kronick SL, Kurz MC, Lin S, et al. Part 4: Systems of care and continuous quality improvement: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation.* 2015;132(18 Suppl 2):S397-413.
11. Jacobs AK, Antman EM, Faxon DP, et al. Development of systems of care for ST-elevation myocardial infarction patients: executive summary. *Circulation*. 2007;116(2):217-30.

12. Jollis JG, Granger CB, Henry TD, et al. Systems of care for ST-segment-elevation myocardial infarction: a report From the American Heart Association's Mission: Lifeline. *Circ Cardiovasc Qual Outcomes.* 2012;5(4):423-8.
13. Kajino K, Iwami T, Daya M, et al. Impact of transport to critical care medical centers on outcomes after out-of-hospital cardiac arrest. *Resuscitation*. 2010;81(5):549-54.
14. Carr BG, Kahn JM, Merchant RM, et al. Inter-hospital variability in post-cardiac arrest mortality. *Resuscitation.* 2009;80(1):30-4.
15. Callaway CW, Schmicker R, Kampmeyer M, et al. Receiving hospital characteristics associated with survival after out-of-hospital cardiac arrest. *Resuscitation.* 2010;81(5):524-9.
16. Carr BG, Goyal M, Band RA, et al. A national analysis of the relationship between hospital factors and post-cardiac arrest mortality. *Intensive Care Med*. 2009;35(3):505-11.
17. Cudnik MT, Schmicker RH, Vaillancourt C, et al. A geospatial assessment of transport distance and survival to discharge in out of hospital cardiac arrest patients: Implications for resuscitation centers. *Resuscitation*. 2010;81(5):518-23.
18. Engdahl J, Abrahamsson P, Bang A, et al. Is hospital care of major importance for outcome after out-of-hospital cardiac arrest? Experience acquired from patients with out-of-hospital cardiac arrest resuscitated by the same Emergency Medical Service and admitted to one of two hospitals over a 16-year period in the municipality of Goteborg. *Resuscitation*. 2000;43(3):201-11.
19. Hansen M, Fleischman R, Meckler G, et al. The association between hospital type and mortality among critically ill children in US EDs. *Resuscitation*. 2013;84(4):488-91.
20. Herlitz J, Engdahl J, Svensson L, et al. Major differences in 1-month survival between hospitals in Sweden among initial survivors of out-of-hospital cardiac arrest. *Resuscitation*. 2006;70(3):404-9.
21. Kjaergaard J, Bro-Jeppesen J, Rasmussen LS, et al. [Differences between hospitals in prognosis after resuscitated out-of-hospital cardiac arrest patients]. *Ugeskr Laeger.* 2009;171(26):2169-73.
22. Stub D, Smith K, Bray JE, et al. Hospital characteristics are associated with patient outcomes following out-of-hospital cardiac arrest. *Heart.* 2011;97(18):1489-94.
23. Davis DP, Fisher R, Aguilar S, et al. The feasibility of a regional cardiac arrest receiving system. *Resuscitation.* 2007;74(1):44-51.
24. Heffner AC, Pearson DA, Nussbaum ML, et al. Regionalization of post-cardiac arrest care: implementation of a cardiac resuscitation center. *Am Heart J*. 2012;164(4):493-501.e2.
25. Mooney MR, Unger BT, Boland LL, et al. Therapeutic hypothermia after out-of-hospital cardiac arrest: evaluation of a regional system to increase access to cooling. *Circulation.* 2011;124(2):206-14.
26. Spaite DW, Bobrow BJ, Vadeboncoeur TF, et al. The impact of prehospital transport interval on survival in out-of-hospital cardiac arrest: implications for regionalization of post-resuscitation care. *Resuscitation.* 2008;79(1):61-6.
27. Bosson N, Kaji AH, Niemann JT, et al. Survival and neurologic outcome after out-of-hospital cardiac arrest: results one year after regionalization of post-cardiac arrest care in a large metropolitan area. *Prehosp Emerg Care*. 2014;18(2):217-23.
28. Fothergill RT, Watson LR, Virdi GK, et al. Survival of resuscitated cardiac arrest patients with ST-elevation myocardial infarction (STEMI) conveyed directly to a Heart Attack Centre by ambulance clinicians. *Resuscitation.* 2014;85(1):96-8.
29. Lick CJ, Aufderheide TP, Niskanen RA, et al. Take Heart America: A comprehensive, community-wide, systems-based approach to the treatment of cardiac arrest. *Crit Care Med*. 2011;39(1):26-33.
30. Lund-Kordahl I, Olasveengen TM, Lorem T, et al. Improving outcome after out-of-hospital cardiac arrest by strengthening weak links of the local Chain of Survival; quality of advanced life support and post-resuscitation care. *Resuscitation*. 2010;81(4):422-6.
31. Spaite DW, Bobrow BJ, Stolz U, et al. Statewide regionalization of postarrest care for out-of-hospital cardiac arrest: association with survival and neurologic outcome. *Ann Emerg Med*. 2014;64(5):496-506.e1.
32. Tagami T, Hirata K, Takeshige T, et al. Implementation of the fifth link of the chain of survival concept for out-of-hospital cardiac arrest. *Circulation*. 2012;126(5):589-97.
33. Savino PB, Sporer KA, Barger JA, et al. Chest pain of suspected cardiac origin: current evidence-based recommendations for prehospital care. *West J Emerg Med.* 2015;16(70):983-95.
34. Glober NK, Sporer KA, Guluma KZ, et al. Acute stroke: current evidence-based recommendations for prehospital care. *West J Emerg Med*. 2016;17(2):104-28.
35. Liu JM, Yang Q, Pirrallo RG, et al. Hospital variability of out-of-hospital cardiac arrest survival. *Prehosp Emerg Care*. 2008;12(3):339-46.
36. Shin SD, Suh GJ, Ahn KO, et al. Cardiopulmonary resuscitation outcome of out-of-hospital cardiac arrest in low-volume versus high-volume emergency departments: An observational study and propensity score matching analysis. *Resuscitation.* 2011;82(1):32-9.
37. Cha WC, Lee SC, Shin SD, et al. Regionalisation of out-of-hospital cardiac arrest care for patients without prehospital return of spontaneous circulation. *Resuscitation*. 2012;83(11):1338-42.
38. Callaway CW, Schmicker RH, Brown SP, et al. Early coronary angiography and induced hypothermia are associated with survival and functional recovery after out-of-hospital cardiac arrest. *Resuscitation*. 2014;85(5):657-63.
39. Schober A, Sterz F, Laggner AN, et al. Admission of out-of-hospital cardiac arrest victims to a high volume cardiac arrest center is linked to improved outcome. *Resuscitation*. 2016;106:42-8.
40. Mumma BE, Diercks DB, Holmes JF. Availability and utilization of cardiac resuscitation centers. *West J Emerg Med*. 2014;15(7):758-63.
41. Stub D, Schmicker RH, Anderson ML, et al. Association between hospital post-resuscitative performance and clinical outcomes after out-of-hospital cardiac arrest. *Resuscitation*. 2015;92:45-52.
42. Sporer K, Jacobs M, Derevin L, et al. Continuous Quality Improvement Efforts Increase Survival with Favorable Neurologic Outcome after Out-of-hospital Cardiac Arrest. *Prehosp Emerg Care*. 2017;21(1):1-6.

43. Rea TD, Page RL. Community approaches to improve resuscitation after out-of-hospital sudden cardiac arrest. *Circulation*. 2010;121(9):1134-40.
44. Yannopoulos D, Bartos JA, Martin C, et al. Minnesota Resuscitation Consortium's Advanced Perfusion and Reperfusion Cardiac Life Support Strategy for Out-of-Hospital Refractory Ventricular Fibrillation. *J Am Heart Assoc.* 2016;5(6). pii: e003732.
45. Hartke A, Mumma BE, Rittenberger JC, et al. Incidence of re-arrest and critical events during prolonged transport of post-cardiac arrest patients. *Resuscitation.* 2010;81(8):938-42.

Outcomes of Emergency Medical Service Usage in Severe Road Traffic Injury during Thai Holidays

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Introduction: Thailand has the highest mortality from road traffic injury (RTI) in the world. There are usually higher incident rates of RTI in Thailand over long holidays such as New Year and Songkran. To our knowledge, there have been no studies that describe the impact of emergency medical service (EMS) utilization by RTI patients in Thailand. We sought to determine the outcomes of EMS utilization in severe RTIs during the holidays.

Methods: We conducted a retrospective review study by using a nationwide registry that collected RTI data from all hospitals in Thailand during the New Year holidays in 2008–2015 and Songkran holidays in 2008–2014. A severe RTI patient was defined as one who was admitted, transferred to another hospital, or who died at the emergency department (ED) or during referral. We excluded patients who died at the scene, those who were not transported to the ED, and those who were discharged from the ED. Outcomes associated with EMS utilization were identified by using multiple logistic regression and adjusted by using factors related to injury severity.

Results: Overall we included 100,905 patients in the final analysis; 39,761 severe RTI patients (39.40%; 95% confidence interval [CI] 95% CI [39.10%–39.71%]) used EMS transportation to hospitals. Severe RTI patients transported by EMS had a significantly higher mortality rate in the ED and during referral than that those who were not (2.00% vs. 0.78%, $p < 0.001$). Moreover, EMS use was significantly associated with increased mortality rate in the first 24 hours of admission to hospitals (1.38% for EMS use vs. 0.57% for no EMS use, $p < 0.001$). EMS utilization was a significant predictor of mortality in EDs and during referral (adjusted odds ratio [OR] 2.19; 95% CI [1.88–2.55]), and mortality in the first 24 hours of admission (adjusted OR 2.31; 95% CI [1.95–2.73]).

Conclusion: In this cohort, severe RTI patients transported by EMS had a significantly higher mortality rate than those who went to hospitals using private vehicles during these holidays. [West J Emerg Med. 2018;19(2)266-275.]

INTRODUCTION

Road traffic injury (RTI) is a major public health issue. Every year, approximately 1.25 million people die and 20–50 million people worldwide are injured from RTI.[1] RTI also has a huge economic impact, owing to costs of treatment, rehabilitation, accident investigation, and lost productivity. Thailand has the highest RTI mortality rate in the world,[1] which may be attributed in part to the high incidence of drunk driving, high-speed driving, and low incidence of helmet or seatbelt use. The problem is further compounded by poor road

conditions, especially in rural areas.[2]

The incidence of RTIs in Thailand increases during long holiday seasons – such as the New Year's holiday December 31 - January 1 and the traditional Thai New Year's holiday called Songkran, April 13 - 15 – because of high traffic volume and a higher incidence of drunk driving.[2] The high-traffic holiday volume usually lasts seven days since many people add vacation leave to extend their time off.[2] Since 2008 the country has collected RTI data during the holidays as part of a nationwide registry, which has been used for monitoring the incidence of RTIs, establishing public health interventions to prevent accidents, and improving post-crash response, including emergency medical services (EMS).

Similar to other countries, the Thai EMS system was developed as a part of the larger healthcare system, which aims to reduce morbidity and mortality in all emergencies. However, a recent study revealed that EMS use among RTI patients did not improve survival rates.[3] These findings are similar to those of other studies focusing on EMS utilization in all patients with traumatic injuries.[4-6] This indicates that improvement in prehospital care is needed, particularly for RTI patients. There is no global standard solution for RTI management. Understanding the characteristics of EMS utilization and its impact in individual regions is a critical component for improving the quality of the system. To our knowledge, no previous studies have described the impact of EMS utilization on road traffic accidents in Thailand.

As a first step toward improving the prehospital trauma care system in Thailand, which has a high incidence of RTIs, we sought to determine the outcomes of EMS utilization among RTI patients during the New Year and Songkran holidays, using data from a nationwide registry. Furthermore, the results may help other countries establish benchmarks to improve their EMS systems.

Population Health Research Capsule

What do we already know about this issue?
Thailand has a high mortality rate from road traffic injury (RTI), especially over long holiday periods. There is little data describing the impact on the Thai EMS system from more RTI patients during the holidays.

What was the research question?
Was there a difference in outcomes of RTI patients transported by EMS compared to those who were transported by private vehicle?

What was the major finding of the study?
The EMS utilization group had a significantly higher severity and in-hospital mortality rate than the private vehicle group.

How does this improve population health?
The Thai trauma system should be improved to allow earlier access to and resuscitation of patients with RTI, ,especially those transported by EMS.

METHODS

Thailand is a middle-income country in Southeast Asia. In 2015 its estimated population was 67,959,000, with a density of 132.1 per square kilometer.[7] The country has 76 provinces grouped into 13 regional offices (ROs). The Thai Ministry of Public Health allocates funds to these ROs,[8] which includes a budget for EMS organization. The Thai EMS system has been developing since 1995. It includes a two-tiered response, ambulance system that can be activated by dialing 1669. Basic life support (BLS) is provided by nonpublic health-sector organizations and hospital-based ambulances. BLS providers are basic emergency medical technicians (EMT-Bs) who have trained for at least 110 hours, or first responders who have trained for at least 40 hours.

The system provides advanced life support (ALS), administered by nurses through hospital-based ambulances. Certain rural areas have intermediate life support (ILS) provided by intermediate-level EMTs (EMT-I). EMT-Is complete a two-year training curriculum. In some areas that lack access to hospital-based ambulances, a first-response unit (FR) transports patients to hospitals. In 2008 the National Institute of Emergency Medicine (NIEM) was established to regulate EMS policies, EMS quality, and the licensure of EMS providers.[9]

In an effort to prevent RTIs and control the quality of the EMS system during long holidays NIEM established a surveillance system in 2008 that collects RTI data from all hospitals. The surveillance collected data for seven days during each period from the Road Safety Directing Center's announcements. For example, data were collected from December 27, 2013, to January 2, 2014, for the New Year's 2014 holiday and from April 11 - 17 2014 for the Songkran holiday. NIEM used the registry to create prevention campaigns for the entire country, one example of which was the "Don't Drive Drunk "campaign. NIEM also shared the data with police departments as a means to improve law enforcement in each province.

The RTI data-collection form included the name, sex, age, status of road user (e.g., driver, passenger, pedestrian), vehicle of patient, vehicle of party, date and time of accident, type of road (e.g., highway, rural, city) and the province in

which the accident occurred, helmet/seatbelt use, alcohol use, admission/referral status, treatment outcome, length of stay, and post-crash transportation of patient. The form was distributed to all community, provincial, university, and private hospitals during the New Year and Songkran festival periods for the collection of data from all crash victims who accessed hospital care. Assigned data collectors interviewed patients or their relatives. Data on demographics, crash details, and risk factors were collected from interviewing patients or relatives or those who transported patients to the hospital. Data on treatment, outcome and post-crash transportation were collected from medical records. If a patient was admitted to the hospital, the outcome of treatment was reassessed at day 30 after a crash to be consistent with the World Health Organization definition of road traffic death. Alcohol-use information was obtained in various ways: from patients who verbally indicated that they had consumed alcohol prior to the injury; from relatives or from those who transported patients to the hospital; or by physical examination by a health provider, or laboratory testing. These data were then entered into the NIEM electronic database.

This study was reviewed and approved by the Faculty of Medicine Siriraj Hospital Institutional Review Board. We conducted a retrospective review study using data collected by the NIEM registry during the 2008–2015 New Year holiday and 2008–2014 Songkran holiday. We excluded patients who died at the scene and those who were not transported to hospitals because no transportation method for these patients had been recorded in the registry. Severe RTI patients were defined as patients who were admitted to the hospital, were referred, or had died in the emergency department (ED). We also excluded patients who were discharged from EDs.

Subsequently, we categorized data into two cohorts: a control group, and an EMS utilization group, which included patients who were transported to hospitals by FR, BLS, ILS, or ALS ambulances. The registry also recorded the vehicle type. We further classified the data according to whether the victims were vulnerable road users (which included pedestrians, cyclists, and motorcyclists) or non-vulnerable road users.[10] We also categorized the time of the day that patients visited hospitals, dividing the day by 06:00–17:59 and 18:00–05:59. Patients who used helmets and seatbelts were combined. Mortality included death in EDs and during referral, death in the initial 24 hours after admission, and death 1–30 days after admission. Survival was defined as patients who either survived after 30 days of admission or were discharged from hospital.

We analyzed all demographic data comparing EMS and non-EMS utilization using chi-square test. Logistic regression was used to analyze the primary outcome, which was the association between EMS utilization and mortality of RTI patients; we then adjusted the outcome for factors that affected injury severity, such as age, sex, being a vulnerable road user, road characteristics, alcohol consumption, and helmet or seatbelt use.[11-18] We conducted subgroup analyses to identify factors related to the mortality of patients who were transported by EMS. Univariate analysis was conducted using chi-square test and Fisher's exact test. We included factors that have been proven to be associated with RTI severity, as mentioned above, and level of EMS in a multiple logistic regression model. *P* values <0.05 were considered significant. We calculated statistics using R version 3.2.1 (The R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

The nationwide registry of the New Year's holiday reported 214,950 RTI patients in 2008–2015, and that of the Songkran holiday 202,298 RTI patients in 2008–2014. After excluding patients who died at the scene, were not transported to hospitals, or were discharged from the ED, 100,905 severe RTI patients were included in the final analysis **(**Figure**)**. In total, 39,761 RTI patients (39.40%; 95% confidence interval [CI] 95% CI [39.10–39.71]) were transported by EMS.

Table 1 summarizes the demographic characteristics of severe RTI patients during these two major Thai holidays, categorized by mode of transportation. The mean (SD) age of patients transported by EMS was 32.12 (16.30) years, which was significantly greater than that of patients from the non-EMS utilization group (30.38 (17.19); $p < 0.001$). The severe RTI patients in this registry were predominantly male (73.86%). In the EMS utilization group 74.68% were male, and in the control group 73.26% were male. Approximately one-third of the accidents occurred on highway roads (31.53%), of which 38.08% of the victims were transported to the ED by ambulance, which was significantly more than those who were not transported (27.27%). Only 12,945 patients (13.98%) wore a helmet or seatbelt. Almost half of the severe RTI patients (50.88%) were influenced by alcohol. The history of alcohol consumption among patients transported by ambulance was significantly higher than in the control group (54.72% vs. 48.45%; $p < 0.001$).

The mortality rate in EDs and during referral in severe RTI patients transported by EMS was significantly higher than in those who were not (2.00% vs. 0.78%; $p < 0.001$). Moreover, EMS use revealed a mortality rate of 1.38% in the first 24 hours after admission to hospitals, which was significantly higher than the corresponding rate of 0.57% in the control group ($p < 0.001$). EMS utilization was a significant predictor of mortality in EDs and during referral, mortality in the first 24 hours of admission, and mortality in the 1-30 day period following admission to hospitals (Table 2). Following adjusted odds ratio (OR) with age, sex, RO, holiday year, helmet or seatbelt use, alcohol consumption, vulnerable road users, and road characteristics, EMS utilization had 2.19 times higher odds of mortality in EDs and during referral (adjusted OR 2.19; 95% CI [1.88–2.55]). It also significantly increased mortality in the first 24 hours after

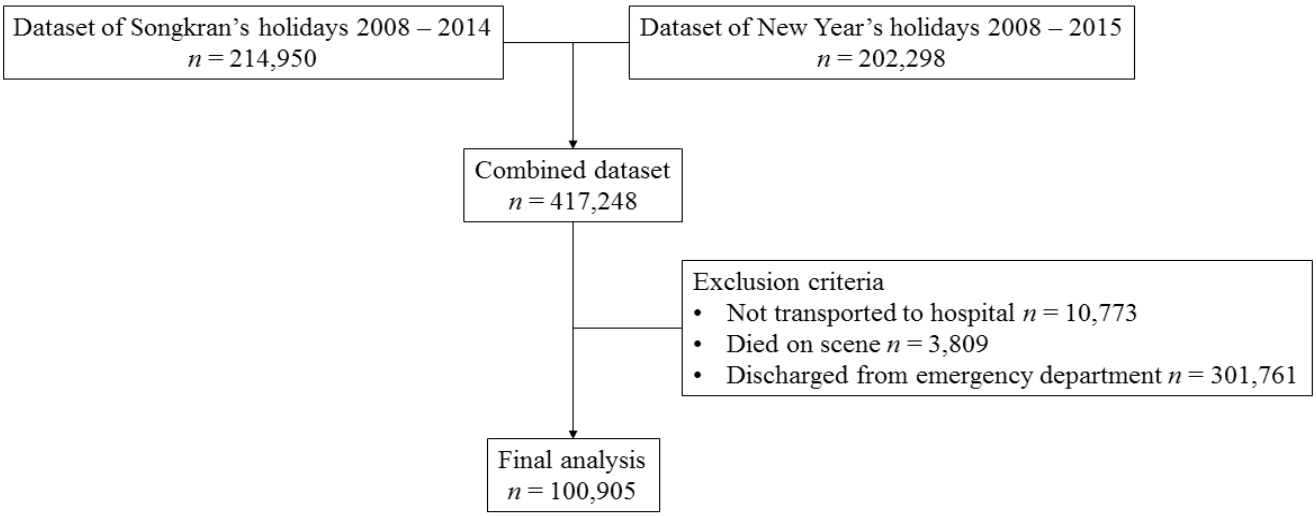

Figure. Flow chart of dataset for analysis of road traffic injuries in Thailand during Songkran's and New Year's holidays.

admission (adjusted OR 2.31; 95% CI [1.95–2.73]). Furthermore, EMS use increased the odds of mortality in the 1- 30 day period following admission to the hospital (adjusted OR 1.57; 95% CI [1.28–1.92]).

Table 3 shows the characteristics of severe RTI patients transported by EMS, categorized by clinical outcomes. The patients who survived after 30 days of admission had been transported by ALS teams significantly less than patients who died (26.91% vs. 64.24% mortality in EDs and during referral, 58.18% mortality in the first 24 hours after admission, and 58.36% mortality in 1- 30 days after admission to the hospital; $p < 0.001$). On the other hand, 14.42% of survival patients wore a helmet or seatbelt, which was significantly higher than among the patients who died (11.36% mortality in EDs and during referral, 9.47% mortality in first 24 hours after admission, and 9.21% mortality in 1 - 30 days after admission to the hospital; $p < 0.001$).

Multiple logistic regression revealed factors associated with mortality in EDs and during referral, mortality in the first 24 hours after admission, and mortality in 1 - 30 days after admission to the hospital, (Tables 4, 5, and 6, respectively). ALS transportation was a significant factor in increased mortality (OR 4.63; 95% CI [3.72–5.82] in mortality in EDs and during referral, OR 3.44; 95% CI [2.73–4.35] in mortality in the first 24 hours after admission, and OR 3.61; 95% CI [2.65–4.96] mortality in 1 - 30 days after admission). Accidents on highway roads increased the odds of mortality in EDs and during referral than those on city roads (OR 1.57; 95% CI [1.19–2.11]). Highway-related injuries also had 1.52-times higher odds of mortality in the first 24 hours of admission (OR 1.52; 95% CI [1.11–2.11]). In contrast, helmet or seatbelt use was a significant factor in decreasing mortality rates (OR 0.56; 95% CI [0.41–0.76] in ED mortalities and during referral, OR 0.64; 95% CI [0.45–0.90] in mortality in the first 24 hours after admission, and OR 0.52; 95% CI [0.30–0.84] mortality in 1 – 30 days after admission).

DISCUSSION

This study describes outcomes of severe RTI patients transported by EMS compared with patients transported by private vehicles. We conducted the analysis using a nationwide registry in Thailand, which has the highest traffic accident mortality rate in the world. Moreover, the registry collected data during holidays with a high incidence of RTIs. In this cohort, severe RTI patients transported by ambulance had a higher mortality rate than patients transported to hospitals by private vehicles, and this finding is in line with those of other studies.[3,4,19] The higher mortality rate might be attributed to the fact that patients who were transported by EMS were more severely injured than those in the control group.

Our results demonstrated that approximately 40% of severe RTI patients were transported to hospitals by ambulance, which was less than reports from other countries. Recently, Huang et al. reported that 73.4% of RTI patients in Taiwan were transported by EMS. One possible reason for not using EMS may have been that patients might not have known or might have forgotten the four-digit (1669) number for ambulance services.[20] This contact number is different from those of other public service agencies such as the police and fire departments. A continuous advertisement of the emergency number should be done to increase EMS use in Thailand.

The demographic data revealed that the patients who used EMS had more factors that increased injury severity than the control group; for example, our analysis demonstrated that severe RTI patients transported by ambulance reported current alcohol consumption more than those who were not. Recent studies have

Table 1. Demographic data of severe road traffic injury patients categorized by EMS* transportation.

Variable	Overall n = 100,905	Non-EMS utilization n = 61,144	EMS Utilization n = 39,761
Age group			
0-8 years old	5,370 (5.32%)	4,090 (6.69%)	1,280 (3.22%)
9 - 17 years old	17,147 (16.99%)	10,989 (17.97%)	6,158 (15.49%)
18 - 60 years old	72,320 (71.67%)	42,418 (69.37%)	29,902 (75.20%)
61 years old and more	6,068 (6.01%)	3,647 (5.96%)	2,421 (6.09%)
Male	74,529 (73.86%)	44,796 (73.26%)	29,733 (74.78%)
Vulnerable road users	85,052 (84.29%)	52,545 (85.94%)	32,507 (81.76%)
Night shift (1800 – 0599)	47,544 (47.47%)	28,348 (46.76%)	19,196 (48.56%)
(Missing n = 746)			
Road type			
(Missing n = 2,443)			
City road	15,781 (15.64%)	9,405 (15.38%)	6,376 (16.04%)
Rural road	50,867 (50.41%)	33,361 (54.56%)	17,506 (44.03%)
Highway road	31,814 (31.53%)	16,672 (27.27%)	15,142 (38.08%)
Helmet or seatbelt	12,945 (13.89%)	7,733 (13.64%)	5,212 (14.27%)
(Missing n = 7,700)			
Alcohol consumption	47,517 (50.88%)	27,657 (48.45%)	19,860 (54.72%)
(Missing n = 7,523)			
Injury in Songkran holiday	47,468 (47.04%)	29,507 (48.26%)	17,961 (45.17%)
Outcomes			
Survival after 30 days	98,202 (97.32%)	60,069 (98.24%)	38,133 (95.90%)
Death in ED and referral	1,271 (1.26%)	474 (0.78%)	797 (2.00%)
Death in first 24 hours of admission	897 (0.89%)	347 (0.57%)	550 (1.38%)
Death in 1 day - 30 days after admission	535 (0.53%)	254 (0.42%)	281 (0.71%)

EMS, emergency medical services; *ED*, emergency department

Table 2. Multiple logistic regression for emergency medical service utilization among severe road traffic injury patients and mortality

Outcomes	Crude OR (95%CI)	Adjusted OR* (95%CI)
Mortality in EDs and during referral	2.62 (2.37 – 2.94)	2.19 (1.88 – 2.55)
Mortality in first 24 hours of admission to hospitals	2.46 (2.15 – 2.81)	2.31 (1.95 – 2.73)
Mortality in 1 - 30 days after admission to hospitals	1.71 (1.44 – 2.02)	1.57 (1.28 – 1.92)

OR, odds ratio; *CI*, confidence interval; *ED*, emergency department.
*Adjusted with factors that affected injury severity such as age, sex, vulnerable road users, road characteristics, alcohol consumption, and helmet or seatbelt usage.[11-18]

reported that alcohol intoxication is associated with greater injury severity and higher mortality rates among RTI patients.[17,21-23] We also found that severe RTI patients transported by EMS were more often injured on highways than patients who were not. This shows that the patients in the EMS use group were more severely injured than those in the control group, since accidents on highways were more likely to have occurred at high speed, which was associated with more severe injuries.[14] Although we analyzed multiple logistic regression to adjust for confounding factors, certain factors related to injury severity were not included in the registry, such as vehicle speed, comorbidity, prehospital care time, or injury severity scores (ISS).[14,24] To find out the real effect

Table 3. EMS* transport of patients with severe road traffic injuries, classified by clinical outcomes

Variable	Survival after 30 days	Death in EDs and during referral	Death in first 24 hours after admission	Death in 1 day - 30 days after admission	P value
	n = 38,133	n = 797	n = 550	n = 281	
Age					<0.001
0-8 years old	1242 (3.27%)	22 (2.76%)	12 (2.18%)	4 (1.42%)	
9 - 17 years old	5971 (15.66%)	75 (9.41%)	82 (14.91%)	30 (10.68%)	
18 - 60 years old	28668 (75.18%)	615 (77.16%)	404 (73.45%)	215 (76.51%)	
>61 years old	2252 (5.91%)	85 (10.66%)	52 (9.45%)	32 (11.39%)	
Male	28479 (74.68%)	605 (75.91%)	434 (78.91%)	215 (76.51%)	0.105
Vulnerable Road Users	31261 (81.98%)	578 (72.52%)	437 (79.45%)	231 (82.21%)	<0.001
Night shift*	18368 (48.45%)	397 (50.00%)	294 (53.75%)	137 (48.75%)	0.081
(Missing n = 231)					
Road type					<0.001
(Missing n =737)					
City road	6143 (16.11%)	107 (13.43%)	80 (14.55%)	46 (16.37%)	
Rural road	16950 (44.45%)	237 (29.74%)	208 (37.82%)	111 (39.50%)	
Highway road	14328 (37.57%)	441 (55.33%)	256 (46.55%)	117 (41.63%)	
Helmet or seatbelt	5077 (14.42%)	70 (11.36%)	43 (9.47%)	22 (9.21%)	<0.001
(Missing n = 3,246)					
Alcohol consumption	38133 (54.74%)	232 (48.03%)	228 (57.43%)	129 (60.56%)	0.005
(Missing n = 3,464)					
Injury in Songkran holiday	17220 (45.16%)	359 (45.04%)	265 (48.18%)	117 (41.64%)	0.329
Holiday					
EMS level					<0.001
ALS	10261 (26.91%)	512 (64.24%)	320 (58.18%)	164 (58.36%)	
ILS	466 (1.22%)	6 (0.75%)	4 (0.73%)	1 (0.36%)	
BLS	7770 (20.38%)	85 (10.66%)	64 (11.64%)	31 (11.03%)	
FR	19636 (51.49%)	194 (24.34%)	162 (29.45%)	85 (30.25%)	

ED, emergency department; **EMS*, emergency medical services, *ALS* Advanced Life Support team; *ILS*, Intermediate Life Support team; *BLS*, Basic Life support team; *FR*, first responder.
*Night shift hours: 1800 – 0559

of EMS use in clinical outcomes of RTI patients, the registry should collect information about other factors related to severity of injuries.

The subgroup analysis identified factors associated with mortality among severe RTI patients transported by EMS. It demonstrated that patients who were transported by ALS teams had significantly increased mortality. This might have been due to the fact that patients transported by ALS teams were at higher risk of increased severity when compared with patients transported by other EMS levels. Another possibility is that ALS team use might increase the on-scene time, due to prehospital interventions such as administering intravenous fluids or performing endotracheal intubation, as opposed to the "scoop and run" concept. This concurs with findings of previous studies that the use of ALS teams did not improve clinical outcomes.[25,26]

The Ontario Prehospital Advanced Life Support Major Trauma Study demonstrated that implementation of ALS teams did not improve the survival of major trauma patients when compared with patients treated by BLS teams.[26] The study also revealed that among patients with a Glasgow Coma Score less than 9 who needed endotracheal intubation, those transported by ALS teams had a significantly lower survival rate.[26] However, our registry did not collect prehospital care time and prehospital intervention. Further studies should be conducted to determine the real effect of ALS teams on the clinical outcomes of RTI patients by analyzing all confounding factors.

Helmet or seatbelt use was a factor that reduced mortality in severe RTI patients transported by ambulance. This concurred with the findings of previous studies that showed that these protective devices reduce injury severity.[13,27,28] Abu-Zidan et al.

Table 4. Factors associated with mortality in the emergency department and during referral among severe RTI patients transported by EMS*.

Variables	Odds ratio (OR)	95% Confidence interval	P value
Male	1.09	0.86 – 1.39	0.465
Age			
0 - 8 years old	Reference		
9 - 17 years –old	0.62	0.35 – 1.13	0.099
18 - 60 years old	0.98	0.60 – 1.71	0.936
> 61 years old	1.53	0.87 – 2.82	0.154
Vulnerable road user	0.90	0.71 – 1.15	0.394
EMS levels			
FR	Reference		
BLS	1.16	0.82 – 1.61	0.387
ILS	1.51	0.46 – 3.61	0.423
ALS	4.63	3.72 – 5.82	<0.001
Road locations			
City roads	Reference		
Rural roads	0.84	0.62 – 1.15	0.263
Highway roads	1.57	1.19 – 2.11	0.002
Helmet or seatbelt usage	0.56	0.41 – 0.76	<0.001
Alcohol consumption	0.76	0.61 – 0.96	0.019

C=0.734

ED, emergency department; **EMS*, emergency medical services, *ALS* Advanced Life Support team; ILS, Intermediate Life Support team; *BLS*, Basic Life support team; *FR*, first responder; *RTI*, road traffic injury.

reported that restrained RTI patients showed significantly less severe injury as well as fewer surgeries compared with unrestrained patients.[27] Furthermore, Nash et al. reported that seatbelt use was associated with a significant reduction in injury severity, mortality rate, and length of stay among RTI patients.[28] Liu et al. reviewed 61 observational studies and found that helmet use was a significant factor in reducing mortality and head injury in motorcycle crashes.[13] Only 13.89% of patients in this cohort wore a helmet or seatbelt, although Thai law requires helmet and seatbelt use. Further studies should be conducted to explore barriers to helmet and seatbelt use.

LIMITATIONS

Although we analyzed data from the largest RTI registry in the country, revealing high mortality rates among RTI patients, our study has certain limitations. First, because it was a retrospective observational study, there were missing data regarding accident time, helmet and seatbelt use, alcohol consumption status, and road characteristics. Second, the collection method in the registry had a potential for recall bias since the data collectors interviewed patients or their relatives at the hospital. Third, the registry collects data only in the long holiday periods. Given the lack of data for non-holidays the registry could not represent the effect of EMS utilization during non-holidays. We also excluded patients who died at the scene and were not transported to hospitals. This might have changed the injury severity of the whole population.

Furthermore, the analysis combined patients using helmet and seatbelt in one variable as a protective factor for overall RTI patients, when the injuries have different mechanisms. Further investigation should conduct subgroup analysis comparing those using motorcycles vs. four-wheel vehicles. Moreover, as mentioned earlier, the registry did not collect data on confounding variables that could affect clinical outcomes, such as ISS, prehospital care time, vehicle speed, or patient comorbidities. Lacking prehospital intervention is another limitation. The registry should collect the prehospital management or link with the Thai EMS database. Alcohol consumption was defined using patient history data and physical examination by the physician, which is not the gold standard. Blood alcohol levels should perhaps be included in the registry. Improving the registry will help enhance our understanding of these characteristics as well as the effects of EMS utilization on clinical outcomes.

Aside from our suggestions to improve the registry, there are further implications from the results of this study. Since we found that the RTI patients transported by EMS during the holidays had increased mortality rates, we recommend that this group of patients be evaluated in a trauma resuscitation room earlier,

Table 5. Factors associated with mortality in the first 24 hours of hospital admission among severe RTI patients transported by EMS*

Variables	Odd ratio (OR)	95% Confidence interval	P value
Male	1.13	0.86 – 1.50	0.383
Age			
0 - 8 years old	Reference		
9 - 17 years –old	1.47	0.71 – 3.57	0.340
18 - 60 years old	1.52	0.76 – 3.58	0.284
> 61 years old	3.19	1.52 – 7.80	0.005
Vulnerable road user	1.06	0.80 – 1.44	0.679
EMS levels			
FR	Reference		
BLS	1.00	0.70 – 1.41	0.998
ILS	1.09	0.27 – 2.91	0.880
ALS	3.44	2.73 – 4.35	<0.001
Road locations			
City roads	Reference		
Rural roads	1.03	0.75 – 1.44	0.865
Highway roads	1.52	1.11 – 2.11	0.011
Helmet or seatbelt usage	0.64	0.45 – 0.90	0.013
Alcohol consumption	1.11	0.86 – 1.42	0.428

C=0.6996

ED, emergency department;, **EMS*, emergency medical services, *ALS* Advanced Life Support team; ILS, Intermediate Life Support team; *BLS*, Basic Life support team; *FR*, first responder; *RTI*, road traffic injury.

especially for patients transported by ALS teams. And to reduce time spent in the ED, prehospital notification should be given to receiving hospitals by the ambulance team before arrival.

CONCLUSION

Transportation of severe road traffic injury patients by EMS was significantly associated with increased mortality in EDs and during referral, as well as mortality in the first 24 hours following hospital admission and mortality from 1 – 30 days after admission. However, certain additional confounding factors must be collected for adjustment in these associations. We recommend improving the Thai RTI registry by reducing confounders. This will enable researchers to identify the actual effects of EMS utilization among severe RTI patients in Thailand. Furthermore, we suggest that severe RTI patients be taken to hospitals during these holidays by ambulance and, especially those taken by ALS team, should be rapidly assessed in the ED. These changes could potentially improve the clinical outcomes of RTI patients in Thailand.

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REFERENCES

1. World Health Organization. Global Health Observatory Data: Number of Road Traffic Deaths. 2017. Available at: http://www.who.int/gho/road_safety/mortality/traffic_deaths_number/en/. Accessed January 5, 2018.

Table 6. Factors associated with mortality 1 to 30 days after hospital admission among severe RTI patients transported by EMS*

Variables	Odds ratio (OR)	95% Confidence interval	P value
Male	0.90	0.63 – 1.30	0.561
Age			
0 - 8 years old	Reference		
9 - 17 years –old	1.26	0.43 – 5.38	0.710
18 - 60 years old	2.14	0.80 – 8.71	0.196
> 61 years old	3.46	1.17 – 14.77	0.047
Vulnerable road user	0.97	0.67 – 1.46	0.887
EMS levels			
FR	Reference		
BLS	0.97	0.60 – 1.55	0.916
ILS	0.65	0.04 – 2.94	0.665
ALS	3.61	2.65 – 4.96	<0.001
Road locations			
City roads	Reference		
Rural roads	0.70	0.48 – 1.04	0.071
Highway roads	0.92	0.63 – 1.36	0.656
Helmet or seatbelt usage	0.52	0.30 – 0.84	0.013
Alcohol consumption	1.28	0.91 – 1.81	0.157

C=0.708

ED, emergency department; **EMS*, emergency medical services, *ALS* Advanced Life Support team; *ILS*, Intermediate Life Support team; *BLS*, Basic Life support team; *FR*, first responder; *RTI*, road traffic injury.

2. Bureau of Health Emergency Response. Public Health Emergency Response (PHER): Accident Emergency Data. 2016. Available at: http://ict-pher.moph.go.th/. Accessed December 5, 2016.
3. Huang CY, Rau CS, Chuang JF, et al. Characteristics and outcomes of patients injured in road traffic crashes and transported by emergency medical services. *Int J Environ Res Public Health.* 2016;13(2):236.
4. Demetriades D, Chan L, Cornwell E, et al. Paramedic vs private transportation of trauma patients. Effect on outcome. *Arch Surg.* 1996;131(2):133-8.
5. Eckstein M, Chan L, Schneir A, et al. Effect of prehospital advanced life support on outcomes of major trauma patients. *J Trauma.* 2000;48(4):643-8.
6. Johnson NJ, Carr BG, Salhi R, et al. Characteristics and outcomes of injured patients presenting by private vehicle in a state trauma system. *Am J Emerg Med.* 2013;31(2):275-81.
7. United Nations Department of Economic and Social Affairs, Population Division. World Population Prospects: The 2015 Revision, Key Findings and Advance Tables. ESA/P/WP.241. 2015. Available at: https://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf. Accessed December 5, 2016.
8. National Health Security Office. NHSO's Structure. 2016. Available at: http://www.nhso.go.th/eng/Site/ContentItems.aspx?type=Mg%3d%3d. Accessed December 5, 2016.
9. National Institute for Emergency Medicine. History. Available at: http://www.niems.go.th/en/View/Page.aspx?PageId=25551114035939822. Accessed December 5, 2016.
10. Decker S, Otte D, Cruz DL, et al. Injury severity of pedestrians, bicyclists and motorcyclists resulting from crashes with reversing cars. *Accid Anal Prev.* 2016;94:46-51.
11. Abu-Zidan FM, Eid HO. Factors affecting injury severity of vehicle occupants following road traffic collisions. *Injury.* 2015;46(1):136-41.
12. Chen H, Chen Q, Chen L, et al. Analysis of risk factors affecting driver injury and crash injury with drivers under the influence of alcohol (DUI) and non-DUI. *Traffic Inj Prev.* 2016;17(8):796-802.
13. Liu BC, Ivers R, Norton R, et al. Helmets for preventing injury in motorcycle riders. *Cochrane Database Syst Rev.* 2008(1):Cd004333.
14. Lu JJ, Xing Y, Wang C, et al. Risk factors affecting the severity of traffic accidents at Shanghai river-crossing tunnel. *Traffic Inj Prev.* 2016;17(2):176-80.
15. Mogaka EO, Ng'ang'a Z, Oundo J, et al. Factors associated with severity of road traffic injuries, Thika, Kenya. *Pan Afr Med J.* 2011;8:20.
16. Plurad D, Demetriades D, Gruzinski G, et al. Motor vehicle crashes: the association of alcohol consumption with the type and severity of injuries and outcomes. *J Emerg Med.* 2010;38(1):12-7.

17. Stubig T, Petri M, Zeckey C, et al. Alcohol intoxication in road traffic accidents leads to higher impact speed difference, higher ISS and MAIS, and higher preclinical mortality. *Alcohol.* 2012;46(7):681-6.
18. Weiss HB, Kaplan S, Prato CG. Analysis of factors associated with injury severity in crashes involving young New Zealand drivers. *Accid Anal Prev.* 2014;65:142-55.
19. Cornwell EE, 3rd, Hennigan K, Belzberg H, et al. Emergency medical services (EMS) vs non-EMS transport of critically injured patients: a prospective evaluation. *Arch Surg.* 2000;135(3):315-9.
20. Monsomboon A, Chantawatsharakorn P, Suksuriyayothin S, et al. Prevalence of emergency medical service utilisation in patients with out-of-hospital cardiac arrest in Thailand. *Emerg Med J.* 2016;33(3):213-7.
21. Tulloh BR and Collopy BT. Positive correlation between blood alcohol level and ISS in road trauma. *Injury.* 1994;25(8):539-43.
22. Waller PF, Hill EM, Maio RF, et al. Alcohol effects on motor vehicle crash injury. *Alcohol Clin Exp Res.* 2003;27(4):695-703.
23. Kasantikul V, Ouellet JV, Smith T, et al. The role of alcohol in Thailand motorcycle crashes. *Accid Anal Prev.* 2005;37(2):357-66.
24. Harmsen AM, Giannakopoulos GF, Moerbeek PR, et al. The influence of prehospital time on trauma patients outcome: a systematic review. *Injury.* 2015;46(4):602-9.
25. Sampalis JS, Lavoie A, Williams JI, et al. Impact of on-site care, prehospital time, and level of in-hospital care on survival in severely injured patients. *J Trauma.* 1993;34(2):252-61.
26. Stiell IG, Nesbitt LP, Pickett W, et al. The OPALS Major Trauma Study: impact of advanced life-support on survival and morbidity. *CMAJ.* 2008;178(9):1141-52.
27. Abu-Zidan FM, Abbas AK, Hefny AF, et al. Effects of seat belt usage on injury pattern and outcome of vehicle occupants after road traffic collisions: prospective study. *World J Surg.* 2012;36(2):255-9.
28. Nash NA, Okoye O, Albuz O, et al. Seat Belt Use and Its Effect on Abdominal Trauma: A National Trauma Databank Study. *Am Surg.* 2016;82(2):134-9.

A Predictive Model Facilitates Early Recognition of Spinal Epidural Abscess in Adults

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Introduction: Spinal epidural abscess (SEA), a highly morbid and potentially lethal deep tissue infection of the central nervous system has more than tripled in incidence over the past decade. Early recognition at the point of initial clinical presentation may prevent irreversible neurologic injury or other serious, adverse outcomes. To facilitate early recognition of SEA, we developed a predictive scoring model.

Methods: Using data from a 10-year, retrospective, case-control study of adults presenting for care at a tertiary-care, regional, academic medical center, we used the Integrated Discrimination Improvement Index (IDI) to identify candidate discriminators and created a multivariable logistic regression model, refined based on p-value significance. We selected a cutpoint that optimized sensitivity and specificity.

Results: The final multivariable logistic regression model based on five characteristics –patient age, fever and/or rigor, antimicrobial use within 30 days, back/neck pain, and injection drug use – shows excellent discrimination (AUC 0.88 [95% confidence interval {0.84, 0.92}]). We used the model's β coefficients to develop a scoring system in which a cutpoint of six correctly identifies cases 89% of the time. Bootstrapped validation measures suggest this model will perform well across samples drawn from this population.

Conclusion: Our predictive scoring model appears to reliably discriminate patients who require emergent spinal imaging upon clinical presentation to rule out SEA and should be used in conjunction with clinical judgment. [West J Emerg Med. 2018;19(2)276-281.]

INTRODUCTION

The incidence of spinal epidural abscess (SEA), a highly morbid and potentially lethal deep tissue infection of the central nervous system, has risen significantly over the past decade.[1,2] Our tertiary care institution has experienced an increase of more than 200%, from 2.5 to 8 cases per 10,000 hospital admissions since 2005.[3] Although the reasons are not clearly defined, various factors, such as an expanded, comorbidly ill, aging population, and procedures or behaviors predisposing to bacteremia, have been posited to contribute to the increased incidence of SEA.

We recently reported the results of a large , case-control study of SEA over the previous decade in a single, tertiary-care, regional, academic medical center to assess possible changes in the epidemiology, risk factors, and clinical manifestations of this infection in order to identify features that could potentially facilitate its early clinical recognition.[3] Because SEA may rapidly and unpredictably evolve to irreversible neurologic injury and diagnostic delays remain common,[4] our goal was to use these data to inform a discrimination model that could be employed at the time of initial clinical presentation to prioritize potential cases for expeditious, advanced imaging to optimize patient outcomes.

METHODS

Study Design

The design and selection criteria for cases and controls have been previously described.[3] To ensure clinical relevance, the case and control groups were drawn from patients who presented with findings that either raised concern for SEA or who underwent a "rule-out" evaluation; magnetic resonance imaging (MRI) or computed tomography and microbiologic data were used to assign patients to the appropriate group. Baystate Medical Center (BMC), a 720-bed tertiary-care, regional, academic medical center currently serving a population of approximately 850,000 people in western Massachusetts experiences more than 33,000 annual adult discharges with a corresponding case-mix index of 1.72, indicating high severity and complexity of its inpatients relative to their diagnosis related group. Encounters were coded as "confirmed" SEA if there was a radiologist-confirmed finding of an epidural lesion on advanced imaging with a positive culture from lesion or blood; "probable" if there was a radiologist-confirmed epidural lesion in the absence of positive cultures from lesion or blood; and "control" if no lesion was identified by the radiologist on the imaging study. This study was approved by the institutional review board.

Statistical Analysis

We preliminarily evaluated baseline comparison between cases and controls using univariable analyses (t-tests, Fisher's exact test) and direct visualization methods (coefficient plots, LOWESS curves). Because our goal was to develop a discrimination model, we used the Integrated Discrimination Improvement Index (IDI) to identify candidate discriminators.[5] The IDI represents the degree to which a candidate variable increases the event probability in cases, while decreasing the event probability in controls, thus discriminating cases from non-cases.

We selected candidate predictive factors if they were immediately discernible upon clinical presentation and if their univariable IDI was >0.02, suggesting meaningful discrimination properties. To reduce bias in the prediction model, candidate variables had to have at least 20 events to be considered.[6] The multivariable logistic regression model initially included all candidate variables and was then refined using a backwards selection process, with a p-value for removal of 0.05. We used Youden's J[7] to identify the cutpoint that maximized sensitivity and specificity. Areas under the receiver operator curve (AUC) of the full- vs. restricted-models were compared using previously described methods.[8] We assessed model fit using the Hosmer-Lemeshow goodness of fit[9] and Stukel[10] tests. Because measures of model validation may be overly optimistic when derived on the sample used for coefficient estimation, we generated bootstrapped validation measures.[11,12] We used Stata 14.2 (StataCorp LLC, College Station TX) and R (http://www.R-project.org/) for analyses.

Population Health Research Capsule

What do we already know about this issue?
Spinal epidural abscess (SEA) is a highly morbid and potentially lethal infection of rising incidence that is often associated with diagnostic delays. Early diagnosis appears to improve outcomes.

What was the research question?
Can a predictive scoring model be developed that may facilitate the early diagnostic recognition of SEA?

What was the major finding of the study?
Through a large, controlled data set, five factors apparent upon clinical presentation showed robust discrimination of cases.

How does this improve population health?
The predictive model appears to reliably discriminate patients who require emergent spinal imaging upon ED presentation to rule out SEA and should be used in conjunction with clinical judgment.

RESULTS

We identified 162 cases ("confirmed" and "probable"), representing 64.8% of 250 admissions in which SEA was deemed to be a significant diagnostic consideration upon clinical presentation, and a "rule-out" process ensued. Demographic and clinical characteristics of the sample overall (i.e., cases and controls) and by case status revealed several variables of potential significance (p-values < 0.05) with their corresponding IDI values (Table 1). Interestingly, several factors that have been previously reported to confer risk for SEA in uncontrolled studies,[1,2], such as diabetes mellitus or the presence of focal neurologic deficits, were not found to differentiate cases from controls.

Nine characteristics met initial criteria as candidate variables based on statistical significance: age (with the quadratic representation); fever/rigor (fever defined as self-reported or measured temperature of ≥100.4°F); non-traumatic back or neck pain; receipt of antimicrobials within 30 days of admission; a previous ED visit within 30 days of admission,; injection drug use; morbid obesity (defined as BMI ≥35 mg/kg^2); radicular pain; and alcohol abuse. Four of these characteristics (radicular pain, previous healthcare visit within 30 days, obesity, and alcohol abuse) were subsequently removed for poor multivariable discrimination based on IDI (Table 1).

Table 1. Characteristics of study sample: overall and by study group.

Factor	Overall (n=250)	Case (n=162)	Control (n=88)	P value*	IDI
Age in Years, mean±SD	59.7±15.6	58.8±13.8	61.4±18.3	< 0.001#	0.23
Age^2, mean±SD	3810.7±1835	3652.8±1634	4101.5±2137		
Fever and/or Rigor	113 (45.2%)	101 (62.3%)	12 (13.6%)	<0.001	0.22
Back and/or Neck Pain	203 (81.2%)	149 (92.0%)	54 (61.4%)	<0.001	0.14
Antimicrobials w/in 30d	63 (25.2%)	57 (35.2%)	6 (6.8%)	<0.001	0.10
Injection Drug Use	37 (14.8%)	33 (20.4%)	4 (4.5%)	<0.001	0.05
Previous ED Visit	108 (43.2%)	82 (50.6%)	26 (29.5%)	0.001	0.04
BMI>35 mg/kg2	43 (17.2%)	34 (21.0%)	9 (10.2%)	0.04	0.02
Radicular Pain	55 (22.0%)	42 (25.9%)	13 (14.8%)	0.05	0.02
Alcohol Abuse	38 (15.2%)	31 (19.1%)	7 (8.0%)	0.03	0.02
Paresthesia	94 (37.6%)	55 (34.0%)	39 (44.3%)	0.13	0.01
Diabetes Mellitus	76 (30.4%)	55 (34.0%)	21 (23.9%)	0.11	0.01
End Stage Renal Disease	15 (6.0%)	13 (8.0%)	2 (2.3%)	0.09	0.01
Spinal Injection w/in 30d	10 (4.0%)	9 (5.6%)	1 (1.1%)	0.10	0.01
HIV/AIDS	4 (1.6%)	1 (0.6%)	3 (3.4%)	0.13	0.01
Focal Weakness	113 (45.2%)	68 (42.0%)	45 (51.1%)	0.18	< 0.01
Altered Mental Status	58 (23.2%)	41 (25.3%)	17 (19.3%)	0.35	< 0.01
Urinary Retention	36 (14.4%)	20 (12.3%)	16 (18.2%)	0.26	< 0.01
Immune Comp. (Non-HIV)	17 (6.8%)	12 (7.5%)	5 (5.7%)	0.79	< 0.01
Bowel/Bladder Incontinence	15 (6.0%)	10 (6.2%)	5 (5.7%)	1.00	< 0.01

*Fisher's exact or independent samples t-test; #Likelihood ratio test
IDI, Integrated Discrimination Improvement Index; *BMI*, body-mass index; *SD*, standard deviation

Multivariable Model

The final prediction model comprising five factors is shown in Table 2. Model fit was improved significantly with the addition of a quadratic term for age, as risk was reduced in the youngest and oldest patients. The multivariable model achieves an AUC of 0.88 (95% CI [0.84, 0.92]) (Figure a). There was no evidence of significant departure from fit (H-L test, p=0.39; Stukel test = 0.37). Fever/rigor was the strongest clinical predictor of case status in the multivariable model, contributing eight percentage points to its AUC.

To aid clinical decision-making we developed a scoring tool (Table 2) by modifying the final regression model in two ways: age and its quadratic term were represented using seven categorical variables reflecting 10-year age intervals; and the final logistic model beta coefficients were rounded to the nearest integer to facilitate scoring. The quadratic term for age indicates that the risk of SEA is not constant as age increases; risk of SEA generally increases with age and then attenuates somewhat in the oldest age group. By representing age in categories, we can incorporate this non-linearity into the risk score. Applying the tool to the sample total scores ranged from 0-11. The mean score for cases was 7.6 (± 1.7) with a range of 3-11. The mean score for controls was 4.9 (± 1.7) with a range of 0-9. The difference in the means was significant ($p < 0.001$). The tool showed similar discriminating properties to the final regression model. The AUC for the tool was 0.88 (95% CI [0.84, 0.92]). Setting a cutpoint of six on our scoring tool resulted in a sensitivity of 89% (95% CI [83%, 93%]) and a specificity of 63% (95% CI [52%, 73%]). At this cutpoint, with a sample prevalence of 65%, the positive predictive value (PPV) was 81% (95% CI [75%, 87%]), and the negative predictive value (NPV) was 75% (95% CI [64%, 85%]). Finally, to increase sensitivity we considered a cutpoint of five or greater as positive: sensitivity was 96% (95% CI [92%, 99%]) and specificity was 34% (95% CI [24%, 45%]). The PPV was 73% (95% CI [665. 79%]) and the NPV was 83% (95% CI [63%, 94%]).

We explored misclassification of the method by examining extreme scores of cases and non-cases. Among cases that presented with the lowest scores were three patients above the age of 60 who presented with none of the clinical features (injection drug use, fever/rigor, back/neck pain, anti-microbial use with 30 days). Among non-cases that scored highest were patients who presented with two or three of the clinical features and were above the age of 30. There were no non-cases who presented with all four of the clinical features. Five cases (3.1%) presented with all four of the clinical features.

Table 2. Final prediction model for spinal epidural abscess.

Characteristics	Prediction model				Clinical score
	Log-odds	Odds ratio	95% CI	p-value	
Fever and/or rigor	2.31	10.09	4.53, 22.44	< 0.001	2
Antimicrobial use within 30d	1.98	7.25	2.55, 20.61	< 0.001	2
Back and/or neck pain	1.80	6.04	2.13, 17.11	0.001	2
Injection drug use	1.61	5.00	1.70, 14.67	0.003	2
Age	0.23	1.26	1.08, 1.48	0.004	-----
Age^2	-0.002	0.998	0.996, 0.999	0.008	-----
20 to < 30					0
30 to < 40					3
40 to < 50					3
50 to < 60					4
60 to < 70					3
70 to < 80					4
80+					3

Model Validation

The model demonstrated excellent discrimination between cases and non-cases (Figure a). To account for biased estimates of model fit and validation, bootstrapped estimates were derived on 1,000 model runs; bias-adjusted estimates of model validity suggested good model fit (Figure b). The model shows excellent agreement between predicted and observed probabilities, particularly at the higher probability levels but slightly underestimates the observed probability at the lowest probability levels. The corresponding c-statistic was 0.86, suggesting excellent discrimination. The model has good predictive strength as indicated by Nagelkerke's R^2 of 0.47.[11]

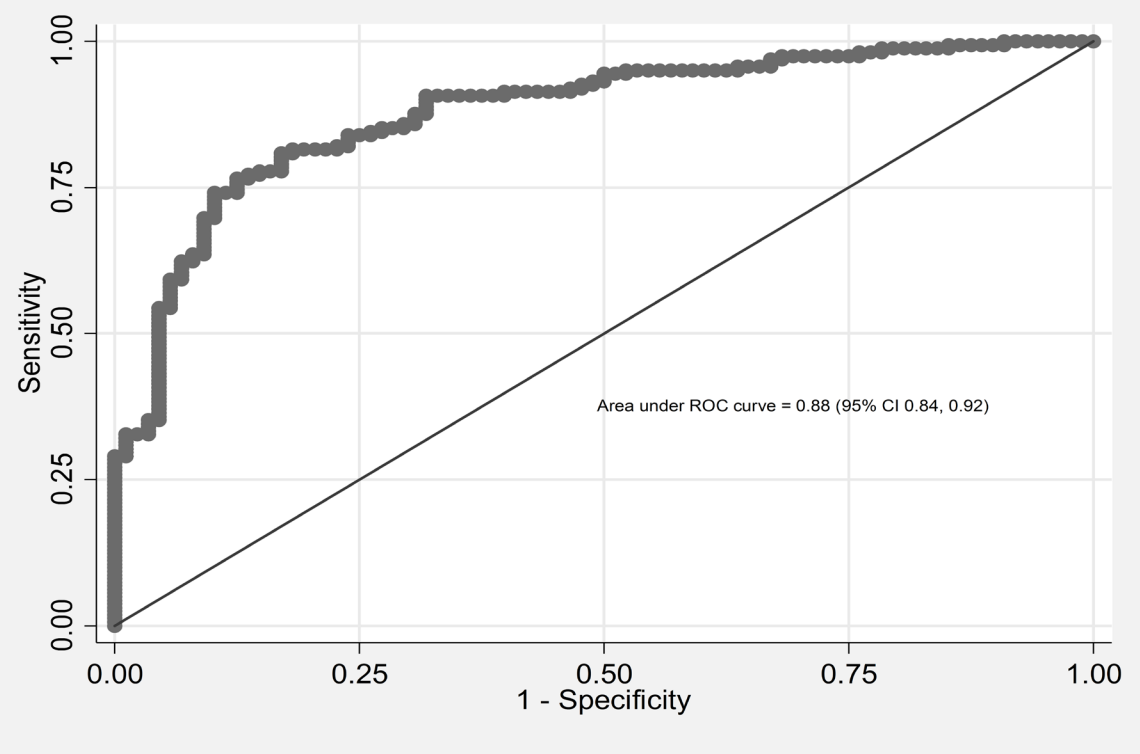
DISCUSSION

The incidence of SEA has progressively increased over the past several decades;[1,2] it has more than tripled over the past decade at our institution and with this, the risk of serious neurologic morbidity has risen commensurately.[3] Although early recognition is essential to preventing irreversible neurologic deficits, diagnostic delays are common.[4] Perhaps the best opportunity for early diagnosis occurs at the time of initial clinical presentation. The majority of patients with SEA present to a healthcare facility with clinical manifestations more than once within 30 days of diagnosis; in most cases, these visits are to the ED.[3,4] Therefore, a clinical scoring tool that could reliably discriminate potential cases and stratify them for emergent spinal imaging at the time of initial clinical presentation would be of value to optimize clinical outcomes in SEA, while also providing stewardship and prioritization of imaging resources.

Diabetes mellitus and other, chronic, co-morbid illnesses are often listed as predisposing risks for SEA in the extant literature.[1,2] Recently reported data from our institution, representing the largest, single-site, published SEA case series (162 cases) with an attendant control group, failed to confirm these as risk factors.[3]

Our predictive model shows excellent agreement between observed and predicted probabilities (Figure). Although further refinement of the model may improve these classification characteristics, maximizing sensitivity and specificity may not be optimal for clinical application. Because of the potentially severe consequences of delaying the diagnosis of SEA, it may be more clinically exigent to maximize sensitivity and thereby sacrifice some degree of specificity. Using our scoring tool with a cutpoint at six, sensitivity appeared to be optimized (89%) at the expense of a modest decrease in specificity (63%). At a higher cutpoint of seven, sensitivity – the ability of the model to correctly detect positives – was reduced to 77% (95% CI [69%, 83%]). At this cutpoint the PPV was 93% (95% CI [87%, 96%]), but the NPV was only 67% (95% CI [58%, 76%]). At a lower cutpoint of five, the modest increase in sensitivity was associated with substantial decrement in specificity (34%) that was felt to be too low for clinical utility.

A previous study evaluated a clinical decision guideline based on elevated serum inflammatory markers to determine the need for advanced spinal imaging in patients potentially at risk for SEA in the ED[13] Although use of the guideline at one institution appeared to reduce diagnostic delays as compared with historical controls, detailed information on the use of MRI was not provided. Additionally, the guideline relies on laboratory testing, which could introduce further delays. We sought to develop a clinically relevant model that was based exclusively on epidemiologic and clinical features that are apparent on initial clinical presentation in order to appropriately triage MR spinal imaging and to reliably facilitate the early recognition of SEA as



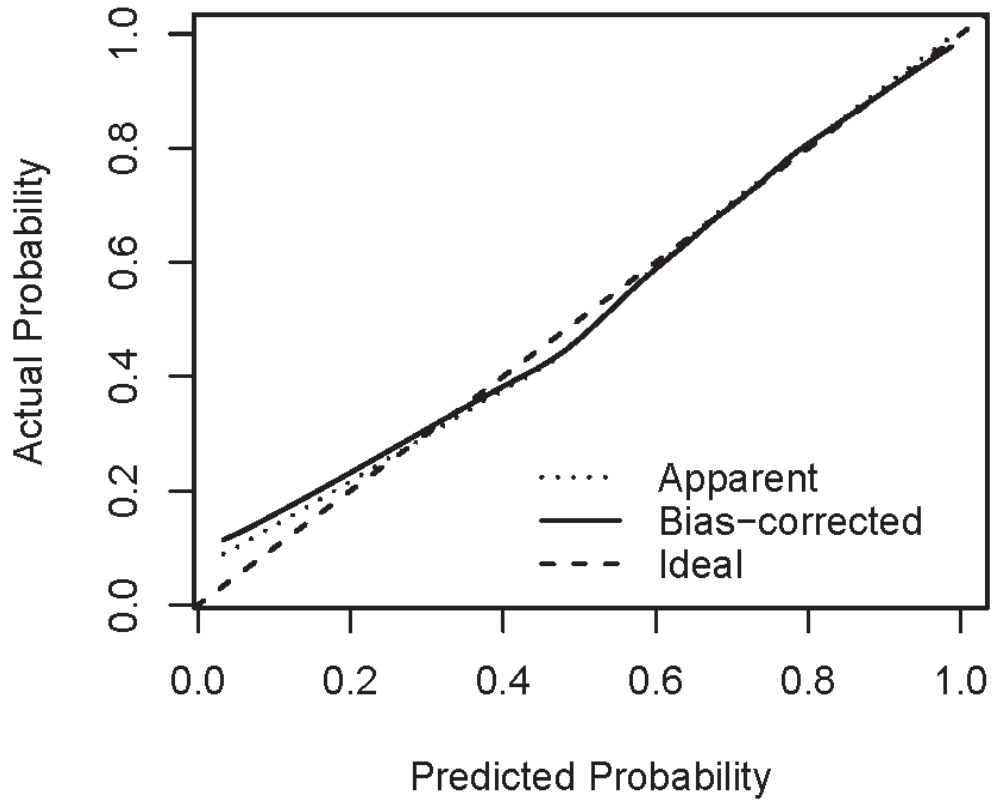


Figure. a) ROC plot of final prediction model (Top) b) calibration plot of final model (bottom).

distinct from other potential spinal pathologies.

LIMITATIONS

Our model has several limitations. The data were drawn from a retrospective, 10-year cohort; thus, the model is based on clinical variables collected at the time of admission or shortly thereafter and available in the record. Although we strove to collect complete data on all variables, it is possible that some potentially useful factors were not considered. Additionally, to optimize the clinical utility of our model, we purposefully limited it to clinical data that would be apparent on initial presentation. We did not consider serum inflammatory markers or other laboratory data in this category. Review of erythrocyte sedimentation rate (ESR) levels in our cohort revealed that this marker was only obtained in approximately 60% of the patients, and the vast majority of these were cases, suggesting that ESR was requested only in the clinical presentations that were highly suspicious for SEA.

Another important limitation of our model is that it was derived from data from a decade-long, retrospective cohort of patients with a confirmed SEA case prevalence of 65% from a single institution; thus, the clinical presentations in this cohort raised at least some level of suspicion for the diagnosis. This scoring model may therefore only be relevant when SEA is reasonably suspected. Our work underscores the known importance of clinical judgment in suspecting the diagnosis of SEA;[1,3] the objective model detailed herein serves to complement this subjective consideration.

Because our institution is a regional, tertiary-care, academic medical center, it is also important to determine whether our data can be extrapolated to other care settings. A prospective evaluation and validation of this model is needed to understand whether it may be useful in an unselected sample of patients presenting for medical attention with a constellation of symptoms and/or signs potentially warranting investigation for SEA. Such an evaluation may also determine if the model can be substantially improved by incorporating additional data that could be ascertained within a short time frame after ED presentation.

CONCLUSION

We have developed a scoring model that appears to reliably discriminate patients who require emergent spinal imaging upon clinical presentation to rule out SEA. It is hoped that our work contributes to raising awareness of this increasingly important, highly morbid, central nervous system infection, and that further enhancement of our model through future prospective validation, prior to its adoption into clinical practice, may limit adverse outcomes from this illness.

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REFERENCES

1. Darouiche RO. Spinal epidural abscess. *N Engl J Med*. 2006;355(19):2012-20.
2. Reihsaus E, Waldbaur H, Seeling W. Spinal epidural abscess: a meta-analysis of 915 patients. *Neurosurg Rev*. 2000;23(4):175-204.
3. Artenstein AW, Friderici J, Holers A, et al. Spinal epidural abscess in adults: A 10-year clinical experience at a tertiary care academic medical center. *Open Forum Infect Dis*. 2016; 3(4):ofw191.
4. Davis DP, Wold RM, Patel RJ, et al. The clinical presentation and impact of diagnostic delays on emergency department patients with spinal epidural abscess. *J Emerg Med*. 2004;26(3):285-91.
5. Pencina MJ, D'Agostino RB Sr, D'Agostino RB Jr, et al. Evaluating the added predictive ability of a new marker: from area under the ROC curve to reclassification and beyond. *Stat Med*. 2008;27(2):157-72.
6. Ogundimu EO, Altman DG, Collins GS. Adequate sample size for developing prediction models is not simply related to events per variable. *J Clin Epidemiol*. 2016;76:175-82.
7. Chen F, Xue Y, Tan MT, et al. Efficient statistical tests to compare Youden index: accounting for contingency correlation. *Stat Med*. 2015;34(9):1560-76.
8. Pepe MS. T*he Statistical Evaluation of Medical Tests for Classification and Prediction*. New York: Oxford University Press, 2003.
9. Hosmer DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*, 3rd ed. Hoboken, NJ: John Wiley & Sons Inc, 2013.
10. Stukel TA. Generalized logistic models. *J Amer Stat Assoc*. 1988;83:426–31.
11. Harrell FE. *Regression modeling strategies: with applications to linear models, logistic regression, and survival analysis*. New York: Springer, 2001.
12. Steyerberg, EW. *Clinical Prediction Models: A Practical Approach to Development, Validation, and Updating*. New York: Springer, 2009.
13. Davis DP, Salazar A, Chan TC, et al. Prospective evaluation of a clinical decision guideline to diagnose spinal epidural abscess in patients who present to the emergency department with spine pain. *J Neurosurg Spine*. 2011;14(6):765-70.

High Prevalence of Sterile Pyuria in the Setting of Sexually Transmitted Infection in Women Presenting to an Emergency Department

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Introduction: The clinical presentations for sexually transmitted infections (STI) and urinary tract infections (UTI) often overlap, and symptoms of dysuria and urinary frequency/urgency occur with both STIs and UTIs. Abnormal urinalysis (UA) findings and pyuria are common in both UTIs and STIs, and confirmatory urine cultures are not available to emergency clinicians to aid in decision-making regarding prescribing antibiotics for UTIs. The objective of this study was to determine the frequency of sterile pyuria in women with confirmed STIs, as well as whether the absolute number of leukocytes on microscopy or nitrite on urine dipstick correlated with positive urine cultures in patients with confirmed STIs. We also sought to determine how many patients with STIs were inappropriately prescribed a UTI antibiotic.

Methods: We performed a retrospective chart review of patients aged 18-50 who had a urinalysis and pelvic examination in the emergency department (including cervical cultures), and tested positive for *Neisseria gonorrhoeae, Chlamydia trachomatis,* and/or *Trichomonas vaginalis.* Descriptive statistics were obtained for all variables, and associations between various findings were sought using the Fisher's exact test for categorical variables. We calculated comparison of proportions using the N-1 chi-squared analysis.

Results: A total of 1,052 female patients tested positive for *Neisseria gonorrhoeae, Chlamydia trachomatis,* and/or *Trichomonas vaginalis* and were entered into the database. The prevalence of pyuria in all cases was 394/1,052, 37% (95% confidence interval [CI] [0.34-0.40]). Of the cases with pyuria, 293/394, 74% (95% CI [0.70-0.78]) had sterile pyuria with negative urine cultures. The prevalence of positive urine cultures in our study population was 101/1,052, 9.6% (95% CI [0.08-0.11]). Culture positive urines had a mean of 34 leukocytes per high-power field, and culture negative urines had a mean of 24 leukocytes per high-power field, with a difference of 10, (95% CI [3.46-16.15]), which was statistically significant (p=0.003). Only 123 cases tested positive for nitrite on the urinalysis dipstick; 50/123, 41% (95% CI [0.32-0.49]) had positive urine cultures, and 73/123, 59% (95% CI [0.51-0.68]) had negative urine cultures. Nitrite-positive urines were actually 18% more likely to be associated with negative urine cultures in the setting of positive STI cases, (95% CI [4.95-30.42], p=0.0048). Antibiotics were prescribed for 295 patients with suspected UTI. Of these, 195/295, 66% (95% CI [0.61-0.71]) had negative urine cultures, and 100/295, 34% (0.33, 95% CI [0.28-0.39]) had positive urine cultures. Chi-square analysis yielded a difference of these proportions of 32% (95% CI [23.92-39.62], p<0.0001).

Conclusion: This study demonstrated that in female patients with STIs who have pyuria, there is a high prevalence of sterile pyuria. Our results suggest that reliance on pyuria or positive nitrite for the decision to add antimicrobial therapy empirically for a presumed urinary tract infection in cases in which an STI is confirmed or highly suspected is likely to result in substantial over-treatment. [West J Emerg Med. 2018;19(2)282-286.]

INTRODUCTION

Patients diagnosed with sexually transmitted infections (STI) are common in the emergency department (ED) setting. The Centers for Disease Control and Prevention (CDC) estimates that nearly 20 million new STIs occur annually.[1] Patients undergoing evaluation for potential STIs will often have had comprehensive evaluation that includes gonococcal and chlamydia testing, wet prep, urinalysis, and urine culture. The clinical presentations for STIs and urinary tract infections (UTIs) may overlap, and symptoms of dysuria and urinary frequency/urgency occur with both STIs and UTIs.[2,3,4] Abnormal urinalysis (UA) findings of leukocyte esterase and pyuria are common in both UTIs and STIs.[3,5-9] STIs have been previously found to be associated with pyuria without bacteriuria.[2,10-11] Furthermore, high STI rates have been reported in women evaluated in an urban ED and diagnosed with UTI.[12-14]

Emergency physicians (EP) must make decisions as to whether to empirically treat for UTIs based on initial UA results alone because confirmatory urine culture results are not readily available for several days after the patient's ED visit. Findings of significant UA pyuria on these patients have the potential to lead EPs to treat the patient for a presumed "UTI" in patients who may actually have STIs and negative urine cultures.[15,16] Additionally, nitrite-positive dipsticks have previously shown high specificity for UTIs,[17-19] but this has not been studied specifically in STI-positive patients. Positive urine cultures have been defined by previous studies as growth of a bacterial pathogen >100,000 (10^5) colonies.[6,10] Sterile pyuria is classified as the presence of more than 5-8 leukocytes per high-power field on microscopy, in the setting of negative urine cultures.[4,20-21]

Treating a patient with sterile pyuria for a UTI can have negative effects, including antibiotic resistance and unnecessary cost to the patient.[7] Antibiotic resistance and limited antibiotic selections are a worldwide public health concern. The patient taking an unnecessary antibiotic can have potential adverse effects, such as allergic reaction, anaphylaxis, or secondary, antibiotic-associated infection such as *C.difficile*.[22] Antibiotic stewardship has become a responsibility for healthcare institutions and antibiotic prescribers, and recently a new standard of Joint Commission Requirements.[23,24] The CDC identified that 20-50% of all antibiotics prescribed in U.S. acute care hospitals are either unnecessary or inappropriate.[23] Not treating a UTI, on the other hand, can lead to pyelonephritis or even sepsis.[25-27] This poses a dilemma for EPs trying to best treat these patients.

Previous studies in ED settings have demonstrated over-diagnosis of UTIs and under-diagnosis of STIs.[3,13] However, prior studies have not specifically evaluated the incidence of sterile pyuria in patients with confirmed STIs. For EPs to provide their patients with optimal empiric antibiotic therapy, it can be helpful to identify whether patients with confirmed STIs commonly have associated culture-positive UTIs. The purpose of this study was to determine the frequency of sterile pyuria in patients with confirmed STIs (*Neisseria gonorrhoeae, Chlamydia trachomatis, and Trichomonas vaginalis*) seen in a community hospital ED. In addition, we examined the urine cultures of STI-positive patients who were prescribed an antibiotic for presumed UTI, and determined how many of those patients actually required antibiotics for positive urine cultures.

We hypothesized that STI-confirmed patients who have pyuria on initial urinalysis would have a high prevalence of sterile pyuria, as the urinalysis results were likely contaminated. We also hypothesized that prescribing UTI antibiotics for patients with suspected STI is unnecessary, and that the majority of these patients will have negative urine cultures.

Population Health Research Capsule

What do we already know about this issue?
The clinical presentations for sexually transmitted infections (STI) and urinary tract infections (UTI) in females often overlap. Physicians may be empirically treating patients for UTIs based upon their initial urinalysis results, even if a STI is confirmed or strongly suspected.

What was the research question?
What is the prevalence of sterile pyuria in women with confirmed STIs?

What was the major finding of the study?
This study found an overall very low incidence of positive urine cultures in women with confirmed STIs, despite pyuria or positive nitrite on initial urinalysis.

How does this improve population health?
These findings have the potential to decrease unnecessary antibiotic prescriptions and overall improve antibiotic stewardship.

METHODS

Study Design

We conducted a retrospective chart review of STI-positive, adult female patients who presented to the ED between January 2008 and December 2012. The chart abstractors were not blinded to the study hypothesis. The institution's central institutional review board approved the study and granted exemption from informed consent.

Study Setting and Population

All charts reviewed were from the ED at an urban, community, teaching hospital with over 85,000 patient visits annually and an associated emergency medicine residency program.

Study Protocol

Inclusion Criteria

We included women in the retrospective chart review if they were age 18-50, had a urinalysis and pelvic examination in the ED (including cervical cultures), and tested positive for *Neisseria gonorrhoeae, Chlamydia trachomatis,* and/or *Trichomonas vaginalis.* Clinical judgment of the EP determined whether the patient had this initial work-up performed upon presentation.

Data Collection

All endocervical cultures were obtained for gonorrhea and chlamydia testing using polymerase chain reaction (PCR) nucleic acid amplification and nucleic acid hybridization with the COBAS AMPLI-COR Analyzer (Roche, Indianapolis, IN). Samples of vaginal secretions were obtained for wet-mount preparation for detection of *Trichomonas* using a light microscope in the laboratory. Urinalysis was performed with the Clinitek ATLAS automated urine chemistry analyzer (Bayer Healthcare, Tarrytown, NY). A lab technician automatically performed microscopy of a centrifuged urine specimen, as well as urine cultures, if a greater than trace amount of protein, blood, nitrite, or leukocyte esterase was present. Urine cultures were plated with a 0.001-ml loop on MacConkey agars.

Definitions

A positive urine culture was defined as growth of a known uropathogen $\geq 10^5$ CFU/ml. Pyuria was defined as more than five leukocytes per high-power field in a centrifuged urine sample.

Outcome Measures

The primary outcome of the study was to determine the prevalence of sterile pyuria in patients with confirmed STIs. Secondary outcomes included the rate of positive urine cultures in women who tested nitrite positive in the study population. Additionally, we sought to determine the number of patients treated with antibiotics for suspected UTI who had negative urine cultures.

Data Analysis

We entered data without patient identifiers into a custom database constructed in Microsoft Excel (version 14.0.7140.5002. ©Microsoft Corp. 2010) and performed analysis with the statistical add-on package Analyze-it, version 2.26 Excel 12+. We sought associations between various findings using Fisher's exact test for categorical variables. Comparison of proportions was calculated using the N-1 chi-squared analysis. We set significance at $p<0.05$ throughout.

RESULTS

During the study period, we entered 1,052 cases into the database. All cases were female patients who tested positive for *Neisseria gonorrhoeae, Chlamydia trachomatis,* and/or *Trichomonas vaginalis.* The mean age was 22.9 years with a range of 14 to 51. The prevalence of each disease in the dataset were the following: gonorrhea 351/1,052, 33% (95% confidence interval [CI] [0.30-0.36]) chlamydia 853/1,052, 81% (95% CI [0.79-0.83]); trichomonas 176/1,052, 17% (95% CI [0.14-0.19]).

The prevalence of pyuria in all cases entered into the database was 394/1,052, 37% (95% CI [0.34-0.40]). Of the cases with pyuria, 293/394, 74% (95% CI [0.70-0.78]) had sterile pyuria with negative urine cultures. The prevalence of positive urine cultures in our total study population was 101/1,052, 9.6% (95% CI [0.08-0.11]) (Figure). Further review of the initial urine-microscopy results of STI-positive patients with pyuria showed that both culture-positive and culture-negative urines had a range of 6-100 leukocytes per high-power field. Culture-positive urines had a mean of 34 leukocytes per high-power field, and culture-negative urines had a mean of 24 leukocytes per high-power field, with a difference of 10, (95% CI [3.46-16.15]), which was statistically significant (p=0.003).

We additionally reviewed the data to examine if nitrite in the urinalysis of these STI-positive cases correlated with positive culture results. Only 123 cases tested positive for nitrite on the urinalysis dipstick; 50/123, 41% (95% CI [0.32-0.49]) had positive urine cultures, and 73/123, 59% (95% CI [0.51-0.68]) had negative urine cultures. Nitrite-positive urines were actually 18% more likely to be associated with negative urine

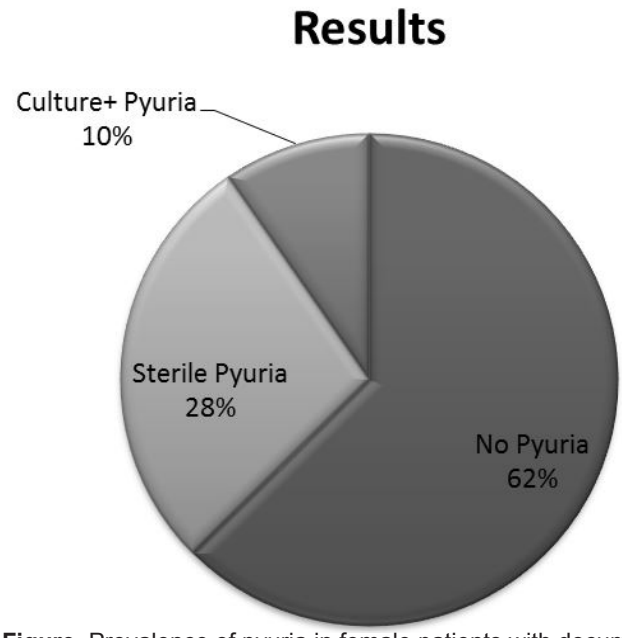

Figure. Prevalence of pyuria in female patients with documented sexually transmitted infections.

cultures in the setting of positive STI cases (95% CI [4.95-30.42], p=0.0048).

In our retrospective review of the 1,052 cases, 295 patients were prescribed antibiotics for suspected UTI. These antibiotics included cephalexin (206), ciprofloxacin (50), nitrofurantoin (36), sulfamethoxazole/trimethoprim (2), and amoxicillin (1). Of these, 195/295, 66% (95% CI [0.61-0.71]) had negative urine cultures, and 100/295, 34% (0.33, 95% CI [0.28-0.39]) had positive urine cultures. Chi-square analysis yielded a difference of these proportions of 32% (95% CI [23.92-39].62, p<0.0001). Of those 100 patients who had positive urine cultures, six grew a pathogen resistant to the antibiotic given for UTI.

DISCUSSION

Previous studies have found that women with urinary symptoms are over-diagnosed with UTI and under-diagnosed with STIs,[3,13,28] but no prior research has specifically analyzed urine results of known STI-positive patients. In this retrospective review of women testing positive for *Neisseria gonorrhoeae, Chlamydia trachomatis,* and/or *Trichomonas vaginalis* over a five-year period at a large metropolitan ED, we found that of the cases with pyuria, 74% of those were sterile pyuria. Our study found a very low overall incidence of positive urine cultures (9.6%) in the setting of women with positive STIs. Of the patients with pyuria, patients with culture-positive urines vs. culture-negative urines had identical ranges of urine leukocytes (6-100 leukocytes per high-power field), but the mean leukocytes were higher in the culture-positive group (33.842 versus 24.034 leukocytes per high-power field).

Prior literature indicates that in the general population the urine-dipstick, nitrite reaction has a low sensitivity but a very high specificity, making a positive result useful in confirming the diagnosis of UTI caused by organisms capable of converting nitrates to nitrite such as *Escherichia coli*.[15,17,21] However, the urine-dipstick test for nitrites has not been studied in STI-positive patients. We found that in the setting of positive STI cases, positive nitrite on the urine dipstick is not a good indication of UTI. Our results showed that in STI-positive cases, nitrite-positive urines were actually 18% more likely to be associated with negative urine cultures.

Current scientific literature emphasizes the need to reduce the use of inappropriate antimicrobials in all healthcare settings due primarily to antimicrobial resistance, but also because of the associated costs and potential adverse effects (including allergic reactions and development of secondary antibiotic-associated infections such as *C.difficile*).[22-24, 29,30] Our study found that of the 295 patients with confirmed STIs who were also prescribed an antibiotic for a presumed UTI, 66% of those were unnecessary, as they had negative urine cultures.

LIMITATIONS

The primary limitations of this study were its retrospective in nature and that it was performed at a single center; however, we obtained sufficient numbers of cases with full datasets to keep the data quality robust. All of the cases in the study were also positive for an STI, as it was retrospective, and all of their culture results were confirmed. This limits the EP to generally apply the results to a specific population (i.e., women who present with dysuria or pelvic pain), as they may not know the patient has a STI at the time of the visit. Another limitation is that we defined a UTI using the previously defined "microbiologic definition" of >100,000 colony-forming units.[6,10,31] Some other studies have defined a UTI with "low-count" colony criteria of 10^2-10^3 CFU/mL;[3,28] had we used a lower threshold we might have calculated more "culture-positive" urines. Additionally, the chart abstractors were not blinded to the study hypothesis, which could have introduced potential bias.

CONCLUSION

This study demonstrates that in female patients with STIs who have pyuria, there is a high prevalence of sterile pyuria. Our results suggest that reliance on pyuria or positive nitrite for the decision to add antimicrobial therapy empirically for a presumed UTI in cases in which an STI is confirmed or highly suspected is likely to result in substantial over-treatment.

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REFERENCES

1. Centers for Disease Control and Prevention. 2013. Sexually transmitted disease surveillance 2012. Centers for Disease Control and Prevention, Atlanta, GA. Available at: http://www.cdc.gov/std/

stats12/surv2012.pdf. Accessed on March 1, 2015.
2. Ronald RA. Urinary tract infections in adults. In: Tan JS, editor. Experts guide to the management of common infectious diseases. Philadelphia: American College of Physicians; 2002:229-50.
3. Tomas ME, Getman D, Donskey CJ, et al. Over diagnosis of urinary tract infection and under diagnosis of sexually transmitted infection in adult women presenting to an emergency department. Patel R, ed. *J Clin Microbiol*. 2015;53(8):2686-92.
4. Glen P, Prashar A, Hawary A. Sterile pyuria: a practical management guide. *Br J Gen Pract*. 2016;66(644):e225-7.
5. Huppert JS, Biro F, Lan D, et al. Urinary symptoms in adolescent females: STI or UTI? *J Adolesc Health.* 2007;40(5):418-24.
6. Hooton TM, Besser R, Foxman B, et al. Acute uncomplicated cystitis in an era of increasing antibiotic resistance: a proposed approach to empirical therapy. *Clin Infect Dis*. 2004;39(1):75-80.
7. O'Connell CM, Ferone ME. *Chlamydia trachomatis* Genital Infections. *Microb Cell*. 2016;3(9):390-403.
8. Pezzlo MT, Wetkowski MA, Peterson EM, et al. Detection of bacteriuria and pyuria within two minutes. *J Clin Microbiol*. 1985;21(4):578-81.
9. Tambyah PA, Maki DG. The relationship between pyuria and infection in patients with indwelling urinary catheters: a prospective study of 761 patients. *Arch Intern Med.* 2000;160(5):673-7.
10. Stamm WE, Wagner KF, Amsel R, et al. Causes of acute urethral syndrome in women. *N Engl J Med*. 1980;303(8):409.
11. Singh D, Marrazzo, JM. Screening and management of genital chlamydial infections. *Infect Dis Clin North Am*. 2013;27(4):739-53.
12. Wilbanks MD, Galbraith JW, Geisler WM. Dysuria in the emergency department: missed diagnosis of *Chlamydia trachomatis*. *West J Emerg Med*. 2014;15(2):227-30.
13. Berg E, Benson DM, Haraszkiewicz P, et al. High prevalence of sexually transmitted diseases in women with urinary tract infections. *Acad Emerg Med.* 1996;3:1030–4.
14. Paavonen J, Vesterinen E. Chlamydia trachomatis in cervicitis and urethritis in women. *Scan J Infect Dis Suppl*. 1982;32:45-54.
15. Leman P. Validity of urinalysis and microscopy for detecting urinary tract infection in the emergency department. *Eur J Emerg Med*. 2002;9(2):141-7.
16. National Guideline Clearinghouse (NGC). Guideline synthesis: Diagnosis and management of lower urinary tract infection. In: National Guideline Clearinghouse (NGC). Rockville (MD): Agency for Healthcare Research and Quality (AHRQ); 2008 (revised 2012).
17. Deville W. The urine dipstick test useful to rule out infection. A meta-analysis of the accuracy. *BMC Urol.* 2004;4:4.
18. Kunin CM, White LV, Hua TH. A reassessment of the importance of `low-count' bacteriuria in young women with acute urinary symptoms. *Ann Intern Med*. 1993;119:454–60.
19. Stamm WE, Counts GW, Running KR, et al. Diagnosis of coliform infection in acutely dysuric women. *N Engl J Med*. 1982;307:463.
20. Eisenstadt J, Washington JA. (1996) Diagnostic microbiology for bacteria and yeasts causing urinary tract infections. In: UTIs: Molecular Pathogenesis and Clinical Management, Mobley HL, Warren JW (Eds), ASM Press, Washington, DC p.29.
21. Pappas PG. Laboratory in the diagnosis and management of urinary tract infections. *Med Clin North Am. 1991;*75:313.
22. May L, Cosgrove S, L'Archeveque M, et al. Antimicrobial stewardship in the emergency department and guidelines for development. *Ann Intern Med*. 2013;62(1):10.
23. Centers for Disease Control and Prevention. Antibiotic stewardship statement for antibiotic guidelines—Recommendations of the healthcare infection control practices advisory committee. 2016. Centers for Disease Control and Prevention, Atlanta, GA. Available at: http://www.cdc.gov/hicpac/Pubs/Antibiotic-Stewardship-Statement.html. Accessed on February 26, 2017.
24. The Joint Commission. Joint Commission Requirements: New Antimicrobial Stewardship Standard. *Jt Comm Perspect.* 2016;36(7):13-48
25. Hodges TL, Zighelboim-Daum S, Eliopoulos GM. Antimicrobial susceptibility changes in Enterococcus faecalis following various penicillin exposure regimens. *Antimicrob Agents Chemother*. 1992;36:121.
26. Kalra OP, Raizada A. Approach to a patient with urosepsis. *J Glob Infect Dis*. 2009;1(1):57-63.
27. Bent S, Nallamothu BK, Simel DL, et al. Does this woman have an acute uncomplicated UTI? *JAMA*. 2002;287(20):2701.
28. Shapiro T, Dalton M, Hammock J, et al. The prevalence of UTI and STD in women with symptoms of a simple UTI stratified by low colony count criteria. *Acad Emerg Med.* 2005;12(1):38-44.
29. Jenkins TC, Knepper BC, Shihadeh K, et al. Long-term outcomes of an antimicrobial stewardship program implemented in a hospital with low baseline antibiotic use. *Infect Control Hosp Epidemiol*. 2015;36(6):664-72.
30. Hamilton KW, Gerber JS, Moehring R, et al. Point-of-prescription interventions to improve antimicrobial stewardship. Weinstein RA. Ed. *Clin Infect Dis.* 2015;60(8):1252-8.
31. Kline KA, Lewis AL. Gram-positive uropathogens. polymicrobial urinary tract infection, and the emerging microbiota of the urinary tract. *Microbiol Spectr.* 2016;4(2):10.

A Tactical Medicine After-action Report of the San Bernardino Terrorist Incident

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INTRODUCTION

On December 2, 2015, terrorism landed in Southern California when two perpetrators aligned with the Islamic State (IS), murdered and wounded 38 civilians at the Inland Regional Center of San Bernardino, California. Military tactics from the battlefields of Iraq and Afghanistan became strategies employed by terrorist organizations against civilians and domestic law enforcement agencies,[1] requiring first-responder agencies to adapt rapidly to threats that are often discussed but rarely encountered. We describe systemic lessons that should be applied by medical directors of law enforcement, and fire and emergency medical services (EMS) agencies during a large-scale tactical medicine response.

Timeline

10:58 A.M - The first 911 call is received, reporting gunshots in the vicinity of the 1300 block of South Waterman Avenue.

10:59 A.M - Call is upgraded to "shots fired" at the Inland Regional Center (IRC) with a description of three suspects dressed in black and carrying assault rifles.

11:00 - Two patrol units from the San Bernardino Police Department (SBPD) are dispatched to the scene.

11:04 A.M - First responding police units are on scene and make entry. At this point the two shooters have departed the building after wounding 36 people, of whom 14 would later die. The initial police teams encounter three deceased victims just outside of the building. Law enforcement quickly clears the ground floor of obvious threats before entering the conference room. Within minutes, local fire and EMS units arrive and stage nearby, and the San Bernardino County Sheriff's Department rescue helicopter begins flying around the IRC.

11:09 A.M - The San Bernardino Police Special Weapons and Tactics (SWAT) Team, which was coincidentally conducting training locally, arrives with a 13-person team, including a SWAT medic. This is the first medical asset to reach the victims. The team medic, after supporting the SBPD SWAT team, performs an initial clearing of the IRC; and begins triaging more than 30 wounded civilians.[2]

11:10 A.M - The Sheriff Department's rescue helicopter lands nearby and offloads two aviation medics. These medics were not wearing their Kevlar® personal protective equipment (PPE). The onboard crew chief takes position as airborne sniper cover.

11:15 A.M - A triage, mass-casualty staging location is established by the tactical commander, and the first floor is reported by SWAT to be secured. This notification triggers the evacuation of the wounded to the triage area. Two deceased victims are transported by law enforcement to a nearby medical center.

11:17 A.M - Trauma centers are notified of the event through ReddiNet, the emergency medical notification system used by all hospitals within the region. Prior to the official notification, a mobile intensive care nurse at Loma Linda had been informed unofficially via a cell phone call from a firefighter dispatched to the scene. Five patients were transported to

Loma Linda University Medical Center (LLUMC) and six to Arrowhead Regional Medical Center (ARMC).[3]

The total time elapsed during the shooting itself is less than five minutes. Unknown to the responders at the time, the terrorists had planted an improvised explosive device (IED) – a backpack containing pipe bombs with a crude remote detonator – in the conference room. The IED did not explode. From the authors' first-hand estimates, there were at least 30 additional rescue personnel in the IRC conference room at the same time the IED was present, and prior to the device being made safe.

In all, seven surrounding agencies and four SWAT teams converged on the IRC. All of the critical shooting victims were quickly dispatched to the closest regional facilities: LLUMC, an American College of Surgeons (ACS) Level I trauma center; and ARMC, an ACS Level II trauma center. All of the critically wounded arrived for definitive trauma care within 57 minutes of being wounded. Resident physician conferences were being held at both centers that day, allowing both facilities to rapidly mobilize trauma and critical care resources for potential incoming casualties.

14:00 P.M. - The medical response is further complicated by a bomb threat that was called into LLUMC. While this call turned out to be a hoax, it required a substantial diversion of resources to clear during a day when law enforcement and EMS personnel were already being pushed to their limits.

15:07-15:13 P.M. - Law enforcement personnel conduct a felony car stop, and suspects engage in shootout, which ultimately ends with the death of both suspects.

LESSONS LEARNED

Lesson 1: There is a distinct difference between a qualified SWAT paramedic and a paramedic responding as part of a rescue task force (RTF).

Paramedics embedded with SWAT teams are trained to coordinate with team movements within the hot (unsafe) zone, providing medical support for the team as it progresses. Conversely, the current paradigm is that EMS personnel can be trained to enter the warm (safe) zone to conduct rescue operations when escorted by law enforcement. However, paramedics familiar with the RTF model are neither equipped nor trained sufficiently to provide care while under a direct threat.[4] While these skill sets overlap they are not synonymous, and medical directors must not assume tactical paramedics integrated with the law enforcement SWAT will provide a sufficient medical resource for an RTF model.

The contrast between SWAT paramedics and RTF paramedics was highlighted in two ways. First, as the event unfolded, it became evident that responding fire and EMS units were not accustomed to combined operations with law enforcement. Their corresponding equipment packages and communications networks were different from those of the law enforcement responders. Furthermore, while clearly identified as an "active shooter" event by the first patrol units, the initial setup closely followed that of a mass casualty incident (MCI). The tactical command post was established to the north and the casualty collection area/treatment to the south (Figures 1 and 2). It is estimated that the south location was possibly within the blast radius of the IEDs left in the building. If this estimation was correct, by definition it means that the triage area was established in the hot zone (unsafe zone) and not on the warm/cold (safe zone) border as is traditionally taught. Regardless, in the presence of a dynamic threat it may become necessary to ensure traffic control to and create a perimeter for the treatment area (Figures 3 and 4).

Secondly, SWAT medics do not carry complete Advanced Life Support equipment due to their operational mandate for mobility. While they are often paramedics or physicians, their role as a SWAT medic is to provide medical aid only when operationally appropriate because their primary mission is to ensure the effectiveness of the law enforcement team. [The caveat is that a member of the public will receive priority because the duty of law enforcement is to ensure the safety and wellbeing of citizens.] Although a SWAT medic may enter deep within the hot zone with their tactical element, he or she does not carry equipment sufficient to provide sustained care for a large number of casualties in that zone. The support for ongoing evacuation care must come from follow-up resources, such as those provided by the RTF medical elements.[5]

Finally, within the current milieu of civilian, public, mass-shooting incidents, the latest data on civilian wounding patterns do not fit the prototype of the exsanguinating extremity injury, and thus are not amenable to the hemorrhage control techniques mastered by the tactical medic such as the use of tourniquets. These patients require rapid extrication, advanced resuscitation, and transport by a dedicated RTF component; they cannot be attended to solely by tactical medics.[6]

Learning Point #1

Recently, RTF has become a "buzz word" that first-responder departments use to demonstrate their effectiveness in tactical events. However, the role and implementation of such teams varies markedly from agency to agency. In practice, interoperability must continue to be emphasized by both command and ground-level units, and it must be practiced on a recurring basis to prevent confusion of operational objectives. On the day of the San Bernardino shooting only three fire agencies in the county had active RTF programs in place. Communication between these units was extremely strained by existing systems and the varied understanding of RTF concepts. Ensuring cohesive and coherent medical education across agencies will not only provide law enforcement with understanding of medical priorities, but also familiarize EMS with the tactical priorities of their law enforcement partners.

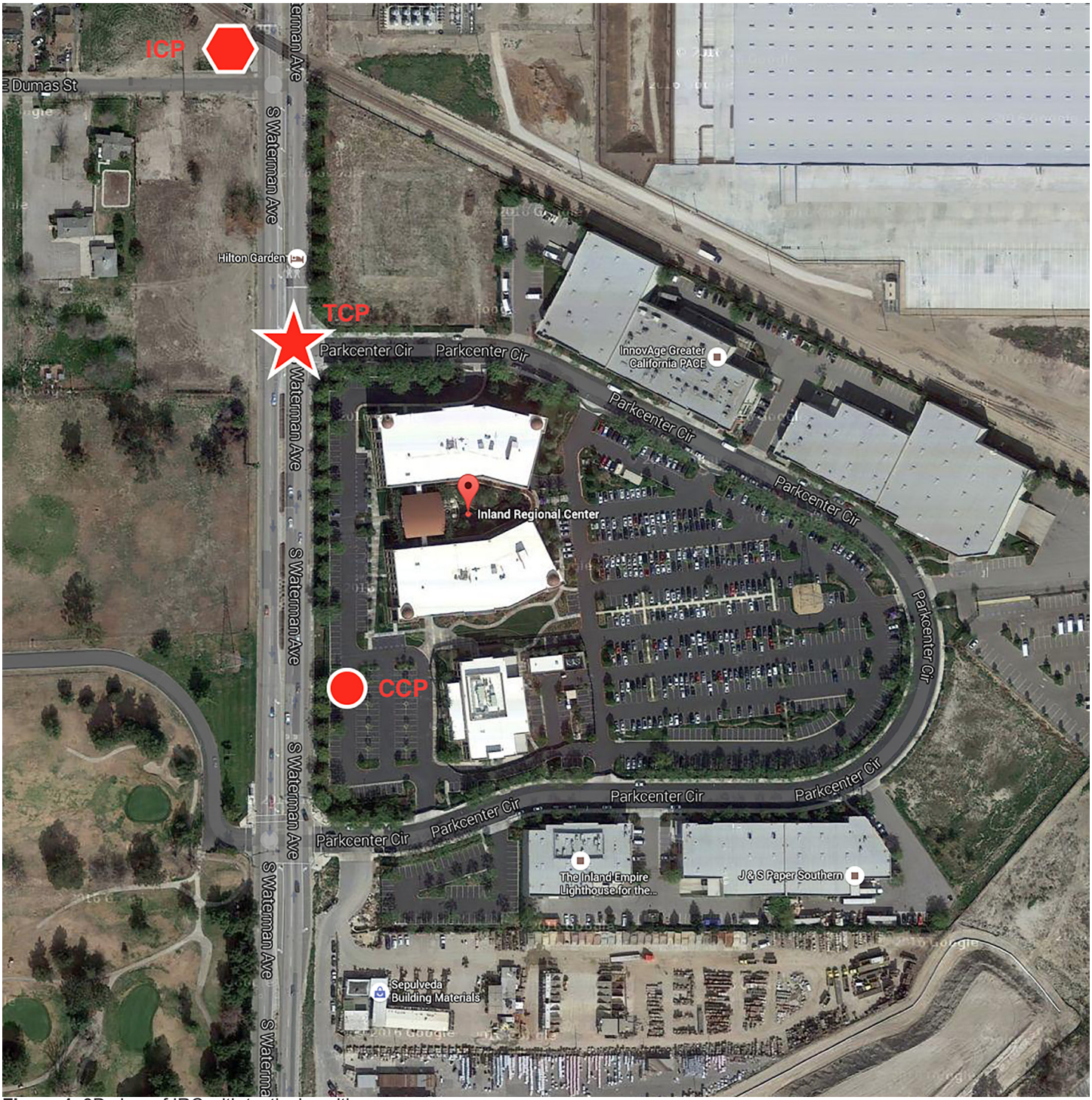

Figure 1. 3D view of IRC with tactical positions.
ICP, Incident Command Post; *TCP*, Tactical Command Post; *CCP*, Casualty Collection Point.

Lesson 2: When possible, there should be a law enforcement medical coordinator (LEMC) within the command post structure.

As many law enforcement agencies begin to deploy their own medical assets, it is critical that EMS medical directors recognize the tactical medical resource as separate from but augmenting the overall medical profile. This position falls outside the realm of the medical branch of the incident command system (ICS) because of its integration with operational teams. Thus, a law enforcement medical coordinator (LEMC) may provide a

Figure 2. Casualty collection point.

conduit to both EMS and fire assets as well as providing operational input to the incident commander.

The LEMC would then provide the commander with critical information that may be overlooked by the traditional medical branch of the ICS. First, the ability to conduct an in-depth, medical-threat assessment using operational data gathered by law enforcement and combined with EMS resources will provide on-scene commanders with a much better perspective on potential threats and limitations to operational plans.

Secondly, this position will provide improved integration between the tactical elements of the response and the force protection and rescue elements of the task force. Creating a LEMC position ensures proper allocation of both human and medical assets. Because SWAT medics operate within the law enforcement branch and not the medical branch, there is potential for duplication of efforts and general disorganization. This occurred in San Bernardino. Despite the traffic management by the SBPD, local resources pouring into the area of the shooting caused an obstacle to staged EMS assets. Medical resources were also being dispatched in duplicate with their respective law enforcement teams. Consolidated coordination of these assets would improve law enforcement support as well as integration for agencies less experienced with the RTF model.

Ideally this position would be filled by an active or former tactical medical provider – preferably a physician with knowledge of both the tactical and EMS functions. The benefits include continuous evaluation of the medical threat from law enforcement assets in the hot zone as well as EMS and fire in the warm/cold zone. Additionally, the LEMC would oversee resource need and distribution among the operational teams. Designating one individual streamlines the process and enables the SWAT medic to focus solely on providing emergent aid within the hot zone, while knowing that coordination is being managed by a professional who understands the scene, its evolution, and their needs.

Further, because of the uncertain nature of these operations, agencies must be prepared for extended operations.[7] This possibility was understood by several teams present at the IRC event because they had recently been involved in the manhunt for Christopher Dorner, the disgraced Los Angeles Police Department officer who went on a shooting spree throughout Southern California. As the duration of that event extended several hours teams began to lack the basic necessities such as food and water, and experienced a shortage of personnel needed for the rotation system in order to sustain a high operational tempo. Though the logistics branch of the ICS is theoretically tasked with procurement of supplies for an operation, law enforcement team health remains under the purview of the tactical medic. Therefore, a LEMC would be the ideal person to ensure proper allotment of resources regardless of the duration of operations.

Learning Point #2:

Because of the decentralized nature of SWAT resources during dynamic operations, a LEMC would assist the ICS with reducing or eliminating a conflicting medical response.

Table. A visual correlation of lessons learned with problems encountered on December 2, 2015.

Problem/obstacle	Lesson learned
Recognizing the differences in capabilities between a SWAT medic vs. RTF medic/EMS	SWAT medics may be forward deployed; however, they will have limited resources and focus vs. EMS, which is able to provide more resources but will be unable to safely work closest to the point of injury or near an active/direct threat.
Coordination and deconfliction of EMS resources with law enforcement response in a large event	Establishing a law enforcement medical coordinator at the command post may provide a conduit to both EMS and fire assets as well as providing operational input to the incident commander.
Early forward deployment of amassed EMS resources for life saving measures	Regular RTF training that is cohesive and coherent across agencies will not only provide law enforcement with understanding of medical priorities, but also familiarize EMS with the tactical priorities of their law enforcement partners.
Extended duration of operations	Early planning for personnel rotation/substitution and for providing basic necessities such as food and water to sustain a high operational tempo and sustainment during a prolonged event.
Addressing the future of complex/coordinated attacks	Integrated, scenario-based training for LE and EMS. Recognizing the increasing IED threat and having the resources and training to treat multiple patients with blast injuries and multiple amputations.
Depletion of medical supplies in a multiple casualty event	Forward deployment of medical "4th man bag" stocked with TQs, chest seals, dressings, triage cards/tape in significant quantities. Operators and LE should carry multiple TQs in addition to their IFAKs.
Activation of sprinklers and klaxons and access within a structure	Educate and plan for the electrical shock hazards and biological hazards posed to responders. Waterproof triage tags/colored tape, Knox Box® access for rescuers.
Delay in treating victims with potentially survivable injuries	Training for members of the community to initiate bystander care (TECC First Care Provider guidelines) prior to arrival of EMS. Placement of trauma/MCI equipment stations co-located with AED's in public spaces.
Addressing post-traumatic stress for rescuers, first responders, survivors and witnesses	Recognizing the need for and providing critical incident stress counseling. Team medics at the first opportunity should interact with team members to informally evaluate for signs of post traumatic stress. Providing formal and informal grief/ crisis counseling post event.

LE, law enforcement; *SWAT*, special weapons and tactical team; *RTF*, rescue task force; *EMS*, emergency medical services; *IED*, improvised explosive device; *TQ*, tourniquet; *IFAK*, individual first-aid kit; *TECC*, tactical emergency casualty care; *MCI*, mass casualty incident; *AED*, automated external defibrillator

This position would ideally be filled by an active or former tactical medical provider – preferably a physician with knowledge of both the tactical and EMS functions. The benefits include continuous evaluation of the medical threat to law enforcement assets in the hot zone, as well as EMS and fire in the warm/cold zone. Additionally, the LEMC would oversee resource need and distribution among the operational teams. Designating one individual streamlines the process and also enables the SWAT medic to focus solely on providing emergent aid within the hot zone while knowing that the coordination piece is being managed by a professional who understands the scene, its evolution, and their needs.

Lesson 3: Modern terrorist events use a combination of multiple attackers, improvised weapons (e.g., IEDs), and occasionally centralized command and control.

Law enforcement and fire departments have adapted quickly to minimize the loss of life in high-threat incidents through improved integration and education. Training for these scenarios is more often practiced as isolated events and less frequently combined. As a result, medical directors often outfit their teams in relation to the perceived threat, with PPE and medical equipment designed to protect from handguns and treat the "preventable causes of death."

Despite this traditional mindset, it has been repeatedly demonstrated that modern terrorists coordinate complex attacks, using multiple detonations to "drive" response and inflict maximal damage. Although many of the victims of the San Bernardino terrorist event were shot numerous times, it has been well documented that there were unexploded IEDs in the immediate vicinity of both survivors and rescuers. In the face of multiple, armed attackers using high-powered rifles and multiple explosive devices, the typically-issued PPE is inadequate and the available medical supplies could quickly be exhausted, particularly when treating individuals with blast injuries.

Further, as active-shooter incidents have evolved, the push to incorporate Tactical Emergency Casualty Care (TECC) guidelines by first-responder agencies has accordingly focused on ballistic injuries. This approach emphasizes the need for

hemorrhage control but overlooks both the likelihood of encountering victims with multiple amputations and the complications of blast injury not seen by a penetrating injury (which is only one of the components in a blast injury).

Learning point #3

Medical directors and medical assets should update their education programs to re-emphasize treatment of blast vs. ballistic injury. In addition, focused, mass-casualty management will help agencies and designated LEMCs as to the care and coordination necessary for adequate resource planning.[8]

In light of the threats now faced by our society, merely supplying one tourniquet, one chest seal and one dressing may no longer be sufficient. We recommend that ALL responders (including support personnel) carry tourniquets, while SWAT team members should carry several. In addition, designated law enforcement medical elements should wear the same PPE as their colleagues on patrol.

The development of a portable medical kit for active shooter/suspected terrorist events should be encouraged. Should extra equipment become necessary, this kit should contain multiple tourniquets, triage tape, combination dressing/bandages and large quantities of gauze for hemostasis/wound packing. Contrary to conventional thinking, establishment of an airway is not of primary concern in these types of events, eliminating the need for multiple advanced airway kits.

Most public buildings follow standard security practices, and medical directors and tactical medics should accordingly make basic changes in their response profiles. When the sprinklers were activated in the IRC building, medical assets were unprepared for operations in a wet environment. Moving forward, medical directors should educate and plan for the electrical shock hazards and biological hazards posed to responders in that environment. Rescue equipment should include waterproof triage tags (colored vinyl/plastic tags rather than paper), and teams should have the tools to circumvent difficulties with building access (traditionally law enforcement agencies have not had Knox Box® rapid entry system access) as part of the rescue plan. In the current environment, all tactical teams must have such access.

Finally, agency training can no longer accept notional acknowledgment to the presence of IEDs. The actual procedures for IED, complicated, active shooter incident (ASI) events should now be the standard, practiced scenario.[9] Additionally, the complex and critical nature of injuries seen in these events and the challenge of accessing patients wounded by explosions, demonstrate the necessity for bystander care at the scene of the incident. Municipal and county agencies should consider training communities in TECC First Care Provider guidelines.[10] Similarly, as the community has accepted the placement of automated external defibrillators (AEDs) in high-traffic areas, trauma/MCI equipment stations should also be pre-positioned in such areas and co-located with the AED.[11]

Lesson 4: Despite several responders having military experience, there is a difference when witnessing catastrophic mortality within your own community.

The brutal nature of the San Bernardino attacks and first responders' familiarity with the community and the likelihood of recognizing victims are all powerful stimuli for the development of post-traumatic stress (PTS). Personnel who witnessed casualties within the main conference room were at significantly higher risk than those serving in other locations. In addition to mandatory critical incident stress (CIS) counseling, team medics immediately began interacting with team members to informally evaluate for signs of PTS.

Learning point #4:

Stresses from these critical incidents may be reversed or halted through adaptive responses. Recognition that PTS is a likely outcome to mass casualty events should stimulate medical directors and team medics to create mechanisms for early recognition and practice of adaptive responses both for the individual and the collective. While individual stress is the focus of therapy, shared trauma or group stress remains a possible outcome. This shared trauma may unconsciously change processes within the group, affecting operational capabilities.[12] Restricting access by non-essential personnel to victims remains the most basic process for decreasing stress in all groups.

Additionally, there is a marked difference to the responses expected by responding patrol units and organized SWAT units. While specialized teams may have the infrastructure to address PTS, including their own medical assets, individuals involved in the initial response may find it difficult to participate in departmental programs because they fear stigmatization. Avoidance of formal services may isolate and cause development of maladaptive responses that incur significantly higher risk for long-term pathology.[13]

Formal gatherings of team members and peer groups should be initiated very early to begin discussion of what has been witnessed and to prevent isolation by those most affected. However, support services must remain flexible and available to individuals reaching out to medical directors and team medics. Moreover, these gatherings must be protected from rules of discovery; fostering unguarded discussion/conversation is crucial to this process, and fear of retribution may destroy this process.

Finally, team medics may themselves need assistance following a crisis. It is imperative that medical directors or medical coordinators, as well as team leaders, allow for small-group or peer discussions in the aftermath of a critical event.

CONCLUSION

Militarized terrorist tactics designed to inflict maximum damage to armored military units are now being employed by

terrorists and purveyors of violence against unprotected civilian targets and domestic law enforcement agencies. These tactics, directed at civilians, are causing first responders to adapt at a rapid rate. For example, the classical law enforcement tactic of establishing perimeters and initiating negotiation, which was once considered optimal, is now lower priority compared to stopping active shooters as quickly as possible.

The experiences during and since the San Bernardino attacks of December 2, 2015, have changed the tactics, techniques and procedures of all law enforcement teams involved in the event. This evolving threat challenges first responders in California and across the world to revise and modify medical response to catastrophic events in novel and innovative ways.

Complex, coordinated attacks appear to be the new norm, and they require rapid adaptation in response tactics. Although the breadth and depth of lessons learned from the San Bernardino attacks are beyond the scope of a single paper, the lessons highlighted here provided a stimulus for discussion among the various stakeholders – EMS, law enforcement, EMS medical directors, and the public – about appropriate response in these types of events.

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REFERENCES

1. Serrano RA, B Bennett. "San Bernardino shooters began plotting attack before their marriage, FBI chief says." *Los Angeles Times*. December 9, 2015.
2. Welsh B, Curwen T, Barboza T, et al. San Bernardino medic had 5 seconds to check if each massacre victim was alive or dead. *Los Angeles Times*. December 9, 2015.
3. Lee C, Walters E, Borger R, et al. The San Bernardino, California, terror attack: two emergency departments' response. *West J Emerg Med*. 2016;17(1):1-7.
4. "Rescue Task Force." International Association of Fire Fighters Position Statement. 2013.
5. Smith ER, Iselin B, McKay WS. Toward the sound of shooting: Arlington County, Va., task force rethinks active shooter incident response." *JEMS*. 2009;34(12):48-55.
6. Smith ER, Shapiro G, Sarani B. The profile of wounding in civilian public mass shooting fatalities. *J Trauma Acute Care Surg*. 2016;81(1):86-92.
7. Yarbrough, B. "How lessons from Christopher Dorner manhunt helped police during San Bernardino terrorist attack." *San Bernardino Sun*. February 11, 2016.
8. Biddinger PD, Baggish A, Harrington L, et al. Be prepared – the Boston Marathon and mass-casualty events. *N Engl J Med.* 2013;368(21):1958-60.
9. Roy N, Kapil V, Subbarao I, et al. Mass casualty response in the 2008 Mumbai terrorist attacks. *Disaster Med Public Health Prep.* 2011;5(4):273-9.
10. Callaway D, Bobko J, Smith ER, et al. Building community resilience to dynamic mass casualty incidents: A multiagency white paper in support of the first care provider. *J Trauma Acute Care Surg*. 2016;8(4):665-9.
11. Jacobs LM, Joint committee to create a national policy to enhance survivability from intentional mass casualty and active shooter events. The Hartford Consensus IV: A Call for Increased National Resilience. *Bull Am Coll Surg.* 2016;101(3):17-24.
12. Volkan VD. Traumatized societies and psychological care: expanding the concept of preventive medicine. *Mind and Human Interaction*. 2000;11(3):177-94.
13. Psychological services in disasters. Australian Emergency Management Institute. Bulletin

Baby Shampoo to Relieve the Discomfort of Tear Gas and Pepper Spray Exposure: A Randomized Controlled Trial

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Introduction: Oleoresin capsicum (OC) or pepper spray, and tear gas (CS) are used by police and the military and produce severe discomfort. Some have proposed that washing with baby shampoo helps reduce this discomfort.

Methods: We conducted a prospective, randomized, controlled study to determine if baby shampoo is effective in reducing the severity and duration of these effects. Study subjects included volunteers undergoing OC or CS exposure as part of their police or military training. After standardized exposure to OC or CS all subjects were allowed to irrigate their eyes and skin ad lib with water. Those randomized to the intervention group were provided with baby shampoo for application to their head, neck, and face. Participants rated their subjective discomfort in two domains on a scale of 0-10 at 0, 3, 5, 10, and 15 minutes. We performed statistical analysis using a two-tailed Mann-Whitney Test.

Results: There were 58 participants. Of 40 subjects in the OC arm of the study, there were no significant differences in the ocular or respiratory discomfort at any of the time points between control (n=19) and intervention (n=21) groups. Of 18 subjects in the CS arm, there were no significant differences in the ocular or skin discomfort at any of the time points between control (n=8) and intervention (n=10) groups.

Conclusion: Irrigation with water and baby shampoo provides no better relief from OC- or CS-induced discomfort than irrigation with water alone. [West J Emerg Med. 2018;19(2)294-300.]

INTRODUCTION

Background

Chemical irritant agents are sometimes used by law enforcement officers and by the military to subdue violent or threatening subjects and to control crowds.[1,2] The most common of these agents include oleoresin capsicum (OC), commonly known as pepper spray, and ortho-chlorobenzylidene malononitrile (CS), commonly known as tear gas. Both cause pain and irritation of the eyes, skin and mucosal surfaces.[3] Aerosolized OC preparations are also available to the general public in the United States as a self-defense weapon.

Importance

Pain and irritation from these agents last 15 minutes or more.[3] While many recommendations exist for decontamination and treatment of discomfort produced by these irritants, the effectiveness of these methods have not yet been demonstrated. Two of the common methods used for decontamination are irrigation with tap water and blowing cool air onto the face and

eyes.[3] Some advocate the use of baby shampoo combined with water irrigation; it is theorized that shampoo can emulsify and enhance removal of the irritant molecules and may reduce nociceptor stimulation, thus reducing the severity and duration of irritant effects.[4] Medical personnel in the prehospital and emergency department (ED) settings, police and military personnel, as well as individuals exposed to these chemicals, would benefit from evidence-based recommendations for effective decontamination and treatment to reduce the severity and duration of discomfort caused by these agents.

Goal of This Investigation

We performed a prospective, randomized, controlled trial to determine whether irrigation with water and baby shampoo was superior to water irrigation alone in relieving the acute symptoms produced by tear gas and pepper spray.

Population Health Research Capsule

What do we already know about this issue?
Chemical irritant agents used by law enforcement officers to subdue threatening subjects do not have an evidenced-based recommendation for effective decontamination.

What was the research question?
Is water plus baby shampoo or water irrigation alone superior in relieving the acute symptoms produced by tear gas and pepper spray?

What was the major finding of the study?
Irrigation with water plus baby shampoo provides no better relief from pepper spray- or tear gas-induced discomfort than with water alone.

How does this improve population health?
Similar investigations of proposed decontamination agents should be performed to provide evidence of their efficacy prior to their adoption and deployment.

METHODS

Study Design, Setting and Selection of Participants

We performed a prospective, randomized, controlled study. Volunteer study subjects were police recruits who underwent OC (pepper spray) exposure as part of their training and U.S. Army soldiers who underwent CS (tear gas) exposure as part of their training. The study was approved by the institutional review board. We obtained written, informed consent from each participant prior to study participation. This work was not pre-registered as a clinical trial because the study population's noxious intervention was part of their externally required training.

Interventions

As part of their standard training, each participant received a standardized irritant exposure and completed a training evolution. Police recruits received a two-second (approximate) burst of police issue OC spray (First Defense MK-3, Safariland / Defense Technology, Jacksonville, FL) to the face. They were then required to complete a series of tasks to simulate control and apprehension of a combative criminal suspect. This training sequence lasted approximately 1½-2 minutes.

Military trainees wearing protective gas masks were placed in an enclosed structure that was then saturated with CS gas (No. 98 CS grenade, Smith & Wesson / Lake Erie Chemical Company, Wickliffe, OH). Gas masks were removed and each trainee was exposed to the tear gas for approximately 10 seconds. They were then required to perform a series of training tasks and safely exit the multi-story structure. This training sequence also lasted approximately 1½-2 minutes.

After irritant exposure and completion of their training sequence, all subjects proceeded to a decontamination area and were allowed to irrigate their eyes and skin ad lib with water. Participants were randomized to a control group (water irrigation alone) and intervention group (baby shampoo plus water irrigation). The intervention group was provided a cup containing a unit "dose" of 15cc of Johnson's® baby shampoo (Johnson & Johnson, New Brunswick, NJ) and instructed to apply it liberally to their head, neck, and face. Repeat shampoo "doses" were available ad lib to this group.

Irrigation was provided by a garden hose for police trainees exposed to OC and by a custom-made, multi-station irrigation device for military trainees exposed to CS. This device was constructed of two PVC pipes supported horizontally three feet off the ground and connected to a fire hydrant. Water flow was adjusted to produce an approximately 48-inch column of water from each of 20 holes drilled in each PVC pipe at offset angles (Figure 1).

Outcomes

Subjects verbally rated their discomfort in two domains using a Likert scale of 0 to 10, with zero indicating no discomfort and 10 indicating maximal discomfort. Assessments were recorded at 0, 3, 5, 10, and 15 minutes, with timing starting upon entry to the decontamination area and the first assessment performed prior to any decontamination efforts. Eye and respiratory discomfort were assessed after OC exposure, and eye and skin discomfort were assessed after CS exposure, based on previous experience of the most prominent areas of discomfort with each agent. Per usual training practice, once subjects were subjectively recovered to a sufficient degree to

Figure 1. Irrigation technique and equipment for a) OC (pepper spray), and b) CS (tear gas).

comfortably converse and ambulate, the decontamination segment was concluded and they were allowed to exit the decontamination area to continue with their training activities. There were no protocol violations.

Power Calculation

We performed a power calculation presuming a 95% confidence to detect a clinically significant mean difference of two points on a 10-point Likert scale of discomfort, a standard deviation of one among participants rating their discomfort, alpha = 0.05, and a two-tailed t-test. This revealed that at least eight pairs of subjects (16 subjects total) were required in each of the two exposure groups. (StatMate version 2.00 for Windows, GraphPad Software, San Diego, CA)

Analysis

We entered data into a spreadsheet (Microsoft Excel, Redmond, WA) and performed descriptive analysis. Statistical software (InStat version 3.10 for Windows, GraphPad Software, San Diego, CA) was used to compare groups using the nonparametric Mann-Whitney test to compare means at each time period. We considered a p-value of ≤0.05 statistically significant.

RESULTS

OC (Pepper Spray) Exposure arm

Forty law enforcement recruits received OC exposure and completed the study protocol. The mean age was 28 years (range 21 to 38); 39 of the participants (98%) were male.

The control (n =19) and intervention (n =21) groups reported similar mean initial ocular discomfort of 9.6 vs. 9.7 respectively. This decreased to 8.7 vs. 7.2 by 10 minutes (Figure 2). Mean respiratory discomfort was initially 8.2 vs. 8.6, and changed only slightly to 9.0 vs. 8.2 by 10 minutes (Figure 3). There were no statistically significant differences between the control and intervention groups at any of the time points.

Standard deviation of discomfort ratings after OC exposure averaged 1.66. Participant attrition was significant after 3-5 minutes, as subjects felt improved and left the decontamination area per standard training practice. This resulted in 39 subjects contributing data at the 0 and 3-minute marks, 32 at the 5-minute mark, 10 at the 10-minute mark, and one at the 15-minute mark.

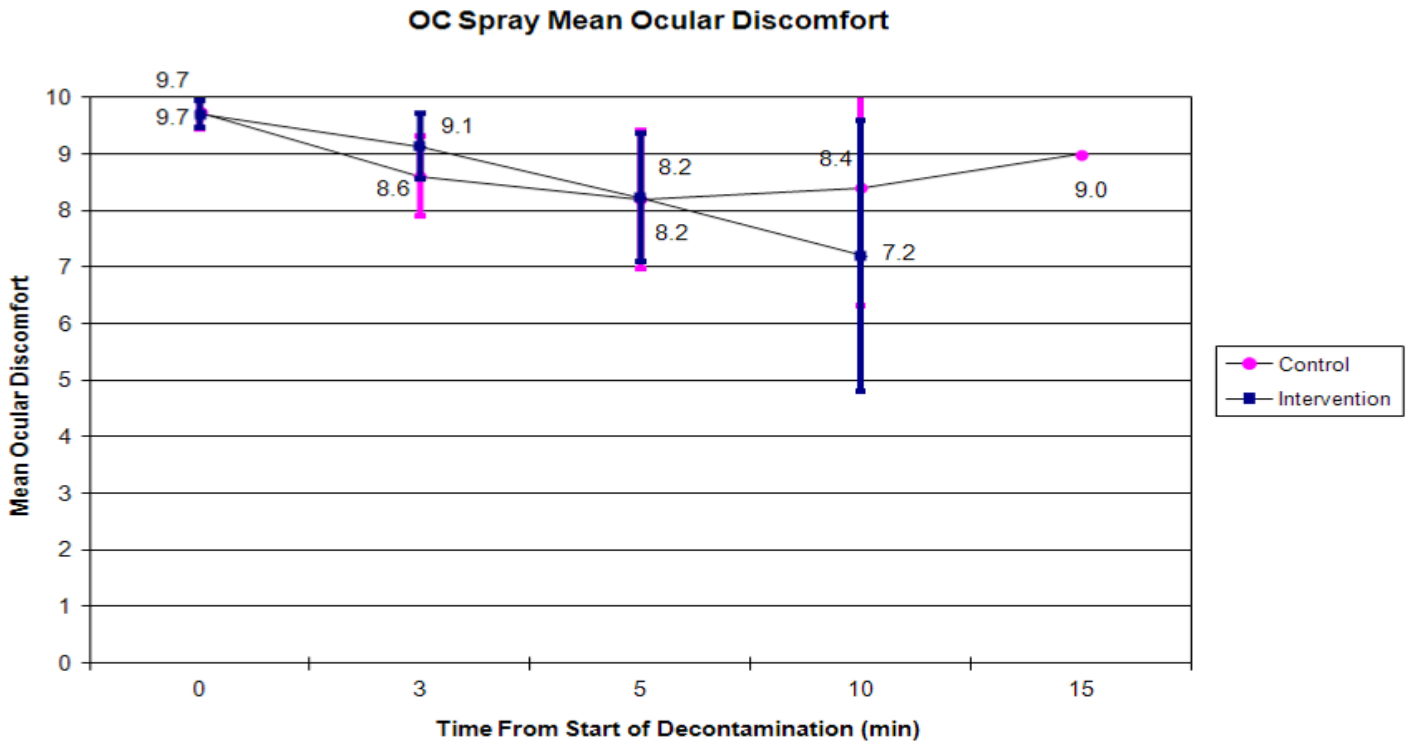

Figure 2. Mean ocular discomfort after OC (pepper spray) exposure. Error bars indicate 95% confidence interval.

CS (Tear Gas) Exposure arm

Eighteen soldiers received CS exposure. The mean age was 26 years (range 20 to 36); 17 of the participants (94%) were male.

The control (n = 8) and intervention (n = 10) groups had mean initial ocular discomfort of 4.5 vs. 6.0. This decreased to zero for both groups at 10 minutes (Figure 4). Mean initial skin discomfort was 6.6 vs. 6.5, and declined to 0.0 vs. 1.0 by 10 minutes (Figure 5). There were no statistically significant differences between the control and intervention groups at any of the time points.

Standard deviation of discomfort ratings after CS exposure averaged 1.75. Participant attrition was also significant in this study arm as subjects felt improved and left the decontamination area per standard training practice. This resulted in 18 subjects contributing data at the 0, 3- and 5=minute marks, four at the 10-minute mark, and zero at the 15-minute mark.

DISCUSSION

Oleoresin capsicum (OC) or "pepper spray" is an oil-based extract from pepper plants of the genus *Capsicum.* The chemically active ingredient is capsaicin, a fat-soluble phenol. OC causes its effect by stimulating type C unmyelinated nerve fibers that cause the release of substance P along with other neuropeptides, causing neurogenic inflammation and vasodilation.[5] These neuropeptides also produce protective reactions of mucus secretion and coughing.[6] Clinically this results in a painful burning sensation of the skin and mucous membranes, blepharospasm (involuntary closing of the eyes), and shortness of breath. Although OC causes a prominent subjective sense of dyspnea due to mucosal irritation, research has shown no objective change in respiratory function.[7] OC has been estimated to be 90% effective in stopping aggressive behavior.[6] A prior review of ED visits for OC exposure found the most common symptoms to be burning, erythema and local irritation to exposed areas.[8]

"Tear gas" is a lay term used to describe a group of irritant chemicals that cause lacrimation. The most commonly used agent by law enforcement is CS. CS is actually a crystalline solid, not a gas, making the term "tear gas" a misnomer; it is insoluble in water and has a small solubility in alcohols.[3] It is aerosolized by multiple techniques including dissolving it in an organic solvent, micro-pulverization into a powder or in use with a thermal grenade that produces hot gases. The most notable acute effects of CS are lacrimation, ocular pain, and blepharospasm.[9] Skin discomfort is also common, and skin erythema and blistering have been seen in rare instances of prolonged exposure.[10] CS also produces irritant effects on other mucosal surfaces and can produce pulmonary symptoms of subjective dyspnea, coughing, and rarely bronchospasm.[11]

A number of topical decontamination agents have been proposed for use after OC and/or CS exposure, including proprietary mixtures sold commercially for decontamination purposes. Despite advertising claims of efficacy, none of these products to the authors' knowledge have been demonstrated to

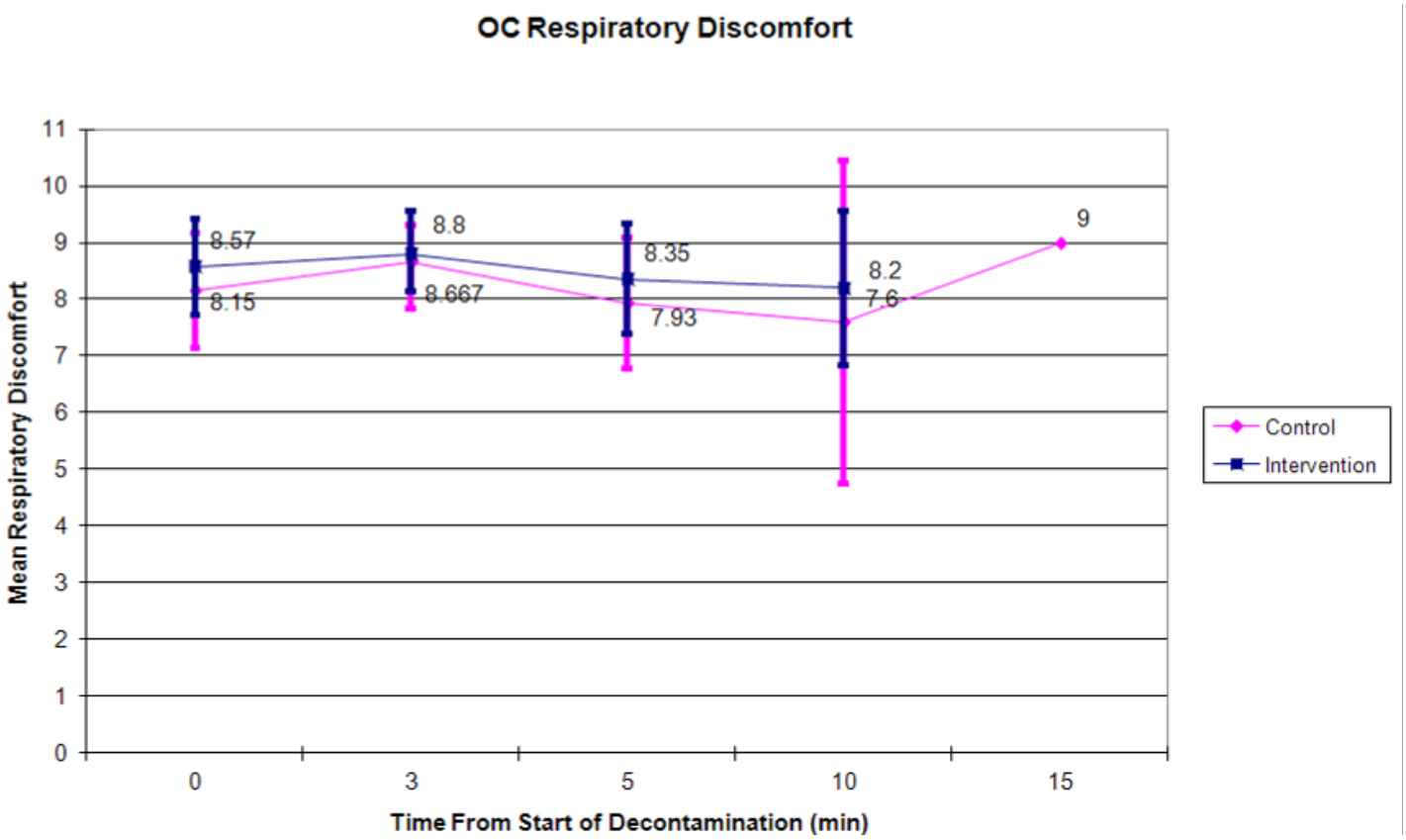

Figure 3. Mean respiratory discomfort after OC (pepper spray) exposure. Error bars indicate 95% confidence interval.

be effective in the published literature to date.

The results of this study indicate that the use of baby shampoo as a decontamination agent after OC and CS exposure provides no better or faster relief from acute symptoms than water irrigation alone. These findings are consistent with a previous study of several potential decontamination agents for OC exposure, including Maalox®, 2% lidocaine gel, milk, and baby shampoo, compared to water irrigation alone.[12] That small but well-done, prospective, randomized study included 10 subjects in each group and did not suggest efficacy for any of the agents studied. The present study confirms and expands on that work by adding a larger group of 40 OC-exposed subjects with serial post-exposure symptom assessments and by extending the evaluation to 18 subjects exposed to CS as well.

A second previous study examined a limited dermal exposure of OC to both forearms of 10 volunteers. Those researchers found that a Maalox®-impregnated, topical dressing provided a small amount of pain relief compared to a saline-impregnated dressing.[13] As acknowledged by the authors, their small study has limited clinical application, as it did not include ocular or mucosal exposure to OC, as typically occurs in law enforcement or self-defense uses.

Both pepper spray and tear gas are known to be generally safe and effective in modifying the behavior of criminal suspects and crowds.[1,2] Their use will likely remain common for the foreseeable future in law enforcement and self-defense settings, and for crowd control. Although these agents rarely produce significant injuries, illness, or fatalities, they are profoundly uncomfortable. Medical and public safety personnel must remain diligent in screening and identifying the minority of exposed subjects who do suffer medical complications, and they should be familiar with the effects of these agents and with appropriate post-exposure decontamination and treatment procedures.

LIMITATIONS

There are several limitations to this investigation. The amount, frequency, and specific method of shampoo application could not be fully standardized in the participants. While a practical and realistic approximation of real-world utilization, it is possible that this intuitive application method did not optimally deliver the shampoo to the eyes or elsewhere and that another method of application could provide additional relief. We assessed only two parameters of discomfort for each type of exposure (eye and respiratory discomfort after OC; eye and skin discomfort after CS). These parameters were chosen based on prior experience and reports, and this was an intentional decision based on concern that assessment of numerous parameters would result in global rather than specific discomfort ratings in subjects

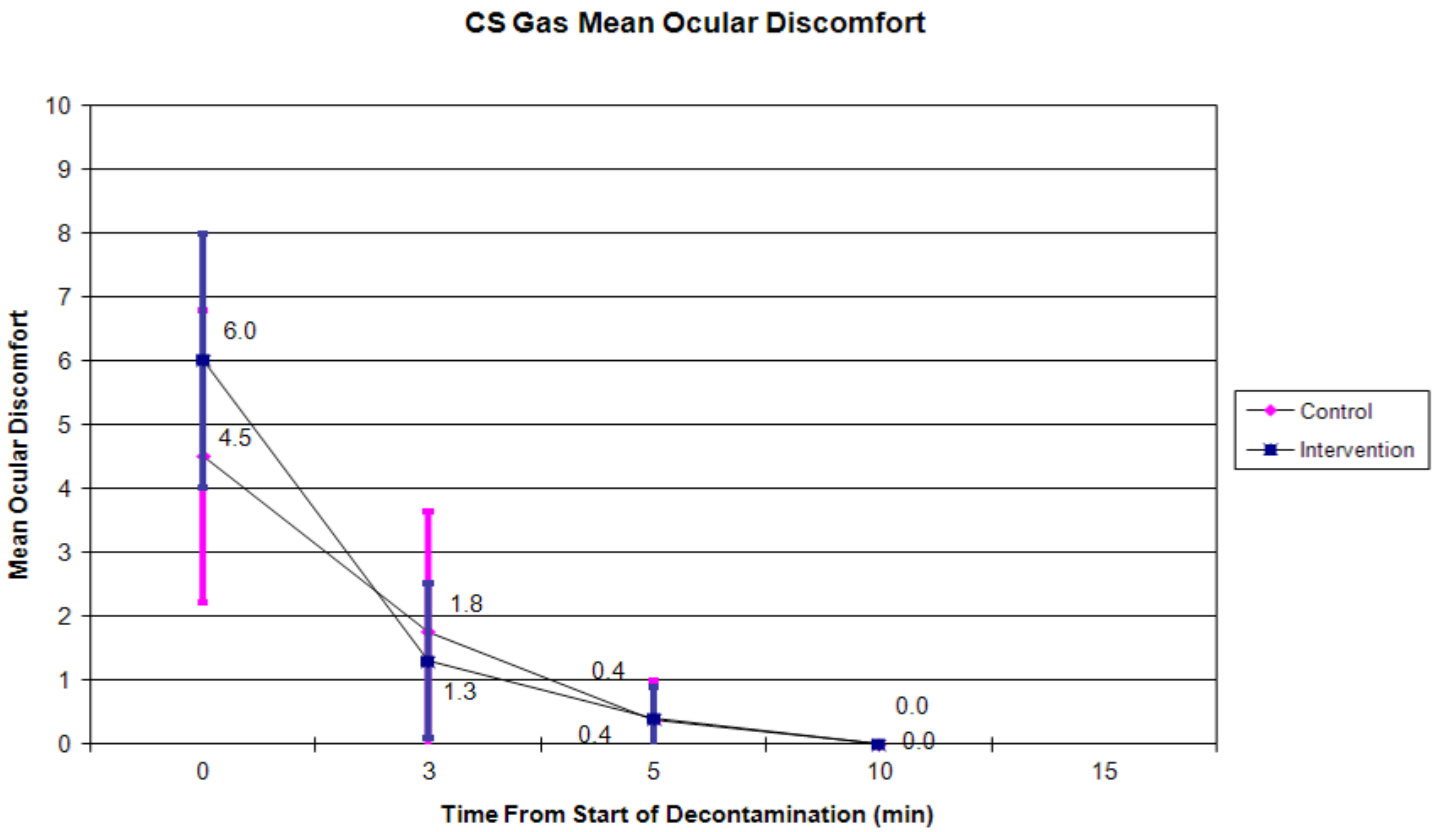

Figure 4. Mean ocular discomfort after CS (tear gas) gas exposure. Error bars indicate 95% confidence interval.

experiencing marked acute discomfort.

Subjects were permitted to leave the decontamination area at their own discretion when they felt ready to continue with their training per traditional training practices; most left prior to the 10- or 15-minute assessment point, leaving few data points and wide confidence intervals (as shown in Figures 2-5) at this time point. Future iterations of this study should include mandatory participation throughout the assessment period to counter this. In addition, future studies with similar methods may use the standard deviations in discomfort ratings that we observed among participants (which were larger than anticipated) in calculating needed sample sizes.

Small sample sizes in this study limited the ability to assess small differences in discomfort ratings. It was not possible to blind the investigators or participants to the agent they received, as an inert lathering agent was not available and may have confounded results if used. It was felt that the prospective, randomized, controlled trial design was the best counter to this limitation. Lastly, the possibility of a placebo effect should not be discounted; individuals who use a "special" decontamination agent to address their discomfort may have an expectation that their symptoms, no matter how severe, are less than what they might experience had they not used the decontamination agent. This expectation may result in belief that the agent is effective based on personal (i.e., anecdotal) experience.

CONCLUSION

This study demonstrates that the addition of baby shampoo to water irrigation does not appear to reduce the severity or duration of the acute discomfort produced by pepper spray or tear gas exposure. Similar investigations of proposed decontamination agents should be performed to provide evidence of their efficacy prior to their adoption and deployment.

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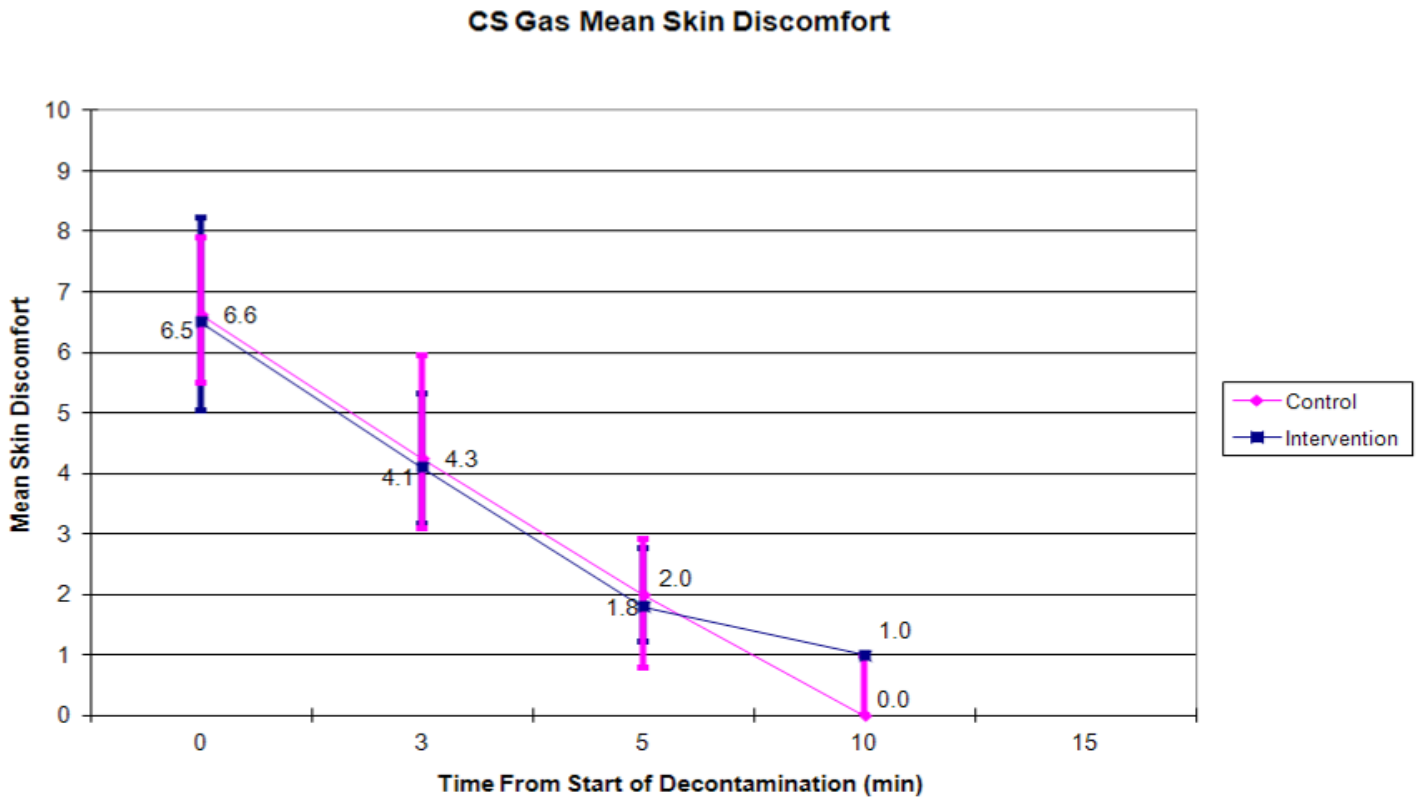

Figure 5. Mean skin discomfort after CS (tear gas) gas exposure. Error bars indicate 95% confidence interval.

REFERENCES

1. MacDonald JM, Kaminski RJ, Smith MR. The effect of less-lethal weapons on injuries in police use-of-force events. *Am J Public Health.* 2009;99(12):2268-74.
2. Carron PN, Yersin B. Management of the effects of exposure to tear gas. *BMJ*. 2009;338:b2283.
3. Smith J, Greaves I. The use of chemical incapacitant sprays: a review. *J Trauma*. 2002;52(3):595-600.
4. Bozeman WP, Winslow JE. Medical aspects of less lethal weapons. *Internet J Rescue Disaster Med.* 2005;5:37-47.
5. Zollman TM, Bragg RM, Harrison DA. Clinical effects of oleoresin capsicum (pepper spray) on the human cornea and conjunctiva. *Ophthalmology.* 2000;107(12):2186-9.
6. Busker RW, van Helden HP. Toxicologic evaluation of pepper spray as a possible weapon for the Dutch police force: risk assessment and efficacy. *Am J Forensic Med Pathol.* 1998;19(4):309-16.
7. Chan TC, Vilke GM, Clausen J, et al. The effect of oleoresin capsicum "pepper" spray inhalation on respiratory function. *J Forensic Sci.* 2002;47(2):299-304.
8. Watson WA, Stremel KR, Westdorp EJ. Oleoresin capsicum (Cap-Stun) toxicity from aerosol exposure. *Ann Pharmacother.* 1996;30(7-8):733-5.
9. Solomon I, Kochba I, Eizenkraft E, et al. Report of accidental CS ingestion among seven patients in central Israel and review of the current literature. *Arch Toxicol.* 2003;77(10):601-4.
10. Viala B, Blomet J, Mathieu L, et al. Prevention of CS "tear gas" eye and skin effects and active decontamination with Diphoterine: preliminary studies in 5 French Gendarmes. *J Emerg Med.* 2005;29(1):5-8.
11. Vaca FE, Myers JH, Langdorf M. Delayed pulmonary edema and bronchospasm after accidental lacrimator exposure. *Am J Emerg Med.* 1996;14(4):402-5.
12. Barry JD, Hennessy R, McManus JG Jr. A randomized controlled trial comparing treatment regimens for acute pain for topical oleoresin capsaicin (pepper spray) exposure in adult volunteers. *Prehosp Emerg Care.* 2008;12(4):432-7.
13. Lee DC, Ryan JR. Magnesium-aluminum hydroxide suspension for the treatment of dermal capsaicin exposures. *Acad Emerg Med.* 2003;10(6):688-90.

Inpatient Trauma Mortality after Implementation of the Affordable Care Act in Illinois

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Introduction: Illinois hospitals have experienced a marked decrease in the number of uninsured patients after implementation of the Affordable Care Act (ACA). However, the full impact of health insurance expansion on trauma mortality is still unknown. The objective of this study was to determine the impact of ACA insurance expansion on trauma patients hospitalized in Illinois.

Methods: We performed a retrospective cohort study of 87,001 trauma inpatients from third quarter 2010 through second quarter 2015, which spans the implementation of the ACA in Illinois. We examined the effects of insurance expansion on trauma mortality using multivariable Poisson regression.

Results: There was no significant difference in mortality comparing the post-ACA period to the pre-ACA period incident rate ratio (IRR)=1.05 (95% confidence interval [CI] [0.93-1.17]). However, mortality was significantly higher among the uninsured in the post-ACA period when compared with the pre-ACA uninsured population IRR=1.46 (95% CI [1.14-1.88]).

Conclusion: While the ACA has reduced the number of uninsured trauma patients in Illinois, we found no significant decrease in inpatient trauma mortality. However, the group that remains uninsured after ACA implementation appears to be particularly vulnerable. This group should be studied in order to reduce disparate outcomes after trauma. [West J Emerg Med. 2018;19(2)301-310.]

INTRODUCTION

Disparities in health outcomes between insured and uninsured patients have been demonstrated throughout medicine[1] and in various surgical settings including trauma[2] and emergency surgery.[3] Insurance-related disparities in trauma outcomes are unique, given that the Emergency Medical Treatment and Active Labor Act (EMTALA) "ensures public access to emergency services regardless of ability to pay."[4]

Recent studies have shown insurance-related disparities in outcomes after both blunt and penetrating trauma,[5,6] with consistently increased mortality for uninsured patients.[2] Despite a growing body of literature demonstrating disparities in trauma outcomes on the basis of race and socioeconomic status, causal mechanisms are poorly understood.[2] Factors that may contribute to observed disparities include host factors such as undiagnosed comorbid disease,[7] prehospital factors such as transport time and trauma catchment areas,[8,9] hospital and provider factors such as differential hospital performance and provider implicit bias,[10,11] and access to post-hospital and rehabilitation care.[2,12]

While the causal mechanisms of worsened outcomes for uninsured patients after trauma remain unclear, we saw Affordable Care Act (ACA)-related healthcare expansion as a natural experiment. The ACA was designed in part to provide access to care for many of the nation's uninsured; given increased mortality for the uninsured following trauma, we expected a concomitant decrease in mortality. Patients may have experienced improved outcomes after enactment of the ACA due to greater access to higher quality hospitals, improved inpatient care, or

improved rehabilitation care in the hospital or beyond.

While the ACA provides a potential opportunity to reduce disparities in care and outcomes, results have thus far been mixed.[13] A recent study surprisingly suggested an increase in trauma mortality after Massachusetts healthcare reform.[14] It is unclear if this effect will be seen nationwide, especially in light of the bulk of previous literature showing poorer outcomes for uninsured trauma patients when compared to their insured counterparts.[2] In Illinois, the ACA led to a 24% decrease in the uninsured population, though its impact on insurance-related trauma disparities has yet to be determined.[15] The primary aim of this study was to determine the impact of ACA-related insurance expansion on trauma mortality in Illinois. The secondary aim was to determine the remaining insurance-level effects of the ACA on trauma mortality in Illinois.

Population Health Research Capsule

What do we already know about this issue?
Uninsured patients die at higher rates after trauma; however, it remains unclear if Affordable Care Act (ACA)-related healthcare expansion will impact trauma mortality.

What was the research question?
Did ACA-related healthcare expansion in Illinois reduce trauma mortality?

What was the major finding of the study?
The ACA did not reduce trauma mortality over the study period, and insurance-related disparities persisted.

How does this improve population health?
Healthcare coverage alone is not sufficient to reduce trauma mortality or insurance-related disparities, highlighting the need for future studies and interventions.

METHODS

Study Design

This was a retrospective, cohort study of Illinois trauma patients. Because we looked at publicly available data that were de-identified, the study was determined to be exempt by the Northwestern University Institutional Review Board.

Study Setting and Population

We performed a retrospective cohort study of administrative data from the Illinois Hospital Association Health Care and Hospital Data Reporting Services (COMPdata) matched to the American Community Survey (ACS) by zip code from third quarter 2010 through second quarter 2015. Cases were defined as patients aged 18-64 who were admitted as inpatients through the emergency department (ED) with trauma-related diagnoses.

Study Protocol

We identified trauma-related *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes (800-959.9) and an ECODE related to major mechanisms of trauma (cut/pierce, fall, gunshot wound, self-inflicted gunshot wound, motor vehicle collision, or other blunt injuries). Other blunt injuries included other traffic accidents and horseback-rider injuries; however, we excluded aviation and boating injuries (E930-940). Admissions were excluded if they had only *ICD-9* codes related to foreign bodies (930-939), burns (940-949), or complications of trauma (958) as has been done in prior studies.[14] We matched records from the COMPdata dataset by patient zip code to five-year (2009-2013) ACS estimates of median household income.

To adjust for severity of injuries, we employed the Trauma Mortality Prediction Model (TMPM), which calculates the individual probability of mortality based on the extent of injury as defined by *ICD-9* injury codes.[16] We excluded admissions if they lacked sufficient injury data for the TMPM to assign an associated probability of mortality. We calculated the Charlson Comorbidity Index (CCI) for each patient to assess preexisting comorbidities and categorized our patients as not ill (CCI=0), moderately ill (CCI>0 and <3), and severely ill (CCI>=3).[17] We dichotomized admissions as pre-ACA (2010-2013) vs. post-ACA (2014-2015) and tested the significance of the association of post-ACA period and mortality.

Outcome Measures

Our primary outcome of interest was the adjusted incident rate ratio (IRR) for trauma mortality comparing post-ACA trauma patients to pre-ACA trauma patients. Our secondary outcome of interest was the adjusted IRR for trauma mortality comparing post-ACA trauma patients to pre-ACA trauma population among the uninsured.

Statistical Analysis

Within our dataset we identified variables that have been demonstrated in the literature to be predictive of trauma mortality and assessed those variables with standard univariate statistics. We subsequently performed two-tailed t-tests for proportions and chi-square tests to identify those variables associated with mortality. Given the low incidence of mortality in this dataset, we used multivariable Poisson regression to provide IRRs that approximate relative risk.[18]

The Poisson regression models included key sociodemographic and clinical variables shown in prior studies to be independent predictors of trauma-related mortality, including age,[19,20] sex,[21] race,[22] socioeconomic status,[23,24] mechanism of injury,[25] injury severity,[16,26,27] and shock as defined by systolic blood pressure less than 90 mm Hg.[28] Our final model included patient age category (18-25, 26-33, 34-45, 46-55, 55-64), sex, race, residence in a low-income zip code (<$35,000 median household income), quarter (to adjust for seasonal variation), insurance status (Medicaid, Medicare, uninsured, private), mechanism of injury, injury severity, comorbidities, shock, and hospital trauma volume as quartiles of total ED trauma visits over the study period. We performed statistical analyses using Stata version 12.1, College Station, TX.[29]

RESULTS

Over the study period, there were 14,298,834 hospital ED visits among Illinois residents age 18-64. We excluded 12,488,064 patients who were not admitted through the ED (discharges, transfers, and patients who were dead on arrival); 1,810,770 patients were admitted through the ED. We excluded 48,109 patients who were not Illinois residents, six with invalid *ICD-9* codes, 1,674,855 who were not trauma patients, and 799 patients with unknown or other insurance types. A total of 87,001 trauma patients met inclusion criteria (Figure 1). Characteristics of this cohort can be seen in Table 1.

Median age was 47, and 66% of the patients were male. Fifty-nine percent of patients were White, 21% were Black, 13% were Latino, and 7% were of other minority or unknown race. Overall, 13% lived in low-income zip codes. Most of the patients in this cohort suffered from falls, MVCs, or other blunt injuries. Penetrating trauma comprised approximately 11% of injuries, including gunshot wounds (GSWs) that accounted for 5.8%. One percent had shock. Most patients were not ill or moderately ill, while only 6% of the trauma population was severely ill at the time of their ED admission. Median probability of mortality based on injury severity as assessed by the TMPM was 1.3%, while approximately 1.7% of our cohort of hospitalized trauma patients died. GSW victims comprised only 5.8% of patients in our study population, but accounted for 18% of deaths overall and 32% of deaths among the uninsured (data not shown).

Within our cohort of trauma patients, the number of uninsured dropped 11% after the implementation of the ACA (95% confidence interval [CI] [10.24-11.26]). The number of Medicaid patients increased by 13% (95% CI [12.23-13.48]), and there was no significant change in the number of privately insured patients (-2.4% 95% CI [-3.15-1.59]) (Figure 2).

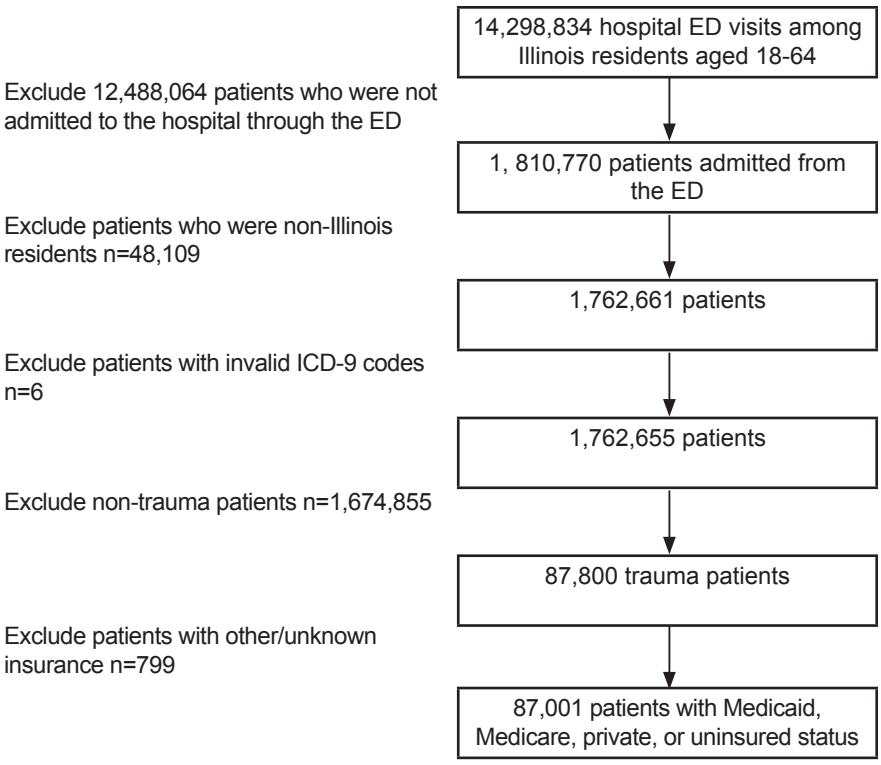

Figure 1. Flowchart for inpatient trauma dataset.
ED, emergency department; *ICD-9*, International Classification of Diseases, Ninth Revision.

Table 1. Baseline characteristics of Illinois trauma patients admitted through the emergency department from third quarter 2010 through second quarter 2015.

Variable	Category	Overall	Pre-ACA	Post-ACA
Patient ID (total)		87,001	62,018	24,983
Mortality (%)		1.69	1.64	1.83
Insurance (%)	Private	48.48	49.17	46.75
	Medicaid	19.38	15.69	28.55
	Medicare	13.00	12.90	13.22
	Uninsured	19.14	22.23	11.48
Age (%)	18-25	15.72	16.11	14.76
	26-33	12.55	12.77	11.99
	34-45	18.23	18.55	17.42
	46-55	25.26	25.42	24.85
	56-64	28.25	27.15	30.97
Male (%)		65.39	65.40	65.38
Race (%)	Black	21.50	21.28	22.05
	White	58.69	59.93	55.60
	Latino	12.63	12.54	12.86
	Other	7.18	6.24	9.49
Low-income (%)	(<$35,000)	14.09	13.88	14.61
Mechanism	GSW-SI	0.17	0.16	0.18
	GSW	5.84	5.52	6.63
	MVC	21.17	21.97	19.19
	Cut/Pierce	4.95	5.08	4.62
	Blunt (no MVC)	17.61	17.93	16.81
	Falls	50.26	49.33	52.57
Shock (%)		1.01	0.94	1.18
Comorbidities	Not ill	72.37	73.69	69.09
	Moderately ill	22.07	21.22	24.18
	Severely ill	5.56	5.08	6.73
TMPM (median %)		1.33	1.33	1.33
TRVOL	<110.2	25.43	25.47	25.33
	110.3-248.4	24.63	24.32	25.41
	284.5-568.8	27.89	27.31	29.33
	568.9+	22.05	22.91	19.93
	N	87,001		

ACA, Affordable Care Act; *GSW*, gunshot wound; *SI-GSW*, self-inflicted GSW; *MVC*, motor vehicle collision; *TMPM*, probability of death as provided by the Trauma Mortality Prediction Model; *TRVOL*, trauma visit volume quartiles.
Volume quartiles indicate average, yearly, inpatient, hospital trauma volume over the study period.

There was also no significant change in the proportion of Medicare patients (0.3% 95% CI -0.81- 0.18). There was a slight increase in overall crude mortality after the implementation of the ACA with an increase of 0.18% (95% CI 0.00, 0.04) (Figure 3).

In our adjusted models, we found that the uninsured died at a higher rate when compared to privately insured patients after adjusting for age, sex, race, low-income zip code, mechanism of injury, shock, TMPM score, Charlson Comorbidity Index, and hospital trauma volume with an IRR=1.24 (95% CI, 1.08-1.43) (Supplement). There was no significant change in adjusted trauma mortality comparing the post-ACA population with the pre-ACA population with an IRR=1.05 (95% CI 0.93-1.17) (Table 2).

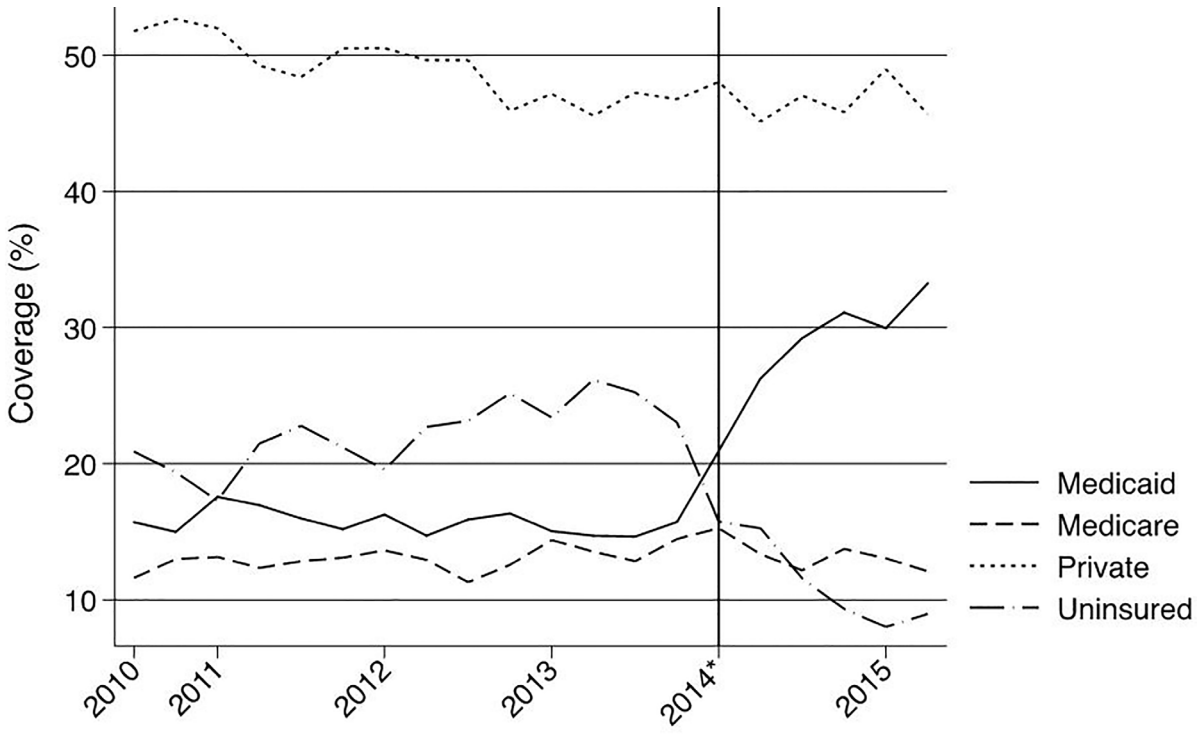

Figure 2. Primary payer mix for trauma inpatients in Illinois from third quarter 2010 through second quarter 2015. *Indicates January 1, 2014, which marks the beginning of insurance expansion in Illinois.

However, among patients who remained uninsured after the implementation of the ACA crude mortality increased by 1.20% (95% CI 0.53, 1.88) (Figure 4), and adjusted mortality increased as well with an IRR=1.46 (95% CI, 1.14-1.88) (Table 3).

DISCUSSION

Our results demonstrate that the patients who remained uninsured after ACA implementation in Illinois had a disproportionately high mortality after trauma. While the ACA-related insurance expansion significantly decreased the number of uninsured adults in Illinois, we did not find a significant decrease in overall trauma mortality after the expansion.

Our data support prior studies that have shown that being uninsured is an independent predictor of mortality after trauma.[2] It might be hypothesized that these differences in mortality are due to mechanisms of injury, which can lead to differential mortality. Penetrating trauma is associated with high mortality rates;[30] however, recent studies have shown that even among patients with blunt injuries alone, uninsured patients die at a higher rate.[6] Many additional factors have been shown to affect mortality of patients presenting with trauma.

The ACA has provided increased coverage for the uninsured in the form of Medicaid expansion for adults up to 138% of the federal poverty level and the Health Insurance Marketplace, which provides access to insurance plans for those who do not qualify for Medicaid.[31] Our study demonstrates that this program effectively reduced the number of uninsured patients in Illinois, confirming findings from prior studies.[15] We hypothesized that if insurance is truly an independent predictor of trauma mortality, then mortality rates should fall after ACA-related insurance expansion, bearing in mind that many of the individual improvements in health status associated with insurance coverage may not be fully realized until years after the initial intervention. However, if hospital and provider factors were the major drivers of insurance-related disparities in outcomes, then we would expect a decrease in trauma mortality after ACA.

Osler et al. found that healthcare reform in Massachusetts paradoxically increased overall trauma mortality.[14] While there was no significant change in overall trauma mortality after ACA insurance expansion in our study, we found that those patients who remain uninsured appear to suffer significantly higher mortality after ACA implementation. We are not suggesting that the ACA is causing a rise in mortality among the remaining uninsured patients as might be inferred from Figure 4, but rather we believe the group that remains uninsured after ACA healthcare expansion is suffering an unusually high burden of trauma-related mortality. Scott et al. suggested that since young people who benefit from the

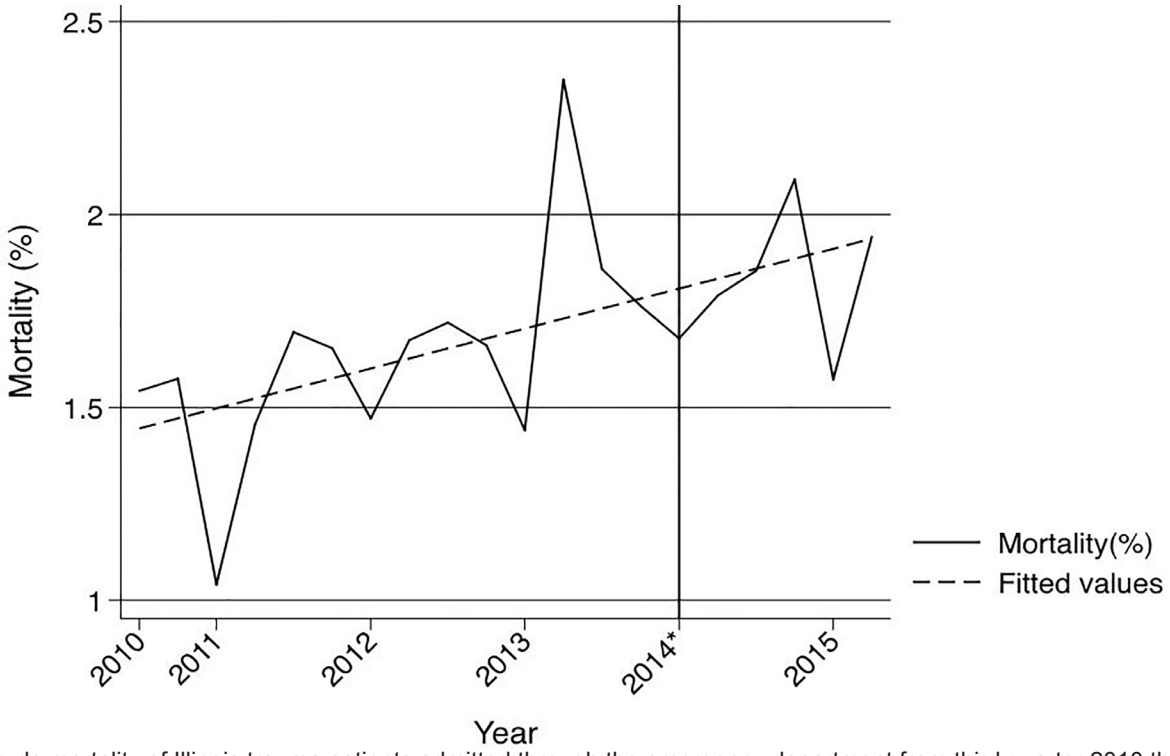

Figure 3. Crude mortality of Illinois trauma patients admitted through the emergency department from third quarter 2010 through second quarter 2015.
*Indicates January 1, 2014, which marks the beginning of insurance expansion in Illinois.

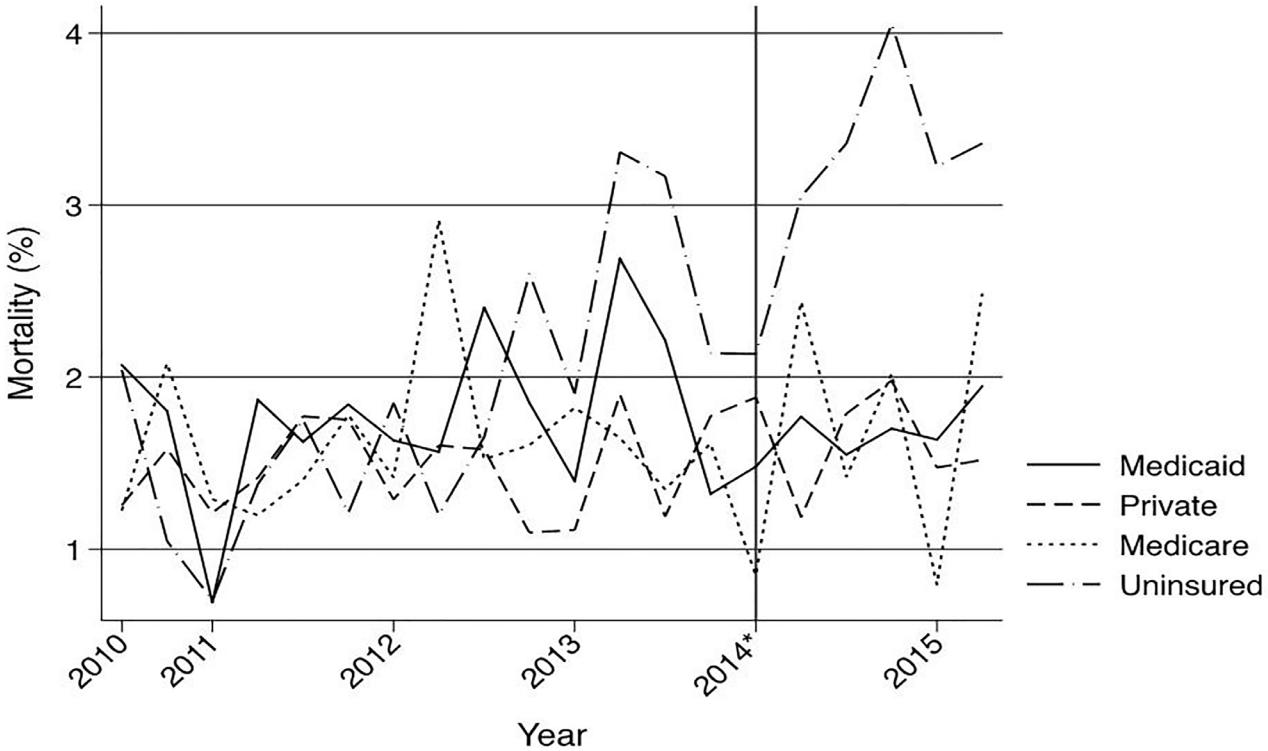

Figure 4. Crude mortality of Illinois trauma patients admitted through the emergency department from third quarter 2010 through second quarter 2015 by insurance type.
*Indicates January 1, 2014, which marks the beginning of insurance expansion in Illinois.

Table 2. Regression model evaluating effects of post-ACA* period and covariates on inpatient trauma mortality in Illinois.

Variable	Category	IRR	95% CI	p
Post-ACA		1.05	0.93 - 1.17	0.43
Age	26-33	1.04	0.86 - 1.25	0.71
(18-24)	36-45	1.00	0.82 - 1.21	0.97
	46-55	1.51	1.26 - 1.80	0.00
	55-64	1.53	1.27 - 1.84	0.00
Male		1.34	1.18 - 1.51	0.00
Race (White)	Other	1.21	1.00 - 1.47	0.05
	Black	0.95	0.82 - 1.10	0.47
Mechanism	Latino	0.83	0.70 - 0.99	0.04
(Falls)	Self-inflicted GSW	3.20	2.31 - 4.42	0.00
	GSW	1.95	1.57 - 2.42	0.00
	MVC	1.24	1.07 - 1.43	0.00
	Cut/Pierce	0.51	0.35 - 0.74	0.00
	Blunt (no MVC)	0.63	0.51 - 0.77	0.00
Shock		3.21	2.71 - 3.79	0.00
Low-Income	(68864+)	0.97	0.83 - 1.13	0.66
Comorbidities	Moderately Ill	1.93	1.71 - 2.19	0.00
(Not ill)	Severely Ill	4.52	3.82 - 5.34	0.00
	TMPM	177.66	140.55 - 224.57	0.00
TRVOL	Quartile 2	1.44	1.18 - 1.74	0.00
(Quartile 1)	Quartile 3	2.09	1.76 - 2.50	0.00
	Quartile 4	1.99	1.65 - 2.41	0.00
Quarter	Quarter 2	1.23	1.05 - 1.43	0.01
(Quartile 1)	Quarter 3	1.22	1.05 - 1.42	0.01
	Quarter 4	1.23	1.05 - 1.44	0.01
	N	87,001		

**ACA*, Affordable Care Act; *IRR*, incidence rate ratio; *GSW*, gunshot wound; *MVC*, motor vehicle collision; *TMPM*, probability of death as provided by the Trauma Mortality Prediction Model; *TRVOL*, trauma visit volume quartiles.
Volume quartiles indicate average yearly inpatient hospital trauma volume over the study period. Reference groups are provided in parentheses.

dependent healthcare expansion are mostly children of insured adults there would be increased disparities between the newly insured and the uninsured.[32] At least a proportion of the increased mortality in our remaining uninsured population may be attributable to this phenomenon. Unmeasured factors are likely contributing to this increased burden of mortality as well. The insurance-related disparities observed in this study may reflect patient factors, hospital or provider factors, or unknown or unmeasured confounders.[2] Unmeasured host-level cofounders in this study that could contribute to the undue burden of mortality in this group include obesity,[33] homelessness,[34,35] and immigration status.[36,37]

Future studies should focus efforts on determining the factors that lead to the high burden of mortality among the remaining uninsured. Better understanding of the underlying reasons for this increased mortality may lead policymakers to enact policies to reduce the disparity between patients who are insured and those who remain uninsured.

LIMITATIONS

This study was limited to Illinois, and its generalizability to the greater United States remains uncertain. Our study was also limited by its retrospective nature and can therefore only comment on association and not causation. Our source, COMPData, provides administrative claims data, which are known to suffer certain limitations.[38,39] We were unable to assess for the impact of proposed mechanisms behind trauma disparities including host factors such as homelessness, obesity,

Table 3. Regression model evaluating effects of post-ACA* period and covariates on uninsured inpatient trauma mortality in Illinois.

Variable	Category	IRR	95% CI	p
Post-ACA		1.46	1.14 - 1.88	0.00
Age	26-33	1.01	0.74 - 1.37	0.97
(18-24)	36-45	0.85	0.59 - 1.22	0.38
	46-55	1.67	1.19 - 2.34	0.00
	55-64	1.79	1.20 - 2.69	0.00
Male		1.20	0.86 - 1.66	0.29
Race (White)	Other	1.53	1.05 - 2.24	0.03
	Black	1.06	0.78 - 1.45	0.70
Mechanism	Latino	1.00	0.72 - 1.39	0.98
(Falls)	Self-inflicted GSW	3.89	2.08 - 7.26	0.00
	GSW	2.31	1.55 - 3.44	0.00
	MVC	1.74	1.25 - 2.41	0.00
	Cut/Pierce	0.72	0.41 - 1.26	0.25
	Blunt (no MVC)	0.61	0.39 - 0.95	0.03
Shock		2.83	2.04 - 3.93	0.00
Low-Income	(68864+)	0.92	0.70 - 1.22	0.56
Comorbidities	Moderately Ill	1.91	1.46 - 2.51	0.00
(Not ill)	Severely Ill	2.81	1.50 - 5.26	0.00
	TMPM	157.11	101.66 - 242.81	0.00
TRVOL	Quartile 2	1.18	0.72 - 1.92	0.51
(Quartile 1)	Quartile 3	1.70	1.11 - 2.61	0.02
	Quartile 4	1.50	0.96 - 2.34	0.07
Quarter	Quarter 2	1.31	0.94 - 1.82	0.11
(Quartile 1)	Quarter 3	1.43	1.04 - 1.97	0.03
	Quarter 4	1.37	0.97 - 1.93	0.07
	N	16,655		

**ACA*, Affordable Care Act; *IRR*, incidence rate ratio; *GSW*, gunshot wound; *SI-GSW*, self-inflicted GSW; *MVC*, motor vehicle collision; *TMPM*, probability of death as provided by the Trauma Mortality Prediction Model; *TRVOL*, trauma visit volume quartiles.
Volume quartiles indicate average yearly inpatient hospital trauma volume over the study period. Reference groups are provided in parentheses.

and both prehospital and post-hospital care. While we were able to adjust for comorbidities in our analysis, we were unable to control for undiagnosed comorbidities, which may be a partial driver of differential mortality in our dataset.

It has been suggested that patients who survive longer are more likely to obtain insurance before discharge thus biasing the uninsured group towards the more severely injured and falsely elevating the mortality in this group, a phenomenon known as survivor treatment assignment bias (STAB).[40] It is certainly feasible that some of the effects of insurance are attributable to STAB; however, we believe that this does not explain the entire association we have identified in this study. To address this potential bias we performed a post-hoc sensitivity analysis restricted to patients who did not die within the first day of hospitalization; the IRR for death among uninsured patients post-ACA was 1.52 with p=0.03 and therefore did not significantly change our major findings. Finally, many of the proposed mechanisms for higher mortality among uninsured patients after trauma are related to the overall health status of individuals, and the effects of preventative care and health maintenance may take years to reach full effect.

CONCLUSION

Uninsured trauma patients die at higher rates in Illinois. Even after the ACA drastically reduced the number of uninsured patients in Illinois, trauma mortality has not fallen. The group that remains uninsured after ACA implementation appears to be suffering a higher burden of mortality. Researchers and policymakers should focus on this vulnerable group to reduce or eliminate these ongoing disparities.

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REFERENCES

1. Hadley J. Sicker and poorer--the consequences of being uninsured: a review of the research on the relationship between health insurance, medical care use, health, work, and income. *Med Care Res Rev.* 2003;60(2 Suppl):3S-75S; discussion 76S-112S.
2. Haider AH, Weygandt PL, Bentley JM, et al. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. *J Trauma Acute Care Surg.* 2013;74(5):1195-205.
3. Schwartz DA, Hui X, Schneider EB, et al. Worse outcomes among uninsured general surgery patients: does the need for an emergency operation explain these disparities? *Surgery.* 2014;156(2):345-51.
4. Emergency Medical Treatment & Labor Act (EMTALA). 2012. Available at: https://www.cms.gov/regulations-and-guidance/legislation/emtala/. Accessed on March 17, 2017.
5. Greene WR, Oyetunji TA, Bowers U, et al. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. *Am J Surg.* 2010;199(4):554-7.
6. Weygandt PL, Losonczy LI, Schneider EB, et al. Disparities in mortality after blunt injury: does insurance type matter? *J Surg Res.* 2012;177(2):288-94.
7. Duron VP, Monaghan SF, Connolly MD, et al. Undiagnosed medical comorbidities in the uninsured: a significant predictor of mortality following trauma. *J Trauma Acute Care Surg.* 2012;73(5):1093-8; discussion 1098-9.
8. Nicholl J, West J, Goodacre S, et al. The relationship between distance to hospital and patient mortality in emergencies: an observational study. *Emerg Med J.* 2007;24(9):665-8.
9. Crandall M, Sharp D, Unger E, et al. Trauma deserts: distance from a trauma center, transport times, and mortality from gunshot wounds in Chicago. *Am J Public Health.* 2013;103(6):1103-9.
10. Haider AH, Hashmi ZG, Zafar SN, et al. Minority trauma patients tend to cluster at trauma centers with worse-than-expected mortality: can this phenomenon help explain racial disparities in trauma outcomes? *Ann Surg.* 2013;258(4):572-9; discussion 579-81.
11. Haider AH, Schneider EB, Sriram N, et al. Unconscious race and class bias: its association with decision making by trauma and acute care surgeons. *J Trauma Acute Care Surg.* 2014;77(3):409-16.
12. Englum BR, Villegas C, Bolorunduro O, et al. Racial, ethnic, and insurance status disparities in use of posthospitalization care after trauma. *J Am Coll Surg.* 2011;213(6):699-708.
13. Adepoju OE, Preston MA, Gonzales G. Health care disparities in the post-Affordable Care Act era. *Am J Public Health.* 2015;105 Suppl 5:S665-7.
14. Osler T, Glance LG, Li W, et al. Survival rates in trauma patients following health care reform in Massachusetts. *JAMA Surg.* 2015;150(7);609-15.
15. Dresden SM, Powell ES, Kang R, et al. Increased emergency department use in Illinois after implementation of the Patient Protection and Affordable Care Act. *Ann Emerg Med.* 2017;69(2):172-80.
16. Glance LG, Osler TM, Mukamel DB, et al. TMPM-ICD9: a trauma mortality prediction model based on ICD-9-CM codes. *Ann Surg.* 2009;249(6):1032-9.
17. Quan H, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care.* 2005:1130-9.
18. Zou G. A modified poisson regression approach to prospective studies with binary data. *Am J Epidemiol.* 2004;159(7):702-6.
19. Perdue PW, Watts DD, Kaufmann CR, et al. Differences in mortality between elderly and younger adult trauma patients: geriatric status increases risk of delayed death. *J Trauma.* 1998;45(4):805-10.
20. Kissoon N, Dreyer J, Walia M. Pediatric trauma: differences in pathophysiology, injury patterns and treatment compared with adult trauma. *CMAJ.* 1990;142(1):27-34.
21. Haider AH, Crompton JG, Chang DC, et al. Evidence of hormonal basis for improved survival among females with trauma-associated shock: an analysis of the National Trauma Data Bank. *J Trauma.* 2010;69(3):537-40.
22. Haider AH, Chang DC, Efron DT, et al. Race and insurance status as risk factors for trauma mortality. *Arch Surg.* 2008;143(10):945-9.
23. Cubbin C, LeClere FB, Smith GS. Socioeconomic status and injury mortality: individual and neighbourhood determinants. *J Epidemiol Community Health.* 2000;54(7):517-24.
24. Ali MT, Hui X, Hashmi ZG, et al. Socioeconomic disparity in inpatient mortality after traumatic injury in adults. *Surgery.* 2013;154(3):461-7.
25. Haider AH, Chang DC, Haut ER, et al. Mechanism of injury predicts patient mortality and impairment after blunt trauma. *J Surg Res.* 2009;153(1):138-42.

26. Losonczy LI, Weygandt PL, Villegas CV, et al. The severity of disparity: increasing injury intensity accentuates disparate outcomes following trauma. *J Health Care Poor Underserved.* 2014;25(1):308-20.
27. Baker SP, O'Neill B, Haddon W, Jr., et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma.* 1974;14(3):187-96.
28. Zenati MS, Billiar TR, Townsend RN, et al. A brief episode of hypotension increases mortality in critically ill trauma patients. *J Trauma.* 2002;53(2):232-6; discussion 236-7.
29. *Stata Statistical Software: Release 12* [computer program]. College Station, TX: StataCorp LP; 2014.
30. Demetriades D, Murray J, Charalambides K, et al. Trauma fatalities: time and location of hospital deaths. *J Am Coll Surg.* 2004;198(1):20-6.
31. Patient protection and affordable care act, 42, §18001 (2010).
32. Scott JW, Sommers BD, Tsai TC, et al. Dependent coverage provision led to uneven insurance gains and unchanged mortality rates in young adult trauma patients. *Health Aff (Millwood).* 2015;34(1):125-33.
33. Neville AL, Brown CV, Weng J, et al. Obesity is an independent risk factor of mortality in severely injured blunt trauma patients. *Arch Surg.* 2004;139(9):983-7.
34. Hibbs JR, Benner L, Klugman L, et al. Mortality in a cohort of homeless adults in Philadelphia. *N Engl J Med.* 1994;331(5):304-9.
35. Ferrada P, Anand RJ, Aboutanos M. The uninsured, the homeless, and the undocumented immigrant trauma patient. revealing health-care disparity at a Level 1 trauma center. *Am Surg.* 2016;82(1):E1-2.
36. Sorenson SB, Shen H. Mortality among young immigrants to California: injury compared to disease deaths. *J Immigr Health.* 1999;1(1):41-7.
37. Ku L, Matani S. Left out: immigrants' access to health care and insurance. *Health Aff (Millwood).* 2001;20(1):247-56.
38. Sarrazin MS, Rosenthal GE. Finding pure and simple truths with administrative data. *JAMA.* 2012;307(13):1433-5.
39. Haut ER, Pronovost PJ, Schneider EB. Limitations of administrative databases. *JAMA.* 2012;307(24):2589; author reply 2589-90.
40. Osler T, Glance LG, Li W, et al. Trauma care does not discriminate: the association of race and health insurance with mortality following traumatic injury. *J Trauma Acute Care Surg.* 2015;78(5):1026-33.

Emergency Department (ED), ED Observation, Day Hospital, and Hospital Admissions for Adults with Sickle Cell Disease

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Introduction: Use of alternative venues to manage uncomplicated vaso-occlusive crisis (VOC), such as a day hospital (DH) or ED observation unit, for patients with sickle cell anemia, may significantly reduce admission rates, which may subsequently reduce 30-day readmission rates.

Methods: In the context of a two-institution quality improvement project to implement best practices for management of patients with sickle cell disease (SCD) VOC, we prospectively compared acute care encounters for utilization of 1) emergency department (ED); 2) ED observation unit; 3) DH, and 4) hospital admission, of two different patient cohorts with SCD presenting to our two study sites. Using a representative sample of patients from each institution, we also tabulated SCD patient visits or admissions to outside hospitals within 20 miles of the patients' home institutions.

Results: Over 30 months 427 patients (297 at Site 1 and 130 at Site 2) initiated 4,740 institutional visits, totaling 6,627 different acute care encounters, including combinations of encounters. The range of encounters varied from a low of 0 (203 of 500 patients [40.6%] at Site 1; 65 of 195 patients [33.3%] at Site 2), and a high of 152 (5/month) acute care encounters for one patient at Site 2. Patients at Site 2 were more likely to be admitted to the hospital during the study period (88.4% vs. 74.4%, p=0.0011) and have an ED visit (96.9% vs. 85.5%, p=0.0002). DH was used more frequently at Site 1 (1.207 encounters for 297 patients at Site 1, vs. 199 encounters for 130 patients at Site 2), and ED observation was used at Site 1 only. Thirty-five percent of patients visited hospitals outside their home academic center.

Conclusion: In this 30-month assessment of two sickle cell cohorts, healthcare utilization varied dramatically between individual patients. One cohort had more hospital admissions and ED encounters, while the other cohort had more day hospital encounters and used a sickle cell disease observation VOC protocol. One-third of patients sampled visited hospitals for acute care outside of their care providers' institutions. [West J Emerg Med. 2018;19(2)311-318.]

INTRODUCTION

Despite the existence of treatment guidelines for vaso-occlusive crisis (VOC) for patients with sickle cell anemia[1] and evidenced-based summaries of treatment to guide emergency physicians,[2] there is tremendous variability in the management of this disorder, the most common complication of sickle cell disease.[1] The guidelines published by the National Health Lung, Blood Institute (NHLBI), and endorsed by the American

Academy of Emergency Medicine, detail an acute pain algorithm.[1] When possible, the NHLBI guidelines recommend treating pain associated with VOC using patient-specific protocols, as well as patient-controlled analgesia, aggressively treating pain plus reassessing the patient's pain and level of sedation every 15-30 minutes. The NHLBI acute pain algorithm recommends treating acute pain in a day hospital (DH) or another short-term stay hospital setting such as an observation unit first, before considering hospital admission for uncomplicated VOC.[1] The need for frequent hospital admission for patients with SCD and its association with premature death has been cited as a major concern for these patients.[3,4,5]

Readmission for patients with SCD within 30 days of the index visit has been cited as a concern.[5] The U.S. 30-day readmission rate for Medicare patients with an index admission averaged 18.4% in 2012, down from 19% in the five years prior.[6] The Centers for Medicare and Medicaid are beginning to monitor and will ultimately penalize hospitals for excess re-admissions within 30 days for the same diagnosis. In 2010, sickle cell anemia ranked number one, at 31.9%, for the percentage of patients readmitted within 30 days of an index visit.[7]

Opportunities to decrease admissions for patients with VOC have been demonstrated by use of a DH model.[8-13] In this model, a hospital will dedicate space and staffing to provide care for patients experiencing a VOC, outside of the emergency department (ED) or an inpatient bed. While a feasible model, there are logistical issues to implementing this model on a national level, especially for small hospitals. Alternatively, 36% of hospitals in the U.S. have implemented an ED observation unit (EDOU),[14] which may prove an alternative to hospital admission and treatment in a DH. The use of an EDOU for the treatment of VOC has been recommended for patients with continued pain, but without another indication for hospital admission.[1,15,16] Transferring patients from an ED to the EDOU allows for more time to resolve the VOC and possibly avoid hospital admission.

In the context of a two-center quality improvement (QI) project designed to implement best practices for the ED management of patients with complications of sickle cell disease,[17,18] we had a unique opportunity to prospectively examine the impact of different utilization rates of DH care, and/or EDOU care on rates of hospital admission for patients with sickle cell anemia experiencing VOC. We also had the opportunity to assess ED encounters and hospitalizations for our two cohorts of patients at outside centers within a 20-mile radius of each study site, an aspect of care rarely reported on.

The objectives of this prospective study were to 1) estimate and contrast the acute healthcare (ED visits, DH visits, ED observation and hospitalizations) utilization of two patient cohorts with sickle cell anemia presenting to one of two academic medical centers, and 2) assess acute care utilization of these cohorts seeking care at outside hospitals, within 20 miles of the home specialty centers.

Population Health Research Capsule

What do we already know about this issue?
Guidelines recommend day hospital or ED observation unit care rather than hospital admission to manage uncomplicated vaso-occlusive crisis pain for patients with sickle cell disease (SCD).

What was the research question?
What are acute healthcare utilization patterns of two different cohorts of patients with SCD?

What was the major finding of the study?
One cohort of SCD patients had more ED visits and hospital admissions; the other had more day hospital and ED observation unit visits.

How does this improve population health?
Institutions can consider ways to implement day hospital or ED observation unit care for patients with vaso-occlusive crisis pain to reduce hospital admissions.

METHODS

Design and Procedures

Data for this project were reported in the context of a two-center QI project.[17,18] Details of the project have been published.[17-20] Briefly, the project attempted to optimize the treatment of VOC in the ED using best practices,[1] while monitoring healthcare utilization and psychosocial referral needs and practices.[17-19] In this paper, we report acute healthcare utilization data only (excluding the number of clinic visits).

Institutional Review Board Approval

The study was approved by the institutional review boards at each of the two study sites. A waiver of consent was obtained at each site to examine ED, DH, ED observation encounters and hospital admissions for all patients with SCD during the study period. A subset of patients had the opportunity to sign consent for participation in an interview regarding care received (results not reported here); and relevant to this report, they had the option of providing consent for the study team to request healthcare use data (ED encounters and hospital admissions) from hospitals within 20 miles of each study site.

Setting

We conducted our study at two urban EDs in the southeastern U.S., each affiliated with an academic medical

center and with an emergency medicine residency training program. Characteristics of study site institutions and the sickle cell populations they serve are listed in Table 1. Differences between the study sites include the following: Site 1 used patient-controlled anesthesia in the ED, while Site 2 did not; Site 1 had a sickle-cell VOC observation unit protocol, while Site 2 did not.

Sample

For 30 months at each institution, all ED records, DH and admission records for patients with SCD (any patient with *ICD-9* diagnosis codes 282.60-282.69, including any SCD complications, such as 517.3 acute chest syndrome, 289.52 splenic sequestration) were assessed for acute care visits. During the study, the Site 1 SCD clinic population averaged 500; at Site 2, the SCD clinic population averaged 195 (695 total for both sites). We included all ED visits and hospital admissions for patients, regardless of whether they were a SCD clinic patient or unknown to the clinic. Patients were recruited during an ED visit or hospitalization for enrollment in the above-mentioned larger QI project. The method used to recruit patients to sign informed consent to monitor outside hospital utilization identified patients based on the first three months of acute care utilization in an effort to balance the number of patients with high ($\geq$ 5 visits), medium (3-4 visits), and low ($\leq$ 2 visits) utilization patterns.

Measures

Our study period was 30 months from October 2011 through March 2014. We assessed all acute care encounters (excluding clinic visits) for patients with sickle cell disease for acute complications of disease, including all ED encounters, EDOU encounters, DH encounters, and hospital admissions.

Statistics

We analyzed the data using SAS 9.2 (Cary, NC). We conducted a Z test for equality of proportions to assess for differences in the sickle cell populations of the study sites.

Acute Care Utilization, Home Institutions

We defined acute care utilization \as the total number of ED encounters, ED observation encounters, DH encounters, and hospital admissions for all patients with SCD. Study site research associates abstracted this data for the study period. If a patient had an ED encounter that resulted in a hospitalization, this accounted for two encounters. If a patient with an ED visit was transferred from the ED to observation under pain management protocol and then admitted, this accounted for three encounters. We purposefully counted each "setting" during the same date as a separate encounter to more comprehensively describe use.

Acute Care Utilization, Outside Institutions

A total of 113 patients signed consent to have outside records assessed. We contacted all hospitals within 20 miles of each study site to obtain the number of acute care encounters (ED encounters or hospitalizations) for consented patients during the 30-month study period. No hospital within 20 miles of the home institutions had a DH or EDOU.

Table 1. Characteristics of study-site institutions and the sickle cell populations they serve.

Characteristic	Site 1	Site 2
Sickle cell disease (SCD) Specialist care	Comprehensive SCD Center with hematologist outpatient services and inpatient care	Comprehensive SCD Center with hematologist outpatient services and inpatient care
Adult ED volume	66,000 visits, year 2014	78,000 visits, year 2014
Inpatient beds, year 2014	919 beds	885 beds
Day hospital hours of operation for sickle cell patients with VOC	8 Hours, 9 to 5 PM, weekdays only.	8 hours, 9 AM to 5 PM, weekdays only
ED observation unit care for patients with SCD VOC	ED Observation unit in place, dedicated observation protocol for treatment of uncomplicated VOC	ED Observation unit in place; however, no dedicated VOC observation protocol in place
Patient specific treatment plans for pain control	In place at time of study initiation	Established during first 6 months 30-month study period
Patient controlled analgesia (PCA)	PCA protocol available in the ED	No PCA use in the ED
Regular sickle cell clinic patients	500 patients	195 patients
SCD Clinic patients with no hospitalizations, ED Visits, or day hospital visits over 2.5 years	203 patients, 40.6%	65 patients, 33.3%

ED, emergency department; *VOC*, vaso-occlusive crisis.

RESULTS

Acute Health Care Utilization for Regular Sickle Cell Clinic Patients

Over the 30-month study period, 427 patients (297 at Site 1 and 130 at Site 2) had acute care encounters. Demographics of the 427 patients seeking acute care are listed in Table 2; the median age was 30 years, but a small number of patients were of advanced age, up to 86 years. Hispanics represented 2.1% of patients. These 427 patients made 4,740 institutional visits to one of the two study sites, totaling 6,627 different acute care encounters (ED encounters, DH encounters, EDOU encounters, hospital admissions, or combinations of these encounters. The range in total number of acute care encounters per site over the 30-month period, including any of the four different encounter types, ranged from a low of 0 (203 of 500 patients [40.6%] at Site 1; 65 of 195 patients [33.3%] at Site 2), and a high of 152 (5/month) acute care encounters for one patient at Site 2.

Acute Health Care Utilization for Patients with Acute Care Encounters

The number of unique patients that had acute care encounters at Site 1 was more than twice the number at Site 2 (297 vs 130), yet the number of hospital admissions was close between sites (983 at Site 1, and 887 at Site 2). The number of ED encounters was greater at Site 2 than Site 1 (1,688 at Site 2 vs. 1,596 at Site 1) despite Site 2 having 45% the number of unique patients. Site 1 used the DH more than Site 2, 1,207 encounters at Site 1 (8.5 visits/patient for 142 patients using the DH at Site 1) vs. 199 encounters at Site 2 (4.4 visits/patient for the 50 patients using the DH at Site 2). Totaling the number of acute care encounters (summing individual components of the different service areas during the study period), Site 1 had fewer acute care encounters per patient, 13.0 versus 21.3 acute care encounters per patient at Site 2, over 30 months.

Table 3 compares the access patterns between the sickle cell populations at each institution. For the group that had at least one acute care encounter during the study period, patients at Site 2 were more likely to be admitted during the study period (88.4% vs. 74.4%, p = 0.0011) and have an ED visit (96.9% vs. 85.5%, P = 0.0002). The percent of patients having at least one DH encounter between sites was not significantly different (47% at Site 1 vs. 38.4% at Site 2, p = 0.073). However, when comparing the number of DH visits of each site per patient requiring acute care encounters, DH was used more atsite 1 (1,207 visits /297 patients= 4.1 visits per patient) than for Site 2 (199 visits /130 patients = 1.5 visits per patient).

Hospital Admission Following a Primary Encounter

Table 4 contrasts the rates of admission following a primary encounter type (excluding the 20 direct admissions [no ED Visit] for Site 1, and 49 direct admissions [no ED Visit] for Site 2 that occurred during the study period). The hospital admission rate was less common following all primary encounters at Site 1 (34%) vs. Site 2 (44%). However, the admission rate following an ED visit was slightly less at Site 2 (47%) vs. Site 1 (53%). Site 2 did not have an ED observation protocol at the time of the study; the admission rate following placement in the EDOU at Site 1 was lower than the admission rate following an ED encounter at either site, at 36%. The hospital admission rate was low following a DH encounter at Site 1: 8%, compared to 24% at Site 2.

Outside Hospital Utilization

We obtained consent from 113 patients to have outside hospitals within 20 miles of their home academic centers queried for medical records of acute care encounters, 56 at Site 1, and 57 at Site 2. For this consented group, there were 190 outside-hospital ED encounters involving 38 patients (5/patient), and 110 outside hospitalizations involving 27 patients (4/patient). These 300 acute care encounters represented 40 of the 113 consented patients; therefore, 35.4% of the patients consented visited hospitals outside their home academic centers for some of their acute care needs. Table 5 compares ED visits and hospital admissions per patient per year; patients from Site 1 had more outside hospital encounters than patients from Site 2.

Table 2. Patient demographics

Parameter	Site 1 N=297	Site 2 N=130	Overall N=427
Age in Years	Mean; Median (range)	Mean; Median (range)	Mean; Median (range)
	32.7 years; 30 (18-78)	32.1 years; 29 (18-86)	32.5 years; 30 (18-86)
Race	N (%)	N (%)	N (%)
Black	286 (96.3%)	129 (99.2%)	415 (97.2%)
White	3 (1%)	0	3 (0.7%)
American Indian	1 (0.3%)	0	1 (0.2%)
Unknown	7 (2.4%)	1 (0.8%)	8 (1.9%)

Table 3. Access patterns of sickle-cell patients with at least one encounter type.

Encounter type	Unique patients with at least one of each encounter type	Site 1, N= 297	Site 2, N=130	P value
Hospital admissions	336	221 (74.4%)	115 (88.4%)	0.0011*
ED visits	377	251 (85.5%)	126 (96.9%)	0.0002*
Day hospital visits	192	142 (47.8%)	50 (38.4%)	0.0735
ED observation unit stays	48	48 (16.1%)	0	

ED, emergency department.

DISCUSSION

To the best of our knowledge, this is the first report of healthcare utilization in patients with SCD that includes DH and ED observation visits, in addition to the routinely reported ED visits and hospitalizations. We intentionally "counted" each encounter, and the numbers are significant. We attempted to dissect the "locations" in an effort to more fully understand all healthcare use for treatment of VOC and to begin to understand the potential for all locations as alternatives for treatment of VOC.

During the project, several changes at both sites affected healthcare utilization options. Immediately prior to the onset of the study, Site 1 opened a new day hospital, enabling the management of mild episodes of VOC crisis with a DH stay; in contrast, at Site 2, the main provider that admitted patients to the DH took an 18-month medical leave, temporarily limiting the use of the DH at Site 2.

Therefore, it is not surprising that the DH was used more for Site 1 patients needing acute pain management of VOC (1,207 encounters for 297 patients at Site 1, vs. 199 encounters for 130 patients at Site 2). It should be noted that the percentage of patients with one or more encounters to the DH at each site was not significantly different. The difference in usage reflected the frequency of DH use per patient during the study period (an average of 4 encounters/patient at Site 1, vs.1.5 encounters/patient at Site 2) rather than the percentage of patients with at least one DH encounter at each site. Another difference in management style is reflected in the hospital admission rate following a DH encounter between sites. Site 1 had a low post-DH encounter hospital admission rate, 8%, compared to Site 2, 24%.

Dedicated DH management of patients with SCD has been shown to reduce full hospital admissions and total costs.[11,12,21] It is clear there was a lower threshold for admission from the DH at Site 2 when compared with Site 1. This reflects practice pattern differences. Emergency physicians should work with area hematologists to explore expanded use of DH treatment of uncomplicated VOC to reduce hospital admission for those cases where hospital admission is not otherwise warranted.

We also report the use of an EDOU to help decrease hospital admission. Site 1 placed 67 patients in the observation unit rather than admitting to the hospital after inability to discharge after the ED stay; the admission rate was less than the SCD-VOC ED admission rate (36% verses 53%). A Brazilian hospital center successfully implemented an EDOU protocol and reduced hospital admissions; however, generalization of findings is limited to the small sample size, as there were less than 30 hospital admissions for sickle cell crisis each year.[22] Two studies proclaiming a 50-55% reduction in hospital admission rates following implementation of a dedicated SCD-VOC observation protocol have been published in abstract form,[15,16] but the detailed reports have yet to be published. Additional details are required before conclusions can be generalized to other settings. However, emergency physicians with access to an EDOU should consider establishing a SCD-observation protocol to reduce hospital admissions for uncomplicated VOC.

Table 4. Admission rates following ED, day hospital, or ED observation encounters at each site.

Encounter types	Site 1 encounters followed by hospital admission	Site 2 encounters followed by hospital admission	P value±
Emergency department	824/1529 (54%)	791/1688 (47%)	0.0222
Day hospital	91/1207 (8%)	47/199 (24%)	0.0001
ED observation unit	24/67 (36%)	0	
Totals*	939/2803 (33%)	838/1887 (44%)	0.0001

±Chi square.

*These totals do not reflect the 20 direct admissions for Site 1, and 49 direct admissions for Site 2.

Table 5. Outside hospital admissions and ED visits for a subset of consented patients.

	Site 1	Site 2
Subset of patients consented for survey of outside hospital* utilization, 113 total patients consented and surveyed	56 patients consented	57 patients consented
190 outside ED visits involving 38 of 113 patients, 33.6% had outside ED visits.	Average of 2.8 ED visits per patient per year over 2.5 years	Average of 0.6 ED visits per patient per year over 2.5 years
110 outside hospitalizations involving 27 of 113 patients, 23.9% had outside hospital admissions)	Average of 1.6 hospitalizations per patient per year over 2.5 years	Average of 0.4 hospitalizations per patient per year over 2.5 years

ED, emergency department.
*Acute health care encounters for enrolled patients at hospitals within 20 miles of each of the two study sites

Few prior studies assessed sickle cell patients' use of hospital facilities outside of their specialists' home institutions. Our finding of 34.5% of SCD patients visiting outside institutions is slightly less than that found by Woods et al. in 1997, who found 39% of SCD patients in the Illinois statewide database used more than one hospital for care.[23] However, our finding of 34.5% outside hospital use is considerably less than Panepinto et. al. study using a database from eight states, which found that 48.7% of adult patients with SCD used more than one hospital.[24] The fact that our patients had access to a hematologist for regular care may have reduced their need to seek care outside of the home institutions, while the other two cited studies reflected a more general SCD patient population, likely with less hematology follow-up care. Furthermore, patients seeking care elsewhere may represent needs unmet by the home institution.[25] Our findings highlight the importance of measuring the cost of outside hospital utilization when studying the financial impact of new treatments or programs initiated at the investigator's institution.

While the majority of patients with sickle cell disease at each study site presented for acute care during the study period, a significant number had no acute care encounters, for a period longer than previously reported previously.[26, 27] Approximately 40% of clinic patients at Site 1, and 33% of clinic patients at Site 2 had no acute care encounters at their hematologist's institution, or at hospitals within 20 miles of the hematologist, during the 2.5-year monitoring period. Our findings should be compared to an eight-state study of statewide inpatient and ED databases that found only 29% of patients had no acute care encounters related to their sickle cell anemia over a 12-month period.[26] Darbari et. al. reported percentages similar to our study, 40%, but the assessment period was only one year.[27] Our findings document 33-40% of two populations of patients with sickle cell disease being managed by hematologists without the need for acute care encounters for period of 30 months. We believe this is an important finding and further refutes the commonly held myth that all patients with SCD are high utilizers.

Another important finding is that a greater proportion of patients at Site 2 had one or more hospital admissions (88.4% at Site 2 vs. 74.4% at Site1), and had one or more ED visits (96.6% at Site 2 vs. 85.5% at Site 1). Furthermore, while the number of patients with acute care encounters at Site 1 was more than twice the number at Site 2 (297 vs. 130), Site 2 patients had more total ED encounters than Site 1 patients (1,688 vs. 1,596 encounters). This again speaks to differences in practice patterns between sites that can be guided with strong input from the patients' hematologists.

It has been documented previously how a minority of patients with SCD account for a disproportionately greater number of encounters;[26-31] however, the variation in acute care usage between sickle cell populations has not been demonstrated previously within a single study. Clearly, the patients at Site 2 had more acute care encounters per patient (21.3 per patient at Site 2, vs. 13.0 per patient at Site 1). Our study did not assess the differences in methods of sickle cell disease management in the outpatient clinics; future study should investigate differences in all management methods, as well as differences in the patient characteristics, to determine the cause of this difference in acute care utilization.

LIMITATIONS

Our study was a prospective observational study, and we did not randomize patients to any specific treatment plan or setting. Although it was our intention to provide optimal and uniform care at both sites, providers at Site 2 were unable to initiate patient-controlled analgesia in the ED. However, use of patient-controlled analgesia at Site 1 had unique problems, including delays to initiation of pain treatment as the device takes more time to set up than simple, single intravenous injection of pain medicine. Patient satisfaction with pain medication (reported previously) was not significantly different between sites.[17]

We did not assess outside hospital use beyond a 20-mile radius of each study site. We learned from discussions with

patients that a few had received acute medical care at facilities outside of the 20-mile radius surrounding the home institutions, but we are not able to quantify or comment further on this care as patients were consented for hospitals only within the 20-mile radius. We observed differences in management styles, but we were unable to determine from this data to what extent the differences we observed were due to physician practice, patient disease severity, or other factors. Each site experienced a deficit in hematologist specialty coverage that reduced the use of the DH until a replacement could be found (three months at Site 1, 18 months at Site 2). Our patient population had access to a hematology specialty clinic during the entire study period; our finding may not be applicable to settings without readily available hematology follow-up[32] and hematologist-directed day hospital management for patients with sickle cell disease.

CONCLUSION

In this 30-month assessment of two sickle cell clinic cohorts, healthcare utilization varied dramatically between individual patients, with no acute care encounters for 33-40% for the two clinic cohorts and a high of five encounters per month for 30 months for one patient at Site 2. One cohort had more hospital admissions and ED encounters, while the other cohort had more day-hospital encounters. The admission rate following an acute care encounter was lower for the site that had fewer ED encounters and hospital admissions per patient. One third of patients visited hospitals for acute care outside of their care providers' institutions.

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REFERENCES

1. Buchannan GR, Yawn BP, Afenyi-Annan AN, et al: Evidenced-Based Management of Sickle Cell Disease, Expert Panel Report 2014. U.S. Department of Health and Human Services NIH, NHLBI. Available at: https://www.nhlbi.nih.gov/sites/www.nhlbi.nih.gov/files/sickle-cell-disease-report.pdf.
2. Glassberg J. Evidenced-based management of sickle cell disease in the emergency department. *Emerg Med Pract.* 2011;13(8):1-20.
3. Powars DR, Chan LS, Hiti A, et al. Outcome of sickle cell anemia: a 4-decade observational study of 1056 patients. *Medicine (Baltimore).* 2005;84(6):363-76.
4. Shankar SM, Arbogast PG, Mitchel E, et al. Medical care utilization and mortality in sickle cell disease: A population-based study. *Am J Hematol.* 2005;80(4):262-70.
5. Ballas SK and Lusardi M. Hospital readmission for adult acute sickle cell painful episodes: frequency, etiology, and prognostic significance. *Am J Hematol.* 2005;79:17-25
6. Gerhardt G, Yemane A, Hickman P, et al. Data shows reduction in Medicare hospital readmission rates during 2012. *Medicare Medicaid Res Rev.* 2013;3(2). pii: mmrr.003.02.b01.
7. Elixhauser A, Steiner C. Readmissions to U.S. hospitals by diagnosis, 2010. Healthcare Cost and Utilization Project website. Available at: http://www.hcup-us.ahrq.gov/reports/statbriefs/sb153.pdf. Accessed October 1, 2015.
8. Yang YM, Shah AK, Watson M, et al. Comparison of costs to the health sector of comprehensive and episodic health for sickle cell disease patients. *Public Health Rep.* 1995;110(1):80-6.
9. Carroll CP, Haywood C Jr, Fagan P, et al. The course and correlates of high hospital utilization in sickle cell disease: evidence from a large, urban Medicaid managed care organization. *Am J Hematol.* 2009;84(10):666-70.
10. Raphael JL, Kamdar A, Wang T, et al. Day hospital versus inpatient management of uncomplicated vaso-occlusive crises in children with sickle cell disease. *Pediatr Blood Cancer.* 2008;51(3):398-401.
11. Ware MA, Hambleton I, Ochaya I, et al. Day-care management of sickle cell painful crisis in Jamaica: a model applicable elsewhere*? Br J Haematol.* 1999;104(1):93–6.
12. Wright J, Bareford D, Wright C, et al. Day case management of sickle pain: 3 years experience in a UK sickle cell unit. *Br J Haematol.* 2004;126(6):878–80.
13. Whiteman LN, Lanzkron S, Stewart RW, et al. Quality improvement process in a sickle cell infusion center. *Am J Med.* 2015;128(5):541-4.
14. Wiler JL, Ross MA, Ginde AA. National study of emergency department observations services. *Acad Emerg Med.* 2011;18(9):959-65.
15. Gowhari M, Kavoliunaite L, Bonnye J, et al. Impact of a dedicated sickle cell acute care observation unit on rate of hospital admission for acute pain crisis. *Blood.* 2015;126:4584.
16. Lyon M, Sturgis LC, Kutlar A, et al: 181Admission rates for an observation unit clinical pathway for the treatment of uncomplicated sickle cell disease vasoocclusive crisis. *Ann Emerg Med.* 2014;64(4):S65-6.
17. Tanabe P, Freiermuth CE, Cline DM, et al. A prospective emergency department quality improvement project to improve the treatment of vaso-occlusive crisis in sickle cell disease: lessons learned. *Jt Comm*

J Qual Patient Saf. 2017;43(3):116-26.

18. Thornton VL, Holl JL, Cline DM, et al. Application of a proactive risk analysis to emergency department sickle cell care. *West J Emerg Med.* 2014;15(4):446-58.
19. Freiermuth CE, Haywood C Jr, Silva S, et al. Attitudes toward patients with sickle cell disease in a multicenter sample of emergency department providers. *Adv Emerg Nurs J.* 2014;36(4):335-47.
20. Freiermuth CE, Silva S, Cline DM, et al. Shift in emergency department provider attitudes towards patients with sickle cell disease. *Adv Emerg Nurs J*. 2016;38(3):199-212.
21. Lanzkron S, Carroll CP, Hill P, et al. Impact of a dedicated infusion clinic for acute management of adults with sickle cell pain crisis. *Am J Hematol.* 2015;90(5):376–80.
22. Campos J, Lobo C, Queiroz AM, et al. Treatment of the acute sickle cell vaso-occlusive crisis in the emergency department: a Brazilian method of switching from intravenous to oral morphine. *Eur J Haematol.* 2014;93(1):34-40.
23. Woods K, Karrison T, Kosby M, et al. Hospital utilization patterns and costs for adult sickle cell patients in Illinois. *Pub Health Rep.* 1997;112(1):44-51.
24. Panepinto JA, Owens PL, Mosso AL, et al. Concentration of hospital care for acute sickle cell disease-related visits. *Pediatr Blood Cancer.* 2012:59(4):685-9.
25. Maxwell K, Streetly A, Bevan D. Experiences of hospital care and treatment-seeking for pain from sickle cell disease; qualitative study. *BMJ*. 1999;318(7198):1585-90.
26. Brousseau DC, Owens PL, Mosso AL, et al. Acute care utilization and rehospitalization for sickle cell disease. *JAMA*. 2010;303(13):1288-94.
27. Darbari DS, Wang Z, Kwak M, et al. Severe painful vaso-occlusive crises and mortality in a contemporary adult sickle cell anemia cohort study. *PLoS One*. 2013;8(11):e79923.
28. Neitert PJ, Abboud MR, Zoller JS, et al. Costs, charges, and reimbursements for persons with sickle cell disease. *J Pediatr Hematol Oncol.* 1999; 21(5):389-96.
29. Panepinto JA, Brousseau DC, Hillary CA, et al. Variation in hospitalization and hospital length of stay in children with vaso-occlusive crises in sickle cell disease. *Pediatir Blood Cancer*. 2005:44(2):182-6.
30. Benjamin LJ, Swinson GI, Nagel RL. Sickle cell anemia day hospital: an approach for the management of uncomplicated painful crises. *Blood*. 2000:95(4):1130-6.
31. Houston-Yu P, Rana SR, Beyer B, et al. Frequent and prolonged hospitalization: a risk factor for early mortality in sickle cell disease patients. *Am J Hematol*. 2003;72(3):201-3.

Reduced Computed Tomography Use in the Emergency Department Evaluation of Headache Was Not Followed by Increased Death or Missed Diagnosis

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Introduction: This study investigated whether a 9.6% decrease in the use of head computed tomography (HCT) for patients presenting to the emergency department (ED) with a chief complaint of headache was followed by an increase in proportions of death or missed intracranial diagnosis during the 22.5-month period following each index ED visit.

Methods: We reviewed the electronic medical records of all patients sampled during a quality improvement effort in which the aforementioned decrease in HCT use had been observed. We reviewed notes from the ED, neurology, neurosurgery, and primary care services, as well as all brain imaging results to determine if death occurred or if an intracranial condition was discovered in the 22.5 months after each index ED visit. An independent, blinded reviewer reviewed each case where an intracranial condition was diagnosed after ED discharge to determine whether the condition was reasonably likely to have been related to the index ED visit's presentation, thereby representing a missed diagnosis.

Results: Of the 582 separate index ED visits sampled, we observed a total of nine deaths and 10 missed intracranial diagnoses. There was no difference in the proportion of death (p = 0.337) or missed intracranial diagnosis (p = 0.312) observed after a 9.6% reduction in HCT use. Among patients who subsequently had visits for headache or brain imaging, we found that these patients were significantly more likely to have not had a HCT done during the index ED visit (59.2% vs. 49.6% (p = 0.031) and 37.1% vs. 26% (p = 0.006), respectively).

Conclusion: Our study adds to the compelling evidence that there is opportunity to safely decrease CT imaging for ED patients. To determine the cost effectiveness of such reductions further research is needed to measure what patients and their healthcare providers do after discharge from the ED when unnecessary testing is withheld. [West J Emerg Med.2018;19(2)319–326.]

INTRODUCTION

Headache is a common complaint in the emergency department (ED).[1] Use of imaging has increased since computed tomography (CT) was introduced in 1972.[2-4] In 2010, CTs were performed in 13.9% of U.S. ED visits, and 48% of these were of the head (HCT).[5] While this rise has been associated with a decline in rates of admission and transfer,[6] multiple sources have suggested that HCT use in the ED could be decreased through quality improvement efforts.[7-10]

The use of HCT by emergency physicians (EP) for

evaluation of headache varies widely, and 97% of EPs surveyed felt that at least some of the imaging studies ordered in EDs were medically unnecessary.[9,15] The American College of Emergency Physiciansreleased its Choosing Wisely Campaign in 2013, which included avoiding HCTs in patients with minor head injury who are at low risk based on validated decision rules.[11,12] During the 2015 Academy of Emergency Medicine Consensus Conference on diagnostic imaging in the emergency department, participants suggested that allowing providers to influence metrics could produce better quality metrics; they also suggested that knowledge translation for the optimization of diagnostic imaging use should be a core area warranting further research.[13,17]

The Centers for Medicare and Medicaid Services (CMS) proposed OP-15, "Use of Brain Computed Tomography in the Emergency Department for Atraumatic Headache," to measure the proportion of HCTs performed on ED patients presenting with a primary complaint of headache that were supported by diagnosis codes; however, its methods were soon questioned.[11,16] In 2012 while OP-15 was still under consideration, we implemented a quality improvement (QI) effort intended to improve the documentation of appropriate diagnoses in support of HCT ordering. As part of this QI effort we addressed some of the criticisms of OP-15 by expanding the indications for HCT and getting input from practicing EPs. Reviewing this QI effort in 2014 we observed that the proportions of HCT use decreased after EPs had reviewed their individual practice data. The primary objective of our present study was to determine whether the observed decrease in HCT use was associated with changes in proportions of death or missed intracranial diagnosis. Secondarily, we sought to determine whether proportions of subsequent cranial imaging or reevaluation of headache differed when compared between those who did and those who did not undergo HCT in the ED.

Population Health Research Capsule

What do we already know about this issue?
A proportion of CTs performed to evaluate headache in ED patients show no acute intracranial pathology. Also, CT utilization rates vary significantly between emergency providers.

What was the research question?
Could we detect an increase in rates of death or missed intracranial diagnoses following a 9.6% decrease in head CT utilization?

What was the major finding of the study?
We observed no increase in rates of death or missed intracranial diagnoses in the 22.5 months following a reduction in head CT use.

How does this improve population health?
This study suggests that the use of collaborative, non-coercive means may enable emergency physicians to decrease head CT use in the ED without increasing death or missed diagnoses.

METHODS

Study Setting

This study was a before-and-after study reviewing electronic medical records (EMR) of patients sampled during a QI effort that took place at a 60,000-visit Midwestern, university-based ED between April 2012 and August 2014. We collected follow-up data by EMR review performed between June-August 2016. This study was approved by the local institutional review board under waiver of informed consent.

Intervention

Quality Improvement Project

Our QI effort was structured to fulfill the practice improvement component of the American Board of Emergency Physicians' Maintenance of Certification requirement.[14] This required collecting data on 10 visits per EP before and after an intervention. We performed two interventions in succession, so our QI effort yielded three epochs: pre-intervention (April-August 2012); post-education (December 2013-March 2014); and post-data review (April-August 2014) (Figure). At the end of each epoch, we sampled 10 visits for headache seen by each EP by searching the EMR for chief complaints of headache, and identifying the 10 most recent ED visits seen by each faculty EP.

For our educational intervention we began by soliciting feedback from EPs on OP-15. Using this feedback we expanded the list of appropriate diagnoses supporting HCT (Table 1). We followed this with a series of emails and lectures explaining CMS OP-15. We also conducted group discussions during educational conferences and faculty meetings to educate EPs on selecting appropriate diagnoses to support HCT ordering and explaining the measurement process, highlighting common pitfalls. During group discussions we invited and answered questions. The explicit goal of education was to improve diagnosis documentation, rather than to decrease HCT ordering. This began in late 2012 and continued through 2013.

The data-review phase took place between January and March of 2014 when individual EPs reviewed their own HCT ordering practices based on data collected for the QI

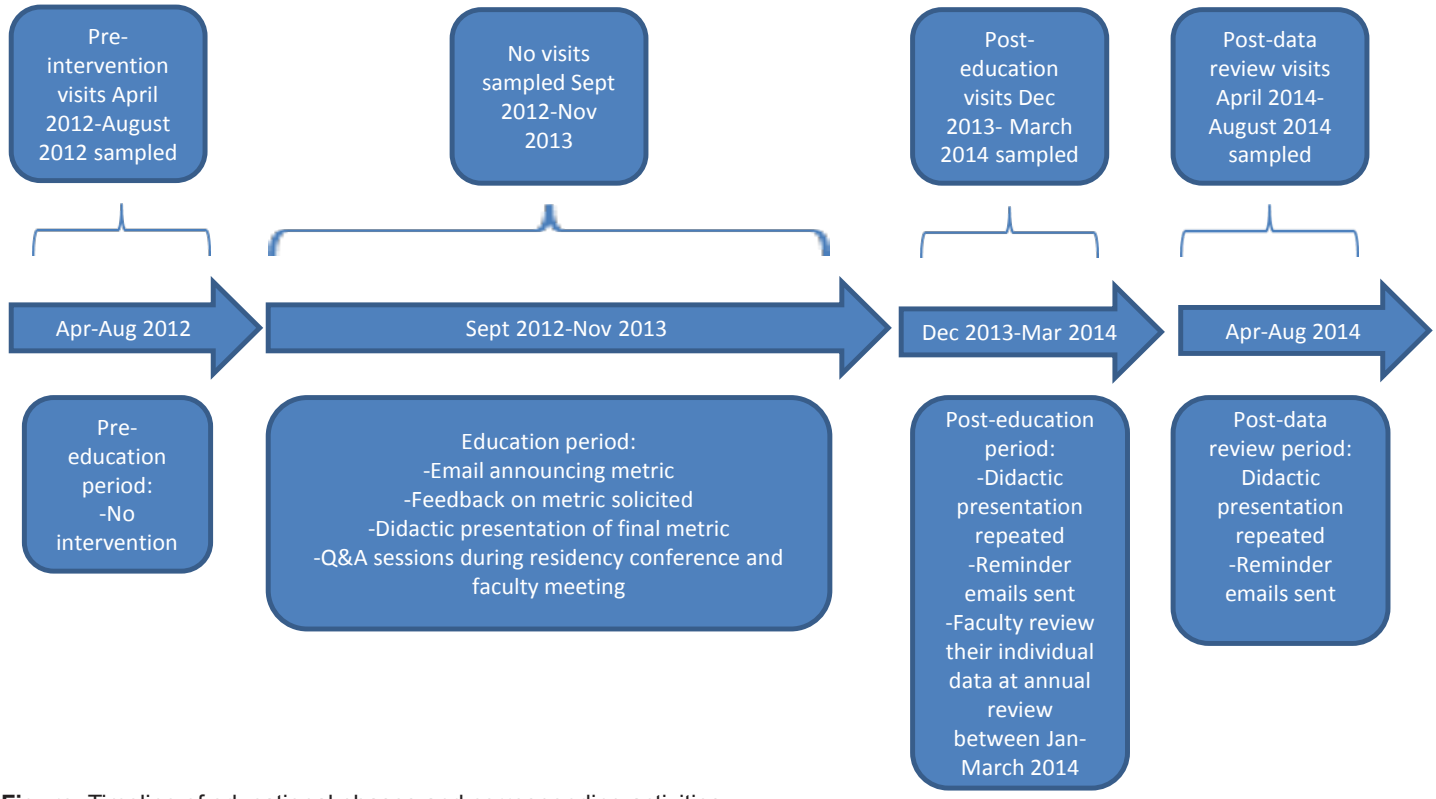

Figure. Timeline of educational phases and corresponding activities.

Table 1. CMS OP-15 and modifications made for QI effort.

Original CMS OP-15	Conditions added for Modified CMS OP-15
Lumbar puncture	Anticoagulant use
Dizziness	New persistent daily headache
Paresthesia	Visual disturbance
Lack of Coordination	A history of any of the following:
Subarachnoid hemorrhage	Ventriculoperitoneal shunt
Complicated headache	Neurosurgical interventions
Thunderclap headache	Coagulation or clotting disorders
Focal neurologic deficit	Subdural hemorrhage
Pregnancy	Epidural hemorrhage
Trauma	Cerebrovascular accident
HIV	Transient ischemic attack
Tumor/mass	Hydrocephalus
ED patients admitted to the hospital	Cerebral aneurysm

CMS, Centers for Medicare and Medicaid Services; *QI*, quality improvement

effort during the pre-intervention phase. These reviews occurred during individual faculty's annual reviews with the department chair. In these meetings we presented each EP with his/her individual proportion of HCT ordering and proportion of appropriate diagnosis assignment. In cases where a HCT was ordered without the assignment of an appropriate supporting diagnosis (from Table 1) we reviewed the ED chart. In keeping with Schuur et al.'s findings, we

found that in the majority of cases a more specific diagnosis than "headache" was clearly supported by information documented in the ED chart, but had not been assigned at the end of the ED visit.[16] During each annual review we informed the EP of the specific cases where HCT was not supported by a diagnosis code and suggested an alternate, more-specific diagnosis or the addition of a secondary diagnosis that would have made this HCT appropriate according to CMS OP-15. This was followed by the post-data review phase when we sampled another 10 headache visits per EP. After our QI effort was completed, we were surprised to note that while there was no decrease in HCT use after the educational intervention, we observed a 9.6% reduction in HCT use after data review.

Data Collection and Measures

In 2016 we decided to use the dataset generated during the QI effort to investigate our study hypothesis: Was a decrease in HCT use followed by an increase in death or missed intracranial diagnosis? A pre-clinical medical student was trained as a reviewer by an emergency medicine attending who was a QI officer with experience in chart review. The trained reviewer then reviewed the EMR for all patients sampled during the QI effort. We reviewed each patient's index ED note for the following: age at time of ED visit; gender; migraine history; known history of significant intracranial pathology; whether brain imaging was performed during the index ED visit; and findings from the brain imaging if performed. We reviewed all ED, neurology, neurosurgery, and primary care clinic notes as well as any HCT or brain magnetic resonance imaging (MRI) results occurring in the 22.5-month period following each index ED visit. This length of time was selected because it was the maximum window available from the last visit in the dataset at the time that data collection began.

Follow-up data included the following: whether a follow-up visit took place for a similar headache; diagnoses assigned at follow-up visits; date of follow-up visit; the service providing follow-up care; whether death was recorded in our EMR; whether brain imaging was performed in the follow-up period; and findings from brain imaging if performed. We distinguished between follow-up for any reason and those related to the ED visit as a marker for sample retention during the follow-up window. Data were entered into a standardized data collection spreadsheet. Prior to data collection we defined all terms in the spreadsheet in a data dictionary. No adjustment was made for trainee involvement or subsequent shift changes at the time of the index ED visit. A priori we defined potential missed diagnosis as the presence of any of the following conditions being found after the index ED visit: aneurysm involving the intracranial or cervical vessels; hydrocephalus; intracranial hypertension; stroke (ischemic or hemorrhagic); intracranial mass; subarachnoid hemorrhage; subdural hemorrhage; epidural hemorrhage; intraparenchymal hemorrhage; or dural sinus thrombosis.

To determine which subsequently-identified intracranial conditions should be counted as missed diagnoses we employed a board-certified EP (SL) to perform an independent review of all records where subsequent intracranial conditions were identified. This reviewer was blinded to the study hypothesis and had not been involved in or measured by the initial QI project. For each potential missed diagnosis, the independent reviewer reviewed the index ED visit note, follow-up visit notes and radiology reports before assigning a determination of whether the subsequently-diagnosed cranial condition could have potentially been diagnosed at the index visit. We labeled these as missed intracranial diagnoses.

Inclusion Criteria

Patients of all ages presenting to the ED complaining of headache who had been sampled for the initial QI effort were eligible for inclusion. Exclusion criteria included patients who arrived after inter-hospital transfer, patients admitted during their index visit, and those with a history of ventriculoperitoneal shunt. For patients with multiple ED visits, only the first visit was used as an index visit.

Key Outcome Measures

The primary outcomes of interest were the proportion of death or missed intracranial diagnoses by epoch. Our secondary outcomes were the proportions of patients that followed up for evaluation of similar headache or those who had subsequent cranial imaging (CT or MRI).

Data Analysis

We compared proportions of HCT performance across study epochs, and tested HCT ordering using chi-squared or Fisher's exact tests, as appropriate. We identified descriptive statistics (proportions) for intracranial findings among those with HCT performed and those with neurological findings identified after the initial visit. We compared outcomes of death, missed diagnoses, identification of a follow-up visit for the same reason as the index ED visit, performance of cranial intervention and brain imaging by epoch and HCT performance. Differences were identified with the Kruskal-Wallis test and Wilcoxon rank-sum test. All tests were considered significant if $p<0.05$ using two-tailed tests, and analysis was completed using SAS 9.4 (SAS Institute, Inc., Cary, NC).

Quality Assurance

The primary reviewer (MM) extracted data from all charts, and a second reviewer (DM) independently reviewed 30 randomly selected charts for quality assurance. Simple agreement ("yes" vs. "no") was greater than or equal to 90% for key reported measures.

RESULTS

We initially sampled 695 ED encounters for headache. After we excluded patients who were admitted to the hospital (19), transferred in after evaluation in another ED (19), or included in the study during a prior visit (75), we had a final sample of 582 separate, index ED encounters during the study period. Patient sex, age, migraine history, or pre-existing history of intracranial pathology did not vary across study epoch (Table 2). HCT performance at the index visit only varied by patient age and by patients with a known, pre-existing intracranial condition. Patients who received a CT during the index visit had a higher median age, and a greater proportion had no known, pre-existing intracranial condition. During our pre-education, post-education and post-data review epochs we observed CT ordering proportions of 33.3%, 36.7%, and 25.4%, respectively ($p = 0.044$) (Table 3).

Primary Outcomes

After a 9.6% reduction in the frequency of HCT use we did not observe a statistically significant difference in proportions of death ($p = 0.337$) or missed diagnoses ($p = 0.312$) between study epochs. Across all epochs, we observed a total of nine deaths and 10 missed intracranial diagnoses (Table 4). No deaths had a missed intracranial diagnosis.

Secondary Outcomes

Among patients who had a subsequent visit for evaluation of the same complaint as the index ED visit, 64% had not had a HCT during the index visit compared to 36% who did ($p = 0.031$). Among patients who had subsequent brain imaging after the index ED visit, 60% did not have a HCT during the index visit compared to 40% who did ($p = 0.006$) (Table 4).

DISCUSSION

During our QI effort we did not observe a decrease in HCT after a year of educational interventions, but we observed a 9.6% decrease after providers reviewed their own data. This accords with the Institute of Medicine suggestion that feeding providers' data back to them may be an important part of effectively changing physician behavior.[19] It is worth noting that during our QI effort we never explicitly instructed providers to decrease HCT ordering. This was motivated by the assumption that our doctors were already trying to do the right thing and avoid unnecessary testing, but that doctors might be capable of being more diligent in diagnosis assignment. The decrease in HCT ordering that we observed came after providers reviewed their own data. So this decrease appears to have resulted from a change that providers took upon themselves after being given the opportunity to look at objective data of their practice patterns and to reflect on what this data told them about their own practice. Happily, this would seem to support our initial assumption that doctors are generally trying to do the right thing.

Previous studies have found that CT pulmonary angiography (CTPA) for evaluation of pulmonary embolism could be safely decreased, thereby decreasing resource utilization without causing harm to patients.[20,21] These studies used probabilistic decision models or looked at inpatient charges, limiting their generalizability to ED patients. The most compelling evidence supporting the safety and cost effectiveness of decreasing CTPA in ED patients had median hospital stays of 7.7 days and medical charges of $6,281.[22] This was in contrast to the typical patient presenting to the ED with headache, where reduced testing may mean no testing. We found that a reduction in HCT use for the evaluation of ED patients with headache was not followed by increased death or missed diagnoses. However, the observations that those patients who returned for reevaluation of the same complaint and those who subsequently received brain imaging were more likely to have not had HCT during index visit calls the true impact of decreasing ED-based testing on overall resource utilization into question.

Table 2. Demographics and medical history of patients sampled by epoch and head CT performance.

		Epoch				CT at Index Visit		
	Overall	1	2	3	P value[1]	Yes	No	P value[1]
Total N(%)	582 (100.0)	174 (29.9)	215 (36.9)	193 (33.2)	***	186 (32.0)	396 (68.0)	***
Sex N(%)								
Female	367 (63.1)	113 (30.8)	1269 (35.2)	125 (34.1)	0.504	124 (33.8)	243 (66.2)	0.216
Male	215 (36.9)	61 (28.4)	86 (40.0)	68 (31.6)		62 (28.8)	153 (71.2)	
Age median (IQR)	34 (23-49)	35 (25-47)	34 (21-53)	34 (46)	0.478	43 (29-56)	31 (21-43)	<0.001
Migraine history N(%)	204 (35.1)	71 (34.8)	69 (33.8)	64 (31.4)	0.161	57 (27.9)	147 (72.1)	0.127
History of significant cranial pathology N(%)	103 (17.7)	31 (30.1)	43 (41.8)	29 (28.2)	0.421	43 (41.8)	60 (58.3)	0.019

[1]Differences in categorical values determined by chi-square analysis; numerical values by Kruskal-Wallis test.

Table 3. Comparison of epoch and follow up by head CT ordering.

	CT at Index Visit		
	Yes; n (%)	No; n (%)	P value
Epoch			
Pre-intervention	58 (33.3)	116 (66.7)	
Post intervention 1	79 (36.7)	136 (63.3)	0.044
Post intervention 2	49 (25.4)	144 (74.6)	
Follow up			
No visit	78 (28.2)	199 (71.8)	
ED Visit	25 (28.4)	63 (71.6)	0.043
Appt-Based Visit	83 (38.3)	134 (61.8)	

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

It may be the case that many patients simply feel that they need some sort of test to have had a thorough evaluation. This is supported by studies finding that ED patients who do not receive CT imaging for headache or for abdominal pain were more likely to return within 30 days.[23,24] A previous study has observed up to three-fold variability in the proportion of HCT use for the evaluation of atraumatic headache in the ED.[15] In our study we observed a convergence between EPs' HCT-ordering proportions when we compared the pre-intervention to the post-data review phases; however, because our study was not designed or powered to investigate this, our observation is only suggestive.

LIMITATIONS

This study has several limitations. As a retrospective chart review, we only had access to information contained in the EMR. Patients who did not follow up with us may have had death or missed diagnoses that we did not observe. In the pre-post study design, however, these factors are likely distributed across time periods, so we do not expect that this study type biased our findings. Approximately 86% of the sample had a subsequent visit within our EMR, suggesting that access to care was good and that the probability of patients seeking care outside our health system was low. Though we cannot exclude other causes of HCT reduction over time, there were no co-existing initiatives in place in the study institution to change HCT ordering practices.

Since we do not practice in a closed medical system, patients could have presented to other systems for care or could have died without presenting to our hospital. To address this issue, we limited the outcomes assessment to patients who received primary care within our university health system by excluding patients who were transferred in, improving the probability that we would capture events. Because of neurosurgical coverage in our predominantly rural state, nearly all patients in our region with significant intracranial pathology would be transferred to our institution for care; therefore, it is unlikely that such outcomes were not captured. This is supported by the observation that over 85% of patients in this study had another encounter in our health system within 22.5 months of the index visit.

The use of an outcome that did not account for the clinical conditions, comorbidities, or appropriateness of initial CT ordering limits the applicability of our findings. However,

Table 4. Medical outcomes and follow up by epoch and head CT order status at index visit

		Epoch				CT at index		
	Overall	Pre-intervention	Post-education	Post- data review	P value[1]	Yes	No	P value[1]
Outcomes	(n=582)	(n =174)	(n=215)	(n=193)		(n=186)	(n=396)	
Death	9 (1.5)	3 (1.7)	5 (2.3)	1 (0.5)	0.337	5 (2.7)	4 (44.4)	0.153
Missed diagnosis	10 (1.7)	2 (1.2)	6 (2.8)	2 (1.0)	0.312	3 (1.6)	7 (70.0)	0.893
Follow up visit for ED complaint	305 (52.7)	93 (53.5)	110 (51.2)	102 (52.9)	0.894	109 (59.2)	196 (64.3)	0.031
Cranial intervention after ED visit	21 (3.6)	8 (4.6)	8 (3.7)	5 (2.6)	0.585	9 (4.8)	12 (57.1)	0.275
Brain imaging done after ED visit	172 (29.6)	56 (32.2)	68 (31.6)	48 (24.9)	0.217	69 (37.1)	103 (59.9)	0.006
Time to follow up [Median (IQR)][3]								
ED visit	24 (6-149)	35 (12-99)	21 (6-134)	56 (3-330)	0.688	9 (3-27)	59 (8-204)	0.012
Appt-based visit	22 (6-76)	25 (7-87)	22 (7-67)	17 (4-76)	0.920	26 (9-76)	19 (5-84)	0.637

ED, emergency department; *CT*, computed tomography; *IQR*, interquartile range.
[1] Differences in categorical values determined by chi-square analysis or Fisher's exact test; numerical values by Kruskal-Wallis test.
[2] Outcomes were not mutually exclusive. Percentages reported represent column percentages, and chi-square analysis represent differences in each outcome by epoch.
[3] Among those with a follow up only.

this type of metric was drafted as part of the proposed quality measure; so interpreting our CT ordering practices in this context parallels the outcomes that might be expected if this metric were more widely adopted. In this way, our study is pragmatic and reflects the limitations of case identification and administrative data use.

CMS OP-15 was found to be unreliable, in part because it relied upon administrative data.[16] We addressed this issue by relying on chart review, the gold standard against which the aforementioned study compared OP-15. This resulted in a more reliable measure but at the cost of a highly labor-intensive technique.

CONCLUSION

We observed no increase in death or missed-diagnosis proportions following a 9.6% reduction in HCT to evaluate ED patients presenting with headache. Patients who subsequently had a repeat visit for the same complaint or underwent HCT after ED discharge were more likely to have not had imaging performed during their index visit. Our study adds to the compelling evidence that there is room to safely decrease CT imaging for ED patients. Determining the cost effectiveness of such reductions requires further research to measure what patients and their healthcare providers do after discharge from the ED when unnecessary testing is withheld.

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REFERENCES

1. Friedman BW, Grosberg BM. Diagnosis and management of the primary headache disorders in the emergency department setting. *Emergency Med Clin of N Am.* 2009;27(1):71-7, viii.
2. Talwalkar A, Ashman JJ. Annual percentage of emergency department visits with selected imaging tests ordered or provided - national hospital ambulatory medical care survey, United States, 2001-2010. *MMWR Morb Mortal Wkly Rep.* 2013;62:455.
3. Kocher KE, Meurer WJ, Fazel R, et al. National trends in use of computed tomography in the emergency department. *Ann Emerg Med* 2011;58(5):452-62.e3.
4. Larson DB, Johnson LW, Schnell BM, et al. Rising use of CT in child visits to the emergency department in the United States, 1995-2008. *Radiology.* 2011;259(3):793-801.
5. Centers for Disease Control and Prevention. National ambulatory medical care survey: 2010 summary tables. Available at: https://www.cdc.gov/nchs/data/ahcd/namcs_summary/2010_namcs_web_tables.pdf. Accessed August 29, 2017
6. Larson DB, Johnson LW, Schnell BM, et al. National trends in CT use in the emergency department: 1995-2007. *Radiology*. 2011;258(1):164-73.
7. Schroeder AR, Redberg RF. The harm in looking. *JAMA Pediatr.* 2013;167(8):693-5.
8. Mills AM, Raja AS, Marin JR. Optimizing diagnostic imaging in the emergency department. *Acad Emerg Med.* 2015;22(5):625-31.
9. Hess EP, Marin J, Mills A. Medically unnecessary advanced diagnostic imaging and shared decision-making in the emergency department: Opportunities for future research. *Acad Emerg Med*. 2015;22(4):475-7.
10. Gawande A. Overkill. An avalanche of unnecessary medical care is harming patients physically and financially. What can we do about it? Available at: http://www.newyorker.com/magazine/2015/05/11/overkill-atul-gawande. Accessed August 29, 2017
11. QualityNet. Imaging efficiency measures. Available at: http://www.qualitynet.org/dcs/ContentServer?c=Page&pagename=QnetPublic%2FPage%2FQnetTier2&cid=1228695266120.
12. American College of Emergency Physicians. Five things physicians and patients should question. 2013. Available at: http://www.choosingwisely.org/wp-content/uploads/2015/02/ACEP-Choosing-Wisely-List.pdf. Accessed August 29, 2017
13. Marin JR, Mills AM. Developing a research agenda to optimize diagnostic imaging in the emergency department: An executive summary of the 2015 academic emergency medicine consensus conference. *Acad Emerg Med.* 2015;22(12):1363-71.
14. American Board of Emergency Medicine. Patient care practice improvement (PI) activity. Available at: https://www.abem.org/public/abem-maintenance-of-certification-(moc)/moc-improvement-in-medical-practice/patient-care-practice-improvement-(pi)-activity/patient-care-practice-improvement-overview. Accessed August 29, 2017
15. Prevedello LM, Raja AS, Zane RD, et al. Variation in use of head computed tomography by emergency physicians. *Am J Med*. 2012;125(4):356-64.
16. Schuur JD, Brown MD, Cheung DS, et al. Assessment of medicare's imaging efficiency measure for emergency department patients with atraumatic headache. *Ann Emerg Med.* 2012;60(3):280-90.
17. Berdahl C, Schuur JD, Fisher NL, et al. Policy measures and reimbursement for emergency medical imaging in the era of payment reform: Proceedings from a panel discussion of the 2015 Academic

Emergency Medicine Consensus Conference. *Acad Emerg Med.* 2015;22(12):1393-9.

18. Kanaan Y, Knoepp UD, Kelly AM. The influence of education on appropriateness rates for CT pulmonary angiography in emergency department patients. *Acad Radiol.* 2013;20(9):1107-14.
19. Ferguson TB. The Institute of Medicine committee report “best care at lower cost: The path to continuously learning health care.” *Circ-Cardiovasc Qual Outcomes*. 2012;5(6):E93-4.
20. Fanikos J, Rao A, Seger AC, et al. Hospital costs of acute pulmonary embolism. *Am J Med.* 2013;126(2):127-32.
21. Troyer JL, Jones AE, Shapiro NI, et al. Cost-effectiveness of quantitative pretest probability intended to reduce unnecessary medical radiation exposure in emergency department patients with chest pain and dyspnea. *Acad Emerg Med.* 2015;22(5):525-35.
22. Kline JA, Jones AE, Shapiro NI, et al. Multicenter, randomized trial of quantitative pretest probability to reduce unnecessary medical radiation exposure in emergency department patients with chest pain and dyspnea. *Circ Cardiovasc Imaging.* 2014;7(1):66-73.
23. Patterson BW, Venkatesh AK, AlKhawam L, et al. Abdominal computed tomography utilization and 30-day revisitation in emergency department patients presenting with abdominal pain. *Acad Emerg Med*. 2015;22(7):803-10.
24. Patterson BW, Pang PS, AlKhawam L, et al. The association between use of brain CT for atraumatic headache and 30-day emergency department revisitation. *AJR Am J Roentgenol.* 2016;207(6):W117-W24.

Educator Toolkits on Second Victim Syndrome, Mindfulness and Meditation, and Positive Psychology: The 2017 Resident Wellness Consensus Summit

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Introduction: Burnout, depression, and suicidality among residents of all specialties have become a critical focus of attention for the medical education community.

Methods: As part of the 2017 Resident Wellness Consensus Summit in Las Vegas, Nevada, resident participants from 31 programs collaborated in the Educator Toolkit workgroup. Over a seven-month period leading up to the summit, this workgroup convened virtually in the Wellness Think Tank, an online resident community, to perform a literature review and draft curricular plans on three core wellness topics. These topics were second victim syndrome, mindfulness and meditation, and positive psychology. At the live summit event, the workgroup expanded to include residents outside the Wellness Think Tank to obtain a broader consensus of the evidence-based toolkits for these three topics.

Results: Three educator toolkits were developed. The second victim syndrome toolkit has four modules, each with a pre-reading material and a leader (educator) guide. In the mindfulness and meditation toolkit, there are three modules with a leader guide in addition to a longitudinal, guided meditation plan. The positive psychology toolkit has two modules, each with a leader guide and a PowerPoint slide set. These toolkits provide educators the necessary resources, reading materials, and lesson plans to implement didactic sessions in their residency curriculum.

Conclusion: Residents from across the world collaborated and convened to reach a consensus on high-yield—and potentially high-impact—lesson plans that programs can use to promote and improve resident wellness. These lesson plans may stand alone or be incorporated into a larger wellness curriculum. [West J Emerg Med. 2018;19(2)327-331.]

INTRODUCTION

Burnout, depression, and suicidality among residents across all specialties have become a critical focus of attention for the medical education community. Prevalence studies have revealed rates of burnout among residents to be as high as 76%, as measured by the Maslach Burnout Inventory (MBI).[1] Residents suffering from burnout have a higher risk than their peers of developing depression, anxiety, and substance-abuse problems.[2] Even more alarmingly, up to 9.4% of fourth-year medical students and interns reported having suicidal thoughts.[3] These numbers are borne out in the estimated 400 physicians who commit suicide each year.[4]

In response to these findings, the Accreditation Council for Graduate Medical Education (ACGME) approved major changes to the Common Program Requirements to begin in July 2017. In section VI.C, residency programs are mandated to educate residents and faculty members in the identification of burnout, depression, and substance abuse and to implement curricula that encourage their optimal wellbeing.[5] However, the ACGME has yet to provide residency programs with concrete guidelines for the creation of wellness curricula to adequately address this mandate.

Many residency programs have already implemented some form of wellness training for their residents. Unfortunately, evidence supporting the efficacy of these interventions is sparse and often limited to single institutions and small sample sizes.[6,7] Nor has the medical education community reached an agreement on the best method of identifying relevant and high-impact wellness topics for residents, or understanding the optimal method for delivery and dissemination of information.

Population Health Research Capsule

What do we already know about this issue?
Programs are now required to provide wellness education for residents. However, no concrete implementation guidelines currently exist for educators.

What was the research question?
What would happen if residents from across the world collaborated and reached consensus on strategies to help improve resident wellness?

What was the major finding of the study?
The outcome of the collaboration was the development of three comprehensive educator toolkits containing resources, reading materials, and lesson plans.

How does this improve population health?
These toolkits address three topics – second victim syndrome, meditation, and positive psychology – identified by residents as important to their education, and provide concrete guidelines for educators to implement curricula.

METHODS

From October 3, 2016, to May 14, 2017, members of the Wellness Think Tank communicated through a shared online platform (#Slack) to discuss the strengths and weaknesses of the wellness programs at their respective training sites. The Think Tank is a virtual community of practice, hosted by a medical education organization Academic Life in Emergency Medicine, which is comprised of 142 emergency medicine (EM) residents from 100 different training programs in North America. Multiple residents noted a haphazard and ineffective approach to teaching wellness topics, which they attributed primarily to a lack of shared knowledge between residency programs. Residents voiced a clear need for more widely-shared lesson plans that focus on the development of practical skills fostering personal wellness.

In preparation for the 2017 Resident Wellness Consensus Summit (RWCS) in-person event on May 15, 2017, an Educator Toolkit working group was created. Using a group consensus process, the residents of the Wellness Think Tank selected and agreed upon three high-yield topics that would benefit educators as an evidence-based, robust resource: second victim syndrome (SVS), mindfulness and meditation, and positive psychology. Each toolkit was designed using Kern's six-step model of curriculum design, active teaching techniques, and accountability to increase engagement. Representing 20 different programs, 8, 16, and 17 residents participated in the development of the SVS, mindfulness and meditation, and positive psychology educator toolkits, respectively. Two faculty members (A.C., N.B.) trained in educational theory, one with a master's degree in medical education, provided oversight.

Twenty-two resident members of the Wellness Think Tank and 22 additional residents attended the live RWCS event. These residents represented 31 EM residency programs located in three different countries. Five faculty members facilitated the event. Members of the Educator Toolkit working group presented their drafts to the RWCS consensus group for review. There, participants discussed the proposed topics, learning objectives, and teaching techniques for each of the three topics. Following the RWCS, each educator toolkit was further refined based on the feedback, which resulted in the final versions presented here.

RESULTS

Three educator toolkit resources were developed through a consensus achieved among residents in the Wellness Think Tank and the live RWCS event over an eight-month period. The three topics include SVS, mindfulness and meditation, and positive psychology. These resources are open access and available in Appendices A-C.

Second Victim Syndrome

A phenomenon growing in national awareness,[8–10] SVS is commonly defined as feelings of guilt, inadequacy, or incompetence following an unexpected, negative patient outcome. Commonly manifesting as anxiety, depression or shame, it often goes unrecognized. It is likely that most healthcare providers experience symptoms of SVS at least once in their careers and the emotional "wear-and-tear" may contribute to burnout, the decision to depart from clinical medicine, or even suicide.[8,11,12] Victims of SVS may require assistance from mentors, colleagues, or mental health professionals to cope with the frequently intense, negative personal and professional ramifications of the experience.[13,14] Awareness of the existence of SVS is critical for residents and faculty so that they may develop strategies to mitigate the negative effects in both themselves and their colleagues.

Despite its relevance across specialties, and especially EM, no published residency curricula discuss SVS. Our toolkit aims to fill that education gap to ensure that residents are prepared for the emotional and professional toll from inevitable negative patient outcomes that will occur during their careers.

To maximize learner engagement and provide flexibility for residency programs, this toolkit includes four "mini-modules" using a flipped-classroom approach (Appendix A). Each module consists of a pre-reading assignment followed by a 20-minute group discussion. Pre-reading establishes a basic knowledge base for the learners and encourages personal reflection prior to the classroom session. Group discussions aid in the practical incorporation of that knowledge into the residents' practice. It is recommended that the four modules be spaced over several months to maximize retention of the material via spaced repetition.[16] The mini-modules may also be combined into a single 60-90 minute session to accommodate didactic conference schedules.

The first module exposes learners to the concept of SVS, as well as potential stages of recovery. This module emphasizes establishing a foundation of knowledge pertaining to SVS, laying the groundwork for later modules to introduce practical tools and concepts for coping with and preventing SVS. The second module describes a method to help recognize SVS in colleagues. Residents and faculty are encouraged to help colleagues identify when they are suffering from SVS and to help create an appropriate follow-up plan. In addition, a method for performing a "hot debriefing" is described, which occurs immediately following a significant mistake or negative patient outcome. The third module serves to make learners aware of resources that are available at their individual institution and encourages learners to access them prior to being affected by SVS. Finally, the fourth module focuses on department-wide prevention of SVS through culture change and the use of routine, group debriefings following difficult resuscitations.[17-21] A standardized post-resuscitation debriefing template is introduced.

Mindfulness and Meditation

Mindfulness is the practice of purposeful and nonjudgmental attentiveness to one's own experience, thoughts, and feelings. Meditation is a technique for resting the mind and attaining a state of consciousness that is distinctly different from the normal waking state. A regular practice of meditation can provide a lasting sense of mindfulness that lasts throughout the day. Both mindfulness and meditation have become more mainstream and socially acceptable ways to manage stress and increase productivity. Within the field of medicine, research has shown that being mindful or developing a meditation practice improves job satisfaction and decreases burnout.[22] Multiple studies have demonstrated benefits to mindfulness and meditation, such as increased empathy, life satisfaction and self-compassion, and decreased anxiety, rumination, and burnout, and decreased cortisol levels.[23] Because EM residents stand to benefit tremendously from these effects, we determined that mindfulness and meditation were important as a wellness toolkit for educators.

Although mindfulness and meditation have become more integrated into some medical schools, these concepts are not frequently found in residency training programs.[24] We developed a mindfulness and meditation lesson plan to address this gap. Our educator toolkit consists of three 30-minute modules and a longitudinal, guided group meditation practice designed to span several months or an academic year.

The two initial modules outline and define meditation, as well as describe how to start a meditation practice. These modules include an opportunity to practice meditating as a group, an invitation to start an individual practice, and a chance to discuss barriers to practice. Ideally, these modules would be offered during the first month of the academic year, separated by one to four weeks. Following the second module, a longitudinal, guided meditation practice should be incorporated at regular intervals (weekly, monthly or quarterly) throughout the residency conference schedule. The final module should be implemented toward the end of the academic year following the longitudinal meditations. This module provides the residents a forum to debrief and reflect on their practices of meditation and

mindful thinking, cultivated throughout the year. It also serves as a chance to consider and evaluate how meditation and mindfulness have impacted individual residents, the residency program, and the department.

Positive Psychology

Positive psychology is the conscious participation in acts to improve wellbeing by creating and nurturing positive feelings, thoughts, and behaviors. In contrast to traditional psychology, which focuses on mitigating illness, positive psychology focuses on the strengths that allow individuals to thrive.[25] Use of positive psychology interventions has been shown to improve wellbeing and decrease depressive symptoms.[26-28] Positive psychology interventions can serve as a useful tool to improve team dynamics and success in stressful situations such as trauma resuscitations.[29] Practicing gratitude, positive self-talk, and intentional acts of kindness have the potential to make emotionally difficult shifts more tolerable and improve physician-patient interactions.

Despite the literature describing the benefits of positive psychology, similar to SVS and mindfulness and meditation, we found no described use of a positive psychology curriculum for residents. To address this gap, we developed a flexible and easy-to-implement positive psychology toolkit, focusing on two positive psychology principles, PERMA (Positive Emotions, Engagement, Relationships, Meaning, Accomplishment) and BTSF (Breathe, Talk, See, Focus). Although these positive psychology principles can be taught together as a two-part, positive psychology lesson plan, each can also be given as a stand-alone session.

PERMA is an evidence-based model for wellbeing that can help residents to more fully engage with their work and thrive in their careers.[30] The PERMA toolkit includes a slide set presentation, brainstorming period, and both paired and group discussion over a period of 50 minutes. The slide set provides a basic introduction to positive psychology, followed by a more detailed description of the PERMA model. Interactive audience participation during the slide presentation is encouraged. A brainstorming activity in pairs and in a larger group follows the slide presentation. The session concludes with a "commitment to act," an exercise in which the learners write down one specific thing that they plan to do differently based on their participation.

BTSF is a skill that can be quickly taught to residents and used in a wide variety of settings. This technique helps an individual cope with an acute stressor by employing one or all four of the following: (1) tactical or box breathing; (2) positive self-talk; (3) visualizing success; and (4) stating or intentionally thinking a specific focus word to hone attention.[31] Similar to the PERMA lesson plan, the BTSF session includes a slide set presentation, active group discussion, and an acute stressor exercise for participants to practice BTSF in a simulated stressful environment over a period of 45 minutes. The slide set specifically describes each of the components of BTSF and concludes with a tactical breathing exercise. The conclusion of the BTSF lesson plan is an acute stressor exercise. We suggest using the children's game, Operation (© Hasbro), or other similar game to simulate stress while practicing the BTSF model. The lesson plan also concludes with a "commitment to act" exercise.

DISCUSSION

The 2017 Resident Wellness Consensus Summit was convened with the ultimate mission to empower EM residents from around the world to lead efforts aimed at decreasing burnout, depression, and suicidality during residency and to increase resident wellbeing. Leading up to the event, many residents collaborated in the Wellness Think Tank over an eight-month period to conduct much of the consensus event prework. Specifically our Educator Toolkit working group focused on developing three widely-applicable, high-yield lesson plans for EM residency programs on the topics of SVS, mindfulness and meditation, and positive psychology.

The lesson plans may stand alone or be incorporated into a larger wellness program. The three toolkits differ in length, scope, and duration for the individual sessions. This design provides greater flexibility for residency programs to schedule into their existing training curriculum. For example, programs with limited time or resources may find a single 45-minute session on positive psychology easier to incorporate than a year-long curriculum that includes classroom sessions and monthly guided meditations, as described in the mindfulness and meditation toolkit.

In an effort to address widespread burnout and unwellness, our goal is for these three topics to be widely covered and implemented by residency programs through the use of these templated lesson plans. Each toolkit provides instruction on practical skills training that can be used on a daily basis, both within and outside of the emergency department. Next steps include measuring the effects of these lesson plans on resident satisfaction, learning, behavior change, and ultimately patient outcomes, as well as burnout, resilience, and job satisfaction.

CONCLUSION

The 2017 Resident Wellness Consensus Summit was a unique and novel consensus event, particularly because its main audience was resident stakeholders. As a product of this wellness summit, three comprehensive lesson plans were developed for resident education on the topics of second victim syndrome, mindfulness and meditation, and positive psychology. These educator toolkit resources were developed through the consensus and collaboration of residents in the Wellness Think Tank and those who attended the live RWCS event.

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REFERENCES

1. Thomas NK. Resident burnout. *JAMA*. 2004;292(23):2880-9.
2. Maslach C, Schaufeli WB, Leiter MP. Job burnout. *Annu Rev Psychol*. 2001;52:397-422.
3. Goebert D, Thompson D, Takeshita J, et al. Depressive symptoms in medical students and residents: a multischool study. *Acad Med*. 2009;84(2): 236-41.
4. Andrew LB, Brenner BE. Physician suicide. *Medscape*. 2017. Available at: http://emedicine.medscape.com/article/806779-overview. Accessed on July 27, 2017.
5. Summary of Changes to ACGME Common Program Requirements Section VI. Accreditation Council for Graduate Medical Education. Available at: http://www.acgme.org/What-We-Do/Accreditation/Common-Program-Requirements/Summary-of-Proposed-Changes-to-ACGME-Common-Program-Requirements-Section-VI. Accessed August 7, 2017.
6. Williams D, Tricomi G, Gupta J, et al. Efficacy of burnout interventions in the medical education pipeline. *Acad Psychiatry.* 2015;39(1):47-54.
7. Raj KS. Well-being in residency: a systematic review. *J Grad Med Educ*. 2016;8(5):674-84.
8. Clancy CM. Alleviating "second victim" syndrome: how we should handle patient harm. *J Nurs Care Qual*. 2012;27(1):1-5.
9. Wu AW. Medical error: the second victim. The doctor who makes the mistake needs help too. *BMJ*. 2000;320(7237):726-7.
10. Edrees H, Connors C, Paine L, et al. Implementing the RISE second victim support programme at the Johns Hopkins Hospital: a case study. *BMJ Open*. 2016;6(9):e011708.
11. Scott SD, Hirschinger LE, Cox KR, et al. The natural history of recovery for the healthcare provider "second victim" after adverse patient events. *Qual Saf Health Care*. 2009;18(5):325-30.
12. Seys D, Scott S, Wu A, et al. Supporting involved health care professionals (second victims) following an adverse health event: a literature review. *Int J Nurs Stud*. 2013;50(5):678-87.
13. Scott SD, Hirschinger LE, Cox KR, et al. Caring for our own: deploying a systemwide second victim rapid response team. *Jt Comm J Qual Patient Saf*. 2010;36(5):233-40.
14. Denham CR. TRUST: The 5 rights of the second victim. *J Patient Saf*. 2007;3(2):107-19.
15. Daniels RG, McCorkle R. Design of an evidence-based "second victim" curriculum for nurse anesthetists. *AANA J*. 2016;84(2):107-13.
16. Stahl SM, Davis RL, Kim DH, et al. Play it again: the master psychopharmacology program as an example of interval learning in bite-sized portions. *CNS Spectr*. 2010;15(8):491-504.
17. Cho SJ. Debriefing in pediatrics. *Korean J Pediatr*. 2015;58(2):47-51.
18. Couper K, Perkins GD. Debriefing after resuscitation. *Curr Opin Crit Care*. 2013;19(3):188-94.
19. Kessler DO, Cheng A, Mullan PC. Debriefing in the emergency department after clinical events: a practical guide. *Ann Emerg Med*. 2015;65(6):690-8.
20. Ireland S, Gilchrist J, Maconochie I. Debriefing after failed paediatric resuscitation: a survey of current UK practice. *Emerg Med J*. 2008;25(6):328-30.
21. Salas E, Klein C, King H, et al. Debriefing medical teams: 12 evidence-based best practices and tips. *Jt Comm J Qual Patient Saf*. 2008;34(9):518-27.
22. Beach MC, Roter D, Korthuis PT, et. al. A multicenter study of physician mindfulness and health care quality. *Ann Fam Med*. 2013;11(5):421-8.
23. Irving JA, Dobkin PL, Park J. Cultivating mindfulness in health care professionals: a review of empirical studies of mindfulness-based stress reduction (MBSR). *Complement Ther Clin Pract*. 2009;15(2):61-6.
24. Rosenzweig S, Reibel DK, Greerson JM, et al. Mindfulness-based stress reduction lowers psychological distress in medical students. *Teach Learn Med.* 2003;15:88–92.
25. Seligman ME, Csikszentmihalyi M. Positive psychology. An introduction. *Am Psychol*. 2000;55(1):5-14.
26. Sin NL, Lyubomirsky S. Enhancing well-being and alleviating depressive symptoms with positive psychology interventions: a practice-friendly meta-analysis. *J Clin Psychol* 2009;65:467–87.
27. Bolier L, Haverman M, Westerhof GJ, et al. Positive psychology interventions: a meta-analysis of randomized controlled studies. *BMC Public Health*. 2013;13:119.
28. Lauria MJ, Rush S, Weingart SD, et al. Potential role for psychological skills training in emergency medicine: Part 1 - Introduction and background. *Emerg Med Australas*. 2016;28:607–10.
29. Lorello G, Hicks C, Ahmed S, et al. Mental practice: A simple tool to enhance team-based trauma resuscitation. *CJEM*. 2016;18(2):136-42.
30. Slavin SJ, Schindler D, Chibnall JT, et al. PERMA: A model for institutional leadership and culture change. *Acad Med*. 2012;87(11):1481.
31. Lauria M, Gallo I, Rush, S, et al. Psychological skills to improve emergency care providers' performance under stress. *Ann Emerg Med*. 2017;[Epub ahead of print].

Executive Summary from the 2017 Emergency Medicine Resident Wellness Consensus Summit

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Introduction: Physician wellness has recently become a popular topic of conversation and publication within the house of medicine and specifically within emergency medicine (EM). Through a joint collaboration involving Academic Life in Emergency Medicine's (ALiEM) Wellness Think Tank, Essentials of Emergency Medicine (EEM), and the Emergency Medicine Residents' Association (EMRA), a one-day Resident Wellness Consensus Summit (RWCS) was organized.

Methods: The RWCS was held on May 15, 2017, as a pre-day event prior to the 2017 EEM conference in Las Vegas, Nevada. Seven months before the RWCS event, pre-work began in the ALiEM Wellness Think Tank, which was launched in October 2016. The Wellness Think Tank is a virtual community of practice involving EM residents from the U.S. and Canada, hosted on the Slack digital-messaging platform. A working group was formed for each of the four predetermined themes: wellness curriculum development; educator toolkit resources for specific wellness topics; programmatic innovations; and wellness-targeted technologies.

Results: Pre-work for RWCS included 142 residents from 100 different training programs in the Wellness Think Tank. Participants in the actual RWCS event included 44 EM residents, five EM attendings who participated as facilitators, and three EM attendings who acted as participants. The four working groups ultimately reached a consensus on their specific objectives to improve resident wellness on both the individual and program level.

Conclusion: The Resident Wellness Consensus Summit was a unique and novel consensus meeting, involving residents as the primary stakeholders. The summit demonstrated that it is possible to galvanize a large group of stakeholders in a relatively short time by creating robust trust, communication, and online learning networks to create resources that support resident wellness. [West J Emerg Med. 2018;19(2)332-336.]

INTRODUCTION

Physician wellness has recently become a popular topic of conversation and publication within the house of medicine and specifically within emergency medicine (EM).[1,2,3,4,5] Multiple major organizations in EM have tackled the issue of physician wellness and burnout, including the 2017 Emergency Medicine Wellness and Resiliency Summit that convened key leaders from those organizations. The purpose of this summit

was to identify areas of overlap and synergy so that collaborative projects and possibly best practices could be established for emergency physician wellness.[6]

National organizations, such as the Accreditation Council on Graduate Medical Education, have recently placed a high priority on resiliency and wellness in trainees.[7] Similar efforts have been undertaken by the American Medical Association,[8] the American College of Emergency Physicians,[9] and the American Academy of Emergency Medicine.[10] Mirroring recent literature showing that emergency physicians are at particularly high risk of burnout syndrome,[11] the rate of burnout among trainees is as high as 60%.[12]

Several recent studies have identified factors associated with increased resiliency[13,14] with one meta-analysis demonstrating several interventions associated with increased resiliency and lower incidence of burnout syndrome in graduate medical education.[15] No literature, however, has focused exclusively on the high-risk burnout population of EM residents. Through a joint collaboration involving Academic Life in Emergency Medicine's (ALiEM) Wellness Think Tank, Essentials of Emergency Medicine (EEM), and the Emergency Medicine Residents' Association (EMRA), a one-day Resident Wellness Consensus Summit (RWCS) was organized. This summit primarily convened a group of essential stakeholders to the conversation, EM residents, to clarify the present state of wellness initiatives among EM training programs, and potentially identify best practices and tangible tools to increase physician wellness. To our knowledge, this is the first national consensus event of its kind comprised primarily of residents focusing on resident wellness.

METHODS

Pre-Conference Preparation

Seven months before the RWCS event, pre-work began in the ALiEM Wellness Think Tank, which was launched in October 2016. The Wellness Think Tank is a virtual community of practice involving EM residents from 100 different training programs in the U.S. and Canada, hosted on the Slack digital-messaging platform (Slack Technologies). A core mission of the community was to convene EM residents in a way that allowed for cross-institutional communication and collaboration. A working group was formed for each of the four themes: wellness curriculum development; lesson plans for specific wellness topics; programmatic innovations; and wellness-targeted technologies. Ideas, conversations, and materials were shared with the broader Wellness Think Tank community ahead of the conference to inform consensus opinions.

RWCS Event

The RWCS was held on May 15, 2017, as a pre-day event prior to the 2017 EEM conference in Las Vegas, Nevada. The event was promoted on EEM's home page, ALiEM blog, the Council of Emergency Medicine Residency Directors and EMRA email listservs, Twitter, and Facebook. Participants in the RWCS included 44 EM residents, including three residents in Fiji. In addition, five EM attendings participated as facilitators and thre EM attendings acted as participants (Table 1). Twenty-two of 44 participants were not part of the Wellness Think Tank, and these participants provided new perspectives to inform the pre-work already done.

The five-hour event was divided between large-group presentations and small-group working time for the four consensus groups. The timeline is outlined in Figure 1. On the day of the event, updates were provided to the public via Twitter through the hashtag #RWCS.

RESULTS

Each of the four working groups worked for seven months leading up to the one-day RWCS event to develop tangible resources that residency programs could use to improve wellness on both the group and individual level. At the summit, the small groups spent their time focusing on creating a consensus for each of the resources. The following is a brief summation of the work from each group.

Wellness Curriculum Development

The group addressed the overwhelming request by residents in the Wellness Think Tank for a formal wellness curriculum within residency training programs. After an extensive search of the existing literature on physician wellness, resiliency, and burnout, a preliminary framework for a longitudinal and comprehensive curriculum was developed. During the summit, the working-group members reviewed the

Table. Demographic data on members of the Wellness Think Tank (WTT) and the Resident Wellness Consensus Summit.

	Wellness Think Tank	Resident Wellness Consensus Summit (WTT/non-WTT members)
Number of residents	142	44 (22/22)
Number of unique residency programs represented by residents	100	31 (30/1)
Number of attendings	12	8 (5/3)

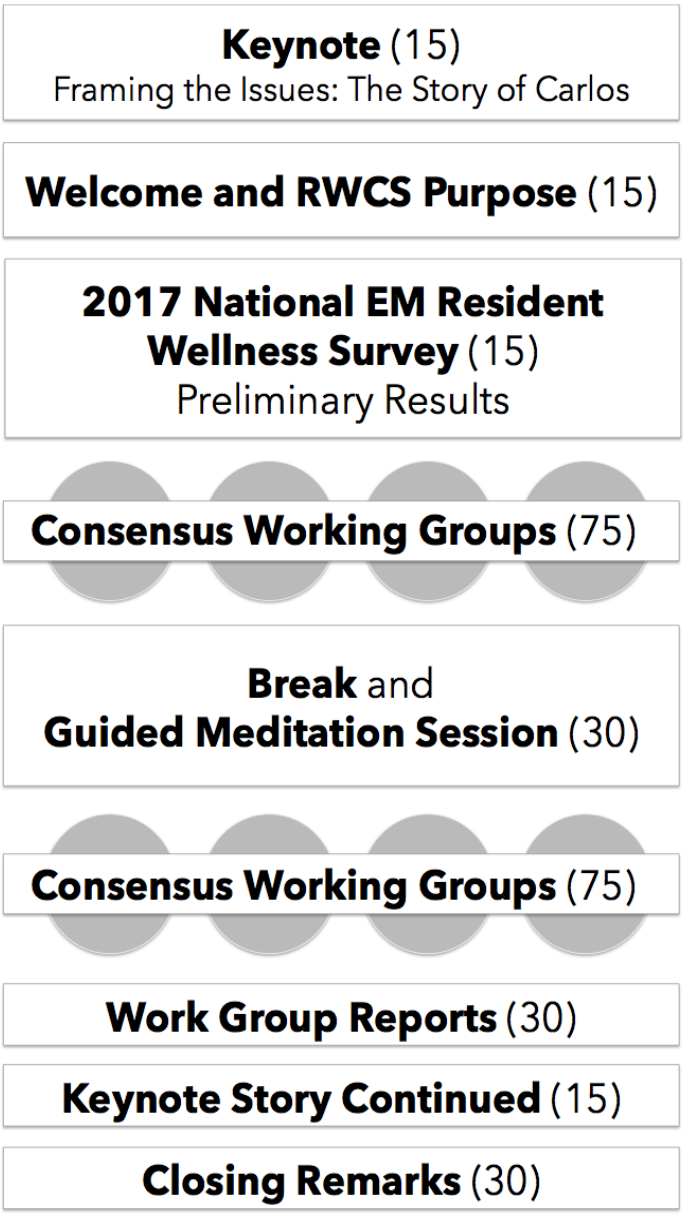

Figure. Segmented timeline of Resident Wellness Consensus Summit event and allotted time for each segment in parentheses (minutes).

framework and recommendations. Several additional critical topics were added, including cultivating workplace wellness, dealing with difficult patients and staff, developing a support network of non-physicians, and debriefing. [WestJEM ref on RWCS Wellness Curriculum]

Educator Toolkit for Specific Wellness Topics

Three different, comprehensive lesson plans were developed: Second Victim Syndrome, Mindfulness and Meditation, and Positive Psychology. These lesson plans focus on practical skills for residents that could be used by training programs either individually or as part of a larger wellness curriculum. During the RWCS event, the working group standardized these curricular resources to ensure that they all included active learning and that sessions lasted no more than 30 minutes. Each lesson plan concludes with a "commitment to act," which adds an essential element of personal accountability for residents. [WestJEM ref on RWCS Educator Toolkit]

Programmatic Innovations

Prior to the RWCS event, this small group attempted to collect a wide range of different wellness activities, resources, and ideas that had been used by residency programs across North America. During this process, it became evident that there was a diverse approach to programmatic initiatives to address each program's unique needs. During the RWCS, in addition to cataloging the initiatives the working-group members developed a resident-level, needs assessment tool and a program-level, structured planning tool. [WestJEM ref on RWCS Innovations]

Wellness-Targeted Technologies

A plethora of apps and other technologies focus on wellness. This group downloaded and experimented with various digital tools that tracked their steps, sleep, meditation, food habits, exercise routines, and daily mood. The focus was to identify the most relevant and practical resource for residents to maintain their wellness and resiliency. At the RWCS event, the working group collated the resources, created themes, added supplemental information for each resource (e.g. cost, platform compatibility, screenshot images), and finalized the database list.

DISCUSSION

The RWCS event is the first step of a transformative, cultural journey focusing on resident health and wellbeing. To our knowledge, this is the first time that residents from across the world collaborated and convened to reach a consensus on these critical issues. The tools developed by the four RWCS working groups will serve as a resource for resident health and wellbeing leaders looking to influence clinical learning environments at the local organizational level for the future. Working at an organizational level is foundational but not sufficient for cultural transformation. An additional paradigm to look at resident health and wellbeing is through the paradigm of a social movement, which the Wellness Think Tank and RWCS event embody.

Veteran organizer and policy expert Marshall Ganz describes four elements necessary to lead successful social movements: relationships, story, strategy, and action.[16] The Wellness Think Tank and RWCS have made inroads in relationships and story, and will hopefully catalyze strategy and action to ensure that resident health and wellbeing becomes a successful social movement.

Relationships

The RWCS leadership team had experience working within the ALiEM culture prior to the RWCS. This led to the development of the Wellness Think Tank to congregate a critical mass of EM residents into a virtual community. Mirroring the ALiEM culture, the Think Tank's culture was based on deep, reciprocal relationships that complement knowledge transactions. These relationships are facilitated by trust,[17] communication, [18,19] and personal learning networks[20] that allow for exponential growth. The networks developed have both strong ties that facilitate commitment and motivation, and weak ties that facilitate entry into new networks and domains.[21] The relationships that the Wellness Think Tank and RWCS created will fuel the networks needed to implement a successful resident health and wellbeing social movement in the future.

Story

Leading up to the RWCS event, invited EM faculty members recorded their own wellness stories. These podcast recordings were paired with blog posts discussing central wellness issues on the ALiEM website. The purpose of these stories was to normalize conversations around physician wellness and to promote an open dialogue leading up to the RWCS.

Furthermore, stories served as anchors and tangible reminders throughout the RWCS event of how resident wellness is a timely and critical issue today, especially in EM. The summit was launched with a story about a resident suicide as told by the resident's program director. As with many stories, the RWCS was presented with a challenge (residents are burned out and committing suicide), a choice (how can the RWCS influence residents and the clinical learning environment?), and a desired outcome (increase the health and wellbeing of residents). At the RWCS conclusion, the aftermath of the resident suicide was shared with the participants.

Strategy

The RWCS event was a unique and novel consensus meeting, involving residents as the primary stakeholders. Additionally, this summit was able to involve a greater number and wider array of participants due to the way in which the pre-work was done. A virtual community of practice, the Wellness Think Tank, was created on a digital messaging application (Slack) to allow for asynchronous collaboration for much of the summit pre-work. Using a virtual platform allowed 142 resident members across North America to engage in the process and provide feedback. In addition to the RWCS pre-work, this community also served as a means for residents to collaborate and educate themselves in various facets of wellbeing. The live event hosted 22 Think Tank members and 22 new resident participants. Involving new participants gave the working groups the opportunity for new feedback and additional input while developing their consensus projects. Next steps include disseminating the resources developed by the small groups and integrating these tools into local residency programs.

Action

Our hope is that the residents who participated in the Wellness Think Tank and RWCS event will embrace their involvement in this grassroots movement to improve physician wellness. The group agreed that there should be a focus on developing community and open communication among physicians discussing the stressors and challenges faced by physicians in training. The RWCS has shown that it is possible to galvanize a large group of stakeholders in a relatively short time by creating robust trust, communication, and learning networks to create specific learning and tools to support resident wellness. We are hopeful that resident wellness will become a successful social movement.

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REFERENCES

1. Kasten J. Resident Burnout: Not just for the "long hours" specialties. *Acad Med*. 2017;92(7):904-5.
2. Obara SA. Moral of the story: combating burnout and apathy. *Acad Med*. 2017;92(7):902-3.

3. Shanafelt T, Swensen S. Leadership and physician burnout: using the annual review to reduce burnout and promote engagement. *Am J Med Qual*. 2017;32(5):563-5.
4. Gulen B, Serinken M, Eken C, et al. Serum S100B as a surrogate biomarker in the diagnoses of burnout and depression in emergency medicine residents. *Acad Emerg Med*. 2016;23(7):786-9.
5. Shanafelt TD, Hasan O, Dyrbye LN, et al. Changes in burnout and satisfaction with work-life balance in physicians and the general US working population between 2011 and 2014. *Mayo Clin Proc.* 2015;90(12):1600-13.
6. Ross PA. Physician Wellness and Resiliency Summit Report. American College of Emergency Physicians website. Available at: https://www.acep.org/_Wellness-Section-Microsite/Physician-Wellness-and-Resiliency-Summit-Report. Accessed on June 28, 2017.
7. Physician well-being. Accreditation Council for Graduate Medical Education website. Available at: https://www.acgme.org/What-We-Do/Initiatives/Physician-Well-Being. Accessed on June 28, 2017.
8. AMA: Steps Forward. Available at: https://www.stepsforward.org/modules?category=wellbeing. Accessed on June 28, 2017.
9. American College of Emergency Physicians website. Available at: https://www.acep.org/emwellnessweek. Accessed June 28, 2017.
10. Wellness Committee. American Academy of Emergency Medicine website. Available at: http://www.aaem.org/about-aaem/leadership/committees/wellness-committee. Accessed on June 28, 2017.
11. Shanafelt TD, Boone S, Tan L, et al. Burnout and satisfaction with work-life balance among US physicians relative to the general US population. *Arch Intern Med*. 2012;172(18):1377-85.
12. Dyrbye LN, West CP, Satele D, et al. Burnout among U.S. medical students, residents, and early career physicians relative to the general U.S. population. *Acad Med.* 2014;89(3):443-51.
13. Raj KS. Well-being in residency: a systematic review. *J Grad Med Educ.* 2016;8(5):674-84.
14. McCann CM, Beddoe E, McCormick K, et al. Resilience in the health professions: a review of recent literature. *International Journal of Wellbeing.* 2013;3(1):60-81.
15. Busireddy KR, Miller JA, Ellison K, et al. Efficacy of interventions to reduce resident physician burnout: a systematic review. *J Grad Med Educ.* 2017 ;9(3):294-301.
16. Ganz M. Leading Change (2010). *Handbook of leadership theory and practice*. Boston, MA: Harvard Business Press.
17. Ankel F, Hanson L. Building Trust: More Oxytocin, Less Epinephrine. International Clinician Educators blog. 2017. Available at: https://icenetblog.royalcollege.ca/2015/11/24/building-trust-more-oxytocin-less-epinephrine/. Accessed on July 2, 2017.
18. Ankel F, Lin M. Building effective communication networks – Part I: home bases, embassies, and outposts. International Clinician Educators blog. 2017. Available at: https://icenetblog.royalcollege.ca/2016/04/05/building-effective-communication-networks-part-i-home-bases-embassies-and-outposts/. Accessed on July 2, 2017.
19. Ankel F, Lin M. Building effective communication networks, part II: more nerve conduction, less bone conduction. International Clinician Educators blog. 2017. Available at: https://icenetblog.royalcollege.ca/2016/04/12/building-effective-communication-networks-part-ii-more-nerve-conduction-less-bone-conduction/. Accessed on July 2, 2017.
20. Ankel F, Swaminathan S. Personal learning networks: a hack to maintain competence. International Clinician Educators blog. 2017. Available at: https://icenetblog.royalcollege.ca/2015/10/02/personal-learning-networks-a-hack-to-maintain-competence/. Accessed on July 2, 2017.
21. Granovetter MS. The strength of weak ties. *American Journal of Sociology*. 1973;78(6):1360-80.

An Evidence-based, Longitudinal Curriculum for Resident Physician Wellness: The 2017 Resident Wellness Consensus Summit

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Introduction: Physicians are at much higher risk for burnout, depression, and suicide than their non-medical peers. One of the working groups from the May 2017 Resident Wellness Consensus Summit (RWCS) addressed this issue through the development of a longitudinal residency curriculum to address resident wellness and burnout.

Methods: A 30-person (27 residents, three attending physicians) Wellness Curriculum Development workgroup developed the curriculum in two phases. In the first phase, the workgroup worked asynchronously in the Wellness Think Tank – an online resident community – conducting a literature review to identify 10 core topics. In the second phase, the workgroup expanded to include residents outside the Wellness Think Tank at the live RWCS event to identify gaps in the curriculum. This resulted in an additional seven core topics.

Results: Seventeen foundational topics served as the framework for the longitudinal resident wellness curriculum. The curriculum includes a two-module introduction to wellness; a seven-module "Self-Care Series" focusing on the appropriate structure of wellness activities and everyday necessities that promote physician wellness; a two-module section on physician suicide and self-help; a four-module "Clinical Care Series" focusing on delivering bad news, navigating difficult patient encounters, dealing with difficult consultants and staff members, and debriefing traumatic events in the emergency department; wellness in the workplace; and dealing with medical errors and shame.

Conclusion: The resident wellness curriculum, derived from an evidence-based approach and input of residents from the Wellness Think Tank and the RWCS event, provides a guiding framework for residency programs in emergency medicine and potentially other specialties to improve physician wellness and promote a culture of wellness. [West J Emerg Med. 2018;19(2)337-341.]

INTRODUCTION

Many recent academic and popular publications have highlighted the fact that physicians are at much higher risk for burnout, depression, and suicide than the general population of the United States. Data from the National Violent Death Reporting System indicate that each year more than 200 physicians in the U.S. commit suicide.[1] Medical students and residents are at especially high risk.[2] Furthermore, emergency physicians are consistently ranked at the top of most burnt-out doctors.[3] This dark problem was recently brought to the

forefront in an email written to the Council of Emergency Medicine Residency Directors by Dr. Christopher Doty, the residency program director at the University of Kentucky, detailing his tragic loss of a resident and its effects on the residency and broader hospital community.

The Accreditation Council for Graduate Medical Education (ACGME) has included the mandate that residency programs address resident wellness within the Common Program Requirements. Emergency medicine (EM) residency programs are now required to provide education to residents and faculty on burnout, depression and substance abuse and are instructed to implement curricula to encourage optimal wellbeing. In 2016 a group of 142 EM residents from across the world began discussing ways to address this issue through the Wellness Think Tank, a virtual community of practice focusing on resident wellness. Members shared personal stories of hardship, identified obstacles to wellness, and brainstormed solutions to this multifaceted problem. This online collaboration also served as the virtual platform to asynchronously collaborate on pre-work for the inaugural Resident Wellness Consensus Summit (RWCS) in Las Vegas, NV, on May 15, 2017.[4] One of the working groups was to develop a structured, longitudinal, residency curriculum based on the existing literature to address resident wellness and burnout. Herein we report the consensus recommendation of the Wellness Curriculum Development working group.

METHODS

The wellness curriculum was developed in two phases. During the first phase, members of the Wellness Curriculum Development working group in the Wellness Think Tank collectively performed an extensive literature search, targeting articles that focused on resident wellness, physician wellness, and previous wellness initiatives. These articles were divided up among the group members and carefully evaluated. They found 21 relevant articles. Individual curricular initiatives were categorized by theme.[1-3,5-7,9-23] These themes informed the initial framework of 10 core topics for the curriculum. For each topic, a sub-team conducted a deeper analysis before providing a description of the module, recommended approach, and additional resources and recommended readings.

The second phase of curriculum development occurred at the RWCS event. Members of the Wellness Curriculum Development workgroup presented the proposed curriculum to other summit attendees for feedback and further evaluation. This working group had a total of 30 members, 27 residents and three attending physicians. The resident cohort of this group specifically contained 15 Wellness Think Tank members, an additional 12 non-Think Tank residents. At the summit, there was consensus that the initial 10 topics were necessary components for the curriculum. Gaps, however, were identified and through further discussion, an additional seven topics were added. Each topic was subsequently reviewed after the RWCS for a final total of 17 modules for the resident physician wellness curriculum.

RESULTS

After a literature search and the RWCS event, we identified 17 foundational topics to incorporate into the resident physician wellness curriculum (Table). Topics were chosen that contribute to personal wellness, with a focus specifically for the EM resident. All of these topics are intended to consist of a short, large-group lecture and small-group breakout sessions. The full curriculum resource, which includes relevant technologies from the Wellness Technologies working group, is outlined in the Appendix.

Introduction

The curriculum is meant to launch at the start of the academic year. The first module, "Introduction to Wellness," focuses on the definition of wellness, a preview of the different components of the curriculum, and what residents should ideally gain from the curriculum. The following "Why Wellness Matters" module examines the concept of burnout and the associated statistics. During this portion of the curriculum, residency training programs should conduct burnout screening for each resident.

Self-Care Series

This seven-part series focuses on everyday necessities that promote physician self-care and wellness. It begins with a qualitative look at wellness activities that physicians perform to maintain their overall wellbeing. This is supported by current literature showing the priority of activities that physicians who display wellness find most important. These include sleep, nutrition, physical fitness, financial health, mindfulness, and having a support network. Specifically for the mindfulness module, another RWCS workgroup created educator toolkits on positive psychology and mindfulness/meditation, which can be incorporated in this section.[4] Each module further delves into specific challenges unique to emergency physicians.

Physician Suicide

This two-module block focuses on the facts and realities of physician suicide. When age-matched with peers from other professions, physicians are at significant risk for suicide.[5] These modules open the discussion on screening for physician suicide for others and oneself, possible resources for intervention, and long-term follow up. Importantly it also provides more exposure to this topic to help normalize the conversation in a respectful and psychologically safe environment.[6]

Clinical Care Series

This four-part series focuses on the following high-stress activities that resident physicians encounter in the emergency department (ED): delivering bad news, managing difficult patient encounters, managing difficult consultants and staff members, and debriefing traumatic events. Because delivering bad news to patients and their families can produce high levels

Table. A longitudinal 17-module physician wellness curriculum for emergency medicine residents.

Topic	Description
1. Introduction to Wellness	Introduction to physician wellness and burnout, the longitudinal wellness curriculum, and a breakout session for interns on "Transitioning to Residency"
2. Why Wellness Matters	Building awareness on burnout, depression and mental health issues in physicians, and that wellness is not the absence of distress
3. Self-Care Series: Wellness Activities of Physicians	A discussion of how physicians stay well through relationships, religion and spirituality, self-care, work, and approach to life
4. Self-Care Series: Sleep	Education on sleep hygiene, scheduling, and practical tips for the shift-based emergency physician life
5. Self-Care Series: Nutrition	Education on the basics of nutrition and how to eat a healthy, balanced diet, particularly for people with busy lifestyles
6. Self-Care Series: Physical Fitness	Education on the basics and scientifically proven benefits of physical fitness, as well as how to get started on an exercise program
7. Self-Care Series: Financial Health	Overview of the basics of budgeting, living within your means, and tackling student loan debt; breakout session recommended specifically for graduating senior residents
8. Self-Care Series: Mindfulness and Reflection	Overview of the concept, scientifically-proven benefits, unwarranted stigma, and practice of mindfulness for the busy resident physician
9. Self-Care Series: Building Your Support Network	Discussion about the importance of a support network for the resident, especially a mentorship program, in promoting wellness and building resiliency
10. Physician Suicide	Education on risk factors for depression and suicide specific to physicians, and how to recognize them in yourself
11. "I Need Help"	Education on how to get mental health help for oneself, with a focus on systems that ensure confidentiality
12. Clinical Care Series: Delivering Bad News	Education for resident physicians on how to deliver bad news to patients and their families
13. Clinical Care Series: Dealing with Difficult Patients	Education on how to appropriately manage difficult patient encounters with evidence-based recommendations for success
14. Clinical Care Series: Dealing with Difficult Consultants and Staff	Education on how to appropriately and professionally interact with difficult consultants and staff members
15. Clinical Care Series: Debriefing Traumatic Events in the Emergency Department	Education about debriefing techniques following significant events in the emergency department to ensure a collective, safe, guided reflection of the event
16. Wellness in the Workplace	Discussion about how individual wellness depends on the supportive workplace wellness culture
17. Dealing with Medical Errors and Shame	Education on how residents can cope with medical errors in a healthy fashion to minimize feelings of inadequacy, shame, and burnout

of real-time and ongoing anxiety for the resident, one module focuses on these stressful conversations. A framework is provided to help them navigate these conversations. Difficult patient encounters can also put undue strain onto the emergency physician. One module thus focuses on dealing with difficult patients, specifically identifying triggers and creating preformed responses while also maintaining physician empathy and the physician-patient relationship.

Such preparation often leads to better patient care and less physician burnout.[7] In the same way that a difficult patient can lead to decreased physician happiness and satisfaction, so can a bad interaction with a consultant or staff member. This module focuses on practical strategies to keep these encounters professional, positive, and effective. The last topic in this series is debriefing traumatic events that occur in the ED. Practical tips are outlined to overcome many of the barriers to conduct these guided group reflections. Within this last module, one might incorporate a discussion of the second victim syndrome, which is an educator toolkit developed by one of the RWCS workgroups.[4] This phenomenon, whereby a healthcare provider is traumatized by an unanticipated, adverse, patient-related event, is an important but often under-recognized problem facing emergency physicians.

Miscellaneous Topics

The last two modules included are no less important. The first addresses the wellness culture within the workplace. Basic on-shift physician wellness needs (e.g., bathroom break, meal,

snack) rely on a supportive culture. It should not be viewed as a sign of weakness to take care of one's basic human needs. Not caring for oneself will ultimately hamper patient care at a time when patients need us working at our very best.

The second module focuses on dealing with medical errors and shame. To err is human, and all physicians will make mistakes. Dealing with the natural feelings of inadequacy and shame in a healthy and constructive manner promotes learning and growth, rather than self-destructive responses and harmful behaviors.

DISCUSSION

The term "physician wellness" has many definitions, and might best be defined as "one's personal recipe for thriving" and not just surviving.[8] It is not, however, merely the absence of burnout, depression, or suicide. Teaching this concept during residency training is an ideal time to address physician wellness. This is especially crucial for EM residents, because EM as a specialty has the highest rate of burnout per the Maslach Burnout Inventory.[3] These new physicians can develop healthy mindset practices, coping skills, and work-life balance habits that they will use throughout their careers.

The proposed 17-topic wellness curriculum focuses on the spectrums of wellness and burnout in a modular fashion, as framed by the existing literature. Based on residency program needs, these modules can be rearranged. Alternatively, suggested materials from some/all of the modules can be emailed to residents to serve as self-study resources.

One study demonstrated that discussing and reflecting on wellness topics in small groups has positive downstream effects. West et al. performed a randomized clinical trial in which all participating physicians were given paid time off to work on aspects of wellness.[9] The intervention arm met in a small group for one hour every two weeks to discuss wellness topics, while the control arm had no formal intervention. The study found that empowerment and engagement at work significantly increased in the intervention arm, and decreased in the control arm. They also found that rates of overall burnout, emotional exhaustion, and depersonalization in the intervention arm dropped substantially and only decreased slightly in the control arm. Thus, a formal wellness curriculum during residency training, if done well, has the potential to make a lasting positive impact on resident wellness. The recent mandate from ACGME to address resident wellness in the Common Program requirements is an important step towards improving resident wellness. Ultimately, a multi-pronged approach toward improving resident wellness will be needed and must include systemic changes in order to reach its full potential.

CONCLUSION

In the past few years, much light has been shed on the colossal topic of wellness, specifically that physicians are at a high risk of suicide and emergency physicians rank highest for physician burnout.[1,3] The RWCS event was created to address this issue specifically at the level of graduate medical education for EM residents. Through pre-work by the Wellness Think Tank community and consensus discussions at the live RWCS event in the Wellness Curriculum Development workgroup, an evidence-based, 17-module, longitudinal, wellness curriculum was designed for EM residency programs. Many of these modules may be applicable for residency programs in other specialties, as well as the broader physician community. As we receive feedback from residency programs, we hope to continually revise and reshape the curriculum with the overarching goal of helping to advance the culture of wellness during residency training beyond one of survival to one of thriving.

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REFERENCES

1. Gold KJ, Sen A, Schwenk TL. Details On suicide among US physicians: data from the National Violent Death Reporting System. *Gen Hosp Psychiatry.* 2013;35(1):45-9.
2. Dyrbye LN, West CP, Satele D, et al. Burnout among US medical students, residents, and early career physicians relative to the general population. *Acad Med*. 2014;89(3):443-51.
3. Shanafelt TD. Changes In burnout and satisfaction with work-life

balance in physicians and the general US working population between 2011 And 2014. *Mayo Clin Proc.* 2015;90(12):1600-13.
4. Battaglioli N, Ankel F, Doty C, et al. An Executive Summary from the 2017 Resident Wellness Consensus Summit. WestJEM manuscript - in press.
5. Downs N, Feng W, Kirby B, et al. Listening To depression and suicidal risk in medical students: the Healer Education Assessment And Referral (HEAR) program. *Acad Psychiatry.* 2014;38(5):547-53.
6. Moutier C, Norcross W, Jong P, et al. The Suicide Prevention And Depression Awareness Program at the University of California, San Diego School of Medicine. *Acad Med.* 2012;87(3):320-6.
7. Sandikci KB, Ustu Y, Sandikci MM, et al. Attitudes and behaviors of physicians in dealing with difficult patients and relatives: a cross-sectional study in two training and research hospitals. *Turk J Med Sci*. 2017;47(1):222-33.
8. Drummond D. Physician Wellness Definition – Thriving vs. Surviving. The Happy MD website. Available at: https://www.thehappymd.com/blog/bid/290733/Physician-Wellness-Definition-Thriving-vs-Surviving. Accessed on August 6, 2017.
9. West CP, Dyrbye LN, Rabatin JT, et al. Intervention to promote physician well-being, job satisfaction, and professionalism: a randomized clinical trial. *JAMA Intern Med*. 2014;174(4):527-33.
10. Weiner EL, Swain GR, Wolf B, et al. A qualitative study of physicians' own wellness-promotion practices. *West J Med*. 2001;174:19-23.
11. Rubin R. Recent suicides highlight need to address depression in medical students and residents. *JAMA.* 2014;312(17):1725-7.
12. Williams D, Tricomi G, Gupta J, et al. Efficacy of burnout interventions in the medical education pipeline. *Acad Psychiatry*. 2004;39:47-54.
13. Sen S, Kranzler HR, Krystal JH, et al. A prospective cohort study investigating factors associated with depression during medical internship. *Arch Gen Psychiatry*. 2010;67(6):557-65.
14. Levey RE. Sources of stress for residents and recommendations for programs to assist them. *Acad Med*. 2001;76(2):142-50.
15. Ey S, Moffit M, Kinzie JM, et al. "If you build it, they will come": attitudes of medical residents and fellows about seeking services in a resident wellness program. *J Grad Med Educ*. 2013;5(3):486-92.
16. Shanafelt TD, Sloan JA, Habermann TM. The well-being of physicians. *Am M Med*. 2003;114:513-9.
17. Wallace JE, Lemaire JB, Ghali WA. Physician wellness: a missing quality indicator. *Lancet*. 2009;374:1714-21.
18. Salles A, Liebert CA, Greco RS. Promoting balance in the lives of resident physicians: a call to action. *JAMA Surgery*. 2015;150(7):607-8.
19. Ishak WW, Lederer S, Mandili C, et al. Burnout during residency training: a literature review. *J Grad Med Educ.* 2009;1(2):236-42.
20. Brazeau CM, Shanfelt T, Durning SJ, et al. Distress among matriculating medical students relative to the general population. *Acad Med.* 2014;89(11):1520-5.
21. Center C, Davis M, Detre T, et al. Confronting Depression and Suicide in Physicians: A Consensus Statement. *JAMA*. 2003;289(23):3161-6.
22. West CP, Shanafelt TD, Kolars JC. Quality of life, burnout, educational debt, and medical knowledge among internal medicine residents. *JAMA*. 2011;306(9):952-60.
23. Daskivich TJ, Jardine DA, Tseng J, et al. Promotion of wellness and mental health awareness among physicians in training: perspective of a national, multispecialty panel of residents and fellows. *J Grad Med Educ*. 2015;7(1):143-7.

Identifying Gaps and Launching Resident Wellness Initiatives: The 2017 Resident Wellness Consensus Summit

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Introduction: Burnout, depression, and suicidality among residents of all specialties have become a critical focus for the medical education community, especially among learners in graduate medical education. In 2017 the Accreditation Council for Graduate Medical Education (ACGME) updated the Common Program Requirements to focus more on resident wellbeing. To address this issue, one working group from the 2017 Resident Wellness Consensus Summit (RWCS) focused on wellness program innovations and initiatives in emergency medicine (EM) residency programs.

Methods: Over a seven-month period leading up to the RWCS event, the Programmatic Initiatives workgroup convened virtually in the Wellness Think Tank, an online, resident community consisting of 142 residents from 100 EM residencies in North America. A 15-person subgroup (13 residents, two faculty facilitators) met at the RWCS to develop a public, central repository of initiatives for programs, as well as tools to assist programs in identifying gaps in their overarching wellness programs.

Results: An online submission form and central database of wellness initiatives were created and accessible to the public. Wellness Think Tank members collected an initial 36 submissions for the database by the time of the RWCS event. Based on general workplace, needs-assessment tools on employee wellbeing and Kern's model for curriculum development, a resident-based needs-assessment survey and an implementation worksheet were created to assist residency programs in wellness program development.

Conclusion: The Programmatic Initiatives workgroup from the resident-driven RWCS event created tools to assist EM residency programs in identifying existing initiatives and gaps in their wellness programs to meet the ACGME's expanded focus on resident wellbeing. [West J Emerg Med. 2018;19(2)342-345.]

INTRODUCTION

Burnout, depression, and suicidality among residents of all specialties have become a critical focus of attention for the medical education community. Prevalence studies have revealed rates of burnout among residents to be as high as 76% as measured by the Maslach Burnout Inventory (MBI).[1] In response to these findings, the Accreditation Council for Graduate Medical Education (ACGME)

approved major changes to the Common Program Requirements in 2017. These changes establish a mandate to educate residents and faculty members in the identification of burnout, depression, and substance abuse and for implementing programs that encourage optimal resident and faculty wellbeing.[2] There are however, no roadmaps or guidelines for residency programs to create such wellness programs to adequately address this mandate.

Many residency programs have already implemented wellness training and initiatives for their residents. Unfortunately, evidence supporting the efficacy of these interventions is sparse and often limited to single institutions and small sample sizes.[3,4] Furthermore, there is no established method of sharing preliminary experiences and lessons learned from these interventions with other residency programs also seeking to improve their wellness curricula.

The 2017 Resident Wellness Consensus Summit (RWCS)[5] convened as a pre-day to a national emergency medicine (EM) conference, Essentials of Emergency Medicine, to address many aspects of resident wellness and burnout. One of the working groups, Programmatic Initiatives, focused specifically on starting an online, crowdsourced, central repository of wellness initiatives in EM residency programs. Additionally, the working group aimed to develop a resident-based needs assessment and implementation instrument to assist programs launch their own wellness programs.

METHODS

In October 2016 a volunteer group of 142 EM residents from 100 training programs across North America formed the Wellness Think Tank, a virtual community of practice focusing specifically on resident wellness. All EM residency programs in North America were invited to enroll up to two EM residents as representatives in the Think Tank. Members of this online community, hosted by a medical education organization Academic Life in Emergency Medicine (ALiEM), communicated with each other using the online platform #Slack. On this shared workspace platform, members discussed the strengths and weaknesses of wellness programs at their respective training sites. During these discussions, residents noted duplicated efforts at different programs and a siloed approach to wellness initiatives, which they attributed primarily to a lack of shared knowledge among residency programs.

All participating residents of the Wellness Think Tank as well as the broader EM resident population in the United States were invited to the in-person RWCS event on May 15, 2017 (Las Vegas, NV).[5] In preparation for the event, a Programmatic Initiatives working group was created within the Wellness Think Tank to develop an initial, centralized, crowdsourced database of existing wellness strategies in EM residency programs. Members of the Wellness Think Tank and the Chief Resident Incubator, another virtual community of practice hosted by ALiEM, were asked to contribute submissions about their local wellness strategies, specifically describing the resources required, whether the initiative or event was child-friendly, and practical implementation tips. A total of 22 resident members from the Wellness Think Tank, and 22 additional EM residents attended the live RWCS event. Of the 44 residents, 13 residents (as well as two faculty facilitators selected by the ALiEM leadership team for their facilitation expertise) served as the final Programmatic Initiatives working group. At the RWCS event, the working group reviewed the residency program initiatives in the database and developed two tools for residency programs – a resident-based, needs-assessment tool to identify gaps in wellness programming and a systematic worksheet to help programs implement new wellness initiatives. Following the RWCS event, the database and tools were further refined based on feedback, ideas, and comments from the Wellness Think Tank resulting in the final versions presented here.

RESULTS

The Programmatic Initiatives working group identified an initial 36 unique residency wellness initiatives, collected from the Wellness Think Tank and Chief Resident Incubator communities. These initiatives are listed in a centralized, searchable, online database open to the public along with a contributor form for future submissions at https://www.aliem.com/wellness-think-tank/wellness-initiatives-database/.

The working group also developed two tools. The first tool is a Resident-Based Needs Assessment Survey on residency wellness programming (Appendix A). This survey should be administered to individual residents to inform programwide strategic planning on wellness activities. This tool was created based on a framework modeled after existing needs-assessment tools on employee wellness in the general workplace.[6,7] The resident needs assessment systematically evaluates the current wellness initiatives in a program, existing wellness interests of the residents, the perception of the culture of wellness, and leadership support for wellness activities. Open-ended questions were included throughout the survey to capture suggestions or further input from residents to encourage creative responses and novel ideas. Although some programs may have a wellness program already in place, the tool can still be used on a yearly basis to help programs adjust based on evolving resident needs.

The second tool (Worksheet on Implementing New Wellness Initiatives) is a systematic worksheet to help residency programs implement new wellness initiatives (Appendix B). Using the principles from Kern's six-step model for curriculum development,[8] the worksheet is

divided into two parts. Part I explores existing resources and previous experiences with wellness initiatives in one's program and at the broader institutional level in a targeted, needs-assessment approach. Part II then focuses on building one, new wellness initiative or strategy. This guides readers to familiarize themselves with stakeholders and potential obstacles to implementation by addressing educational strategies, resource identification, implementation barriers, and outcome measures. Unanswered questions should be addressed before investing time and resources to the initiatives. A sample completed worksheet on developing a resident mentorship program is also included as a guide.

DISCUSSION

Although physicians of all specialties are at increased risk of depression and suicide, emergency physicians are among those at greatest risk.[9-13] Furthermore, burnout rates are high for medical students, residents, and early-career physicians across specialties.[14] To address this, the resident-driven 2017 RWCS event and 2016-17 Wellness Think Tank community focused on developing a consensus on various wellness issues and problems deemed high priority by EM residents. Through online discussions leading up to the RWCS event, residents realized multiple instances of duplicated wellness initiatives at different programs with little to no sharing of their experiences. Thus, the Programmatic Initiatives working group first focused on identifying and publicly sharing existing wellness activities in EM residency programs. The group also assisted programs launching new wellness initiatives and strategies. Our hope is that these collective resources serve as a framework for EM residency programs seeking guidance in meeting the 2017 ACGME Common Program Requirement mandate to build a robust infrastructure and educational strategy to address resident and faculty wellbeing.[2]

CONCLUSION

The Programmatic Initiatives working group for an EM resident-driven consensus conference tackled the specific issues of sharing existing wellness initiatives and creating instruments to help residency programs thoughtfully plan and implement new wellness initiatives.

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REFERENCES

1. Thomas NK. Resident burnout. *JAMA*. 2004;292(23):2880-9.
2. Accreditation Council for Graduate Medical Education. Common Program Requirements, Section VI, with Background and Intent. 2017. Available at: http://www.acgme.org/Portals/0/PFAssets/ProgramRequirements/CPRs_Section%20VI_with-Background-and-Intent_2017-01.pdf. Accessed on August 9, 2017.
3. Williams D, Tricomi G, Gupta J, et al. Efficacy of burnout interventions in the medical education pipeline. *Acad Psychiatry*. 2015;39(1):47-54.
4. Raj KS. Well-being in residency: a systematic review. *J Grad Med Educ*. 2016;8(5):674-84.
5. Battaglioli N, Ankel F, Doty C, et al. An executive summary from the 2017 Resident Wellness Consensus Summit. *WestJEM* manuscript (in press).
6. Needs Assessment/Survey Tools. Project Health. Available at: http://www.projecthealth.ca/understanding-workplace-health/needs-assessmentsurvey-tools. Accessed on July 1, 2017.
7. Step 3: Needs assessment. Queensland Government. Available at: https://workplaces.healthier.qld.gov.au/getting-started/step-three-needs-assessment/. Accessed on July 2, 2017.
8. Thomas PA, Kern DE, Hughes MT, et al. Curriculum development for medical education: a six-step approach. Baltimore: Johns Hopkins University Press, 2016.
9. Center C, Davis M, Detre T, et al. Confronting depression and suicide in physicians: a consensus statement. *JAMA*. 2003;289(23):3161-6.
10. Shanafelt TD, Boone S, Tan L, et al. Burnout and satisfaction with work-life balance among US physicians relative to the general US population. *Arch Intern Med*. 2012;172(18):1377-85.
11. Peckham C. Medscape Lifestyle Report 2017: Race and Ethnicity, Bias and Burnout. *Medscape*. Available at: http://www.medscape.com/features/slideshow/lifestyle/2017/overview#page=1. Accessed on August 21, 2017.
12. Gold KJ, Sen A, Schwenk TL. Details On suicide among US physicians: data from the National Violent Death Reporting System. *Gen Hosp Psychiatry*. 2013;35(1):45-9.

13. Shanafelt TD. Changes In Burnout and satisfaction with work-life balance in physicians and the general US working population between 2011 and 2014. *Mayo Clin Proc*. 2015;90(12):1600-13.

14. Dyrbye LN, West CP, Satele D, et al. Burnout among U.S. medical students, residents, and early career physicians relative to the general U.S. population. *Acad Med*. 2014;89(3):443-51.

Thromboprophylaxis for Patients with High-risk Atrial Fibrillation and Flutter Discharged from the Emergency Department

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Introduction: Many patients with atrial fibrillation or atrial flutter (AF/FL) who are high risk for ischemic stroke are not receiving evidence-based thromboprophylaxis. We examined anticoagulant prescribing within 30 days of receiving dysrhythmia care for non-valvular AF/FL in the emergency department (ED).

Methods: This prospective study included non-anticoagulated adults at high risk for ischemic stroke (ATRIA score ≥7) who received emergency AF/FL care and were discharged home from seven community EDs between May 2011 and August 2012. We characterized oral anticoagulant prescribing patterns and identified predictors of receiving anticoagulants within 30 days of the index ED visit. We also describe documented reasons for withholding anticoagulation.

Results: Of 312 eligible patients, 128 (41.0%) were prescribed anticoagulation at ED discharge or within 30 days. Independent predictors of anticoagulation included age (adjusted odds ratio [aOR] 0.89 per year, 95% confidence interval [CI] 0.82-0.96); ED cardiology consultation (aOR 1.89, 95% CI [1.10-3.23]); and failure of sinus restoration by time of ED discharge (aOR 2.65, 95% CI [1.35-5.21]). Reasons for withholding anticoagulation at ED discharge were documented in 139 of 227 cases (61.2%), the most common of which were deferring the shared decision-making process to the patient's outpatient provider, perceived bleeding risk, patient refusal, and restoration of sinus rhythm.

Conclusion: Approximately 40% of non-anticoagulated AF/FL patients at high risk for stroke who presented for emergency dysrhythmia care were prescribed anticoagulation within 30 days. Physicians were less likely to anticoagulate older patients and those with ED sinus restoration. Opportunities exist to improve rates of thromboprophylaxis in this high-risk population. [West J Emerg Med. 2018;19(2)346-360.]

INTRODUCTION

Atrial fibrillation (AF) and atrial flutter (AFL) independently increase the risk of ischemic stroke five-fold and account for an estimated 15% of ischemic strokes.[1] For this reason, stroke prevention is one of the leading management objectives in the long-term care of patients with AF or AFL (AF/FL), regardless of rhythm duration or permanence.[2-5] Validated thromboembolism risk scores exist to help readily identify the high-risk AF/FL population that would benefit from long-term anticoagulation.[6-9] Nevertheless, underuse of thromboprophylaxis persists nationally and internationally, in large measure because physicians incorrectly assess levels of risks and benefits.[10-19]

Non-anticoagulated patients with AF/FL commonly seek rhythm-related care in the emergency department (ED).[15,20-22] AF patients who present for emergency care have a higher incidence of stroke and death than patients seen in other venues.[23] In some settings, more than half of AF patients discharged from the ED fail to achieve outpatient follow-up within 90 days of discharge, regardless of insurance status.[24] In such cases, an ED visit may provide a critical opportunity for a stroke-prevention intervention. Such encounters may also serve as a sentinel event for those at high risk for stroke, facilitating important changes in their health behavior.[25-30] Physicians can seize on such teachable moments to educate high-risk AF/FL patients on stroke risk and prevention and, when appropriate, to recommend or prescribe anticoagulation.[15, 31]

Initiating anticoagulation at the time of ED discharge for stroke-prone patients does not increase bleeding rates and contributes to decreased mortality.[32] Some patients, however, might prefer to have this shared decision-making conversation with a provider aware of their values and preferences, e.g., a primary care provider or cardiologist.[3] Nevertheless, emergency physicians (EP) are an important link in the chain of multi-specialty care coordination for the stroke-prone AF/FL population—whether they initiate the discussion of thromboprophylaxis or actually prescribe anticoagulation.[33,34]

The initiation of thromboprophylaxis to ED patients with AF/FL at high risk for stroke has not been extensively studied. The literature that exists, however, demonstrates under-prescribing in countries around the world.[12, 15, 20, 35-37] The prescribing practices in U.S. community EDs, however, are not well understood.

We undertook a multicenter, prospective, observational study to evaluate the anticoagulation practice patterns of community EPs and short-term, post-ED care providers in the management of patients with non-valvular AF/FL considered at high risk for ischemic stroke. We also sought to identify factors influencing initiation of oral anticoagulation. We hypothesized that increasing age, lack of cardiology involvement in the patient's ED care, and restoration of sinus rhythm before ED discharge would decrease the likelihood of receiving an oral anticoagulant prescription. Lastly, we reviewed the electronic health records of the patients discharged without anticoagulation to evaluate documented reasons for withholding anticoagulation and provision of educational material on AF/FL stroke risk and prevention.

Population Health Research Capsule

What do we already know about this issue?
Oral anticoagulation can reduce strokes by two-thirds in patients with non-valvular atrial fibrillation or flutter (AF/FL), yet many high-risk patients remain untreated.

What was the research question?
What is the incidence of anticoagulation initiation within 30 days of emergency AF/FL care for high stroke- risk patients?

What was the major finding of the study?
Only 41% of untreated high-risk patients received an anticoagulant prescription at ED discharge or in the following 30 days.

How does this improve population health?
Multidisciplinary efforts to reduce strokes in high-risk AF/FL patients will need to address physician misunderstandings of anticoagulation risks and benefits and improve patient education.

METHODS

The study was approved by the Kaiser Permanente Northern California (KPNC) Institutional Review Board. Waiver of informed consent was obtained due to the observational nature of the study.

Study Design and Setting

This study was a sub-analysis of a prospective observational study (TAFFY, Treatment of AF/FL in the emergencY department).[38] The source population was based within KPNC, a large integrated healthcare delivery system that provides comprehensive medical care for four million members across 21 medical centers. KPNC members

represent approximately 33% of the population in areas served and are highly representative of the local surrounding and statewide population.

Emergency care was provided by emergency medicine residency-trained and board-certified (or board-prepared) EPs. During the study period (May 2011 to August 2012), the annual census of each of the seven EDs ranged from 25,000 to 78,000. No departmental policies were in place at the participating EDs to govern the short-term anticoagulation management of patients with AF/FL. Patient care was left to the discretion of the treating EPs.

All facilities had pharmacy services available around-the-clock for discharge medications and supplemental patient education. Oral anticoagulation medications in use within KPNC during the study period were warfarin and dabigatran, warfarin being the drug of choice at the time. Furthermore, each facility had its own pharmacy-managed, phone-based Outpatient Anticoagulation Service that managed outpatient warfarin use and provided close follow-up and monitoring of these patients, akin to similar programs in other KP regions in the U.S.[39, 40] The percent time in therapeutic range for the international normalized ratio during the study period varied by facility and ranged from 70% to 74%, calculated with a six-month look-back period using the Rosendaal linear interpolation method.[41]

Selection of Participants

In the TAFFY study, adult (≥18 years) KPNC health plan members in the ED with electrocardiographically-confirmed non-valvular AF/FL were eligible for prospective enrollment if their atrial dysrhythmia fell into any one of these three categories: (1) symptomatic AF/FL; (2) AF/FL requiring ED treatment for rate or rhythm control; or (3) the first known electrocardiographically-documented episode of AF/FL (that is, newly diagnosed). Patients were ineligible if they were transferred in from another ED, were receiving only palliative comfort care, had an implanted cardiac pacemaker/defibrillator, or had been resuscitated from a cardiac arrest in the ED or just prior to arrival. The treating EPs enrolled patients via convenience sampling and were provided a small token of appreciation for their bedside data collection. No research assistants facilitated enrollment.

This anticoagulation study included TAFFY patients who were (1) not taking oral anticoagulants at the time of ED presentation; (2) at high risk for thromboembolic complications based on a validated thromboembolism risk score; and (3) discharged home directly from the ED. Only a patient's first enrollment was included in this analysis. We used the validated Anticoagulation and Risk Factors in Atrial Fibrillation (ATRIA) stroke risk score (see below) to identify our AF/FL population at high risk for thromboembolism, as it has been shown to be more accurate than the $CHADS_2$ or CHA_2DS_2-VASc stroke risk scores.[9, 42, 43]

Methods and Measurements

TAFFY variables collected prospectively at the time of patient care included presenting symptoms; characterization of the atrial dysrhythmia (AF, AFL, or both; new, first-time diagnosis; physician's impression of clinical category [intermittent/recurrent; chronic/sustained, 24/7; unclear]; recent onset of rhythm-related symptoms [<48 hours]); comorbid diagnoses; ED management (rate reduction, attempted cardioversion); cardiology consultation; discharge rhythm and discharge pharmacotherapy. To minimize the effect that structured data collection might have on stroke prevention and to improve the odds of describing real-world behavior, the physician education material and data collection tool mentioned none of the following: hemorrhage risk, thromboembolic risk, risk scoring, indications for anticoagulation, post-ED follow-up care, or this study's objectives and hypotheses. We undertook monthly manual chart review audits at each medical center to identify cases that were TAFFY-eligible but had not been enrolled to assess potential selection bias between the enrolled and missed-eligible populations.

After completion of the enrollment period, we extracted additional demographic and clinical variables from the health system's comprehensive integrated electronic health record. These included additional patient characteristics and oral anticoagulation prescription, prescriber, and outpatient follow-up within 30 days of ED discharge.

Stroke Risk

We retrospectively calculated the ATRIA stroke risk score from structured data in the comprehensive electronic health record using definitions of score variables from the original derivation and validation studies.[9] The ATRIA stroke risk score uses weighted scoring based on points assigned for age, prior history of ischemic stroke, female gender, diabetes mellitus, chronic heart failure, hypertension, known proteinuria, and estimated glomerular filtration rate <45 ml/min/1.73 m^2 or end-stage renal disease treated with dialysis or kidney transplant (Table 1).[9] Patients with an ATRIA score ≥7 were categorized as high risk.

Bleeding Risk

We characterized predicted bleeding risk using a modified HAS-BLED score.[44, 45] HAS-BLED is an acronym for hypertension (uncontrolled, >160 mmHg systolic), abnormal renal/liver function (one point for presence of renal or liver impairment, maximum two points), stroke (previous history, particularly lacunar), bleeding history or predisposition (anemia), labile international normalized ratio (INR) (i.e., therapeutic time in range <60%), elderly (>65 years), drugs or alcohol (antiplatelet agents, nonsteroidal anti-inflammatory drugs; one point for drugs plus one point for alcohol excess, maximum two points). Patients with a HAS-BLED risk score of ≥3 were deemed at high risk for bleeding. We modified the

Table 1. ATRIA stroke risk score components and point assignment for adults with atrial fibrillation.[9]

Risk factor	Points assigned*
Age, yr	
≥85, with prior ischemic stroke	9
75 to 84, with prior ischemic stroke	7
65 to 74, with prior ischemic stroke	7
<65, with prior ischemic stroke	8
≥85, without prior ischemic stroke	6
75 to 84, without prior ischemic stroke	5
65 to 74, without prior ischemic stroke	3
Female gender	1
Diabetes mellitus	1
Chronic heart failure	1
Hypertension	1
Proteinuria	1
eGFR<45 ml/min/1.73 m^2 or end-stage renal disease	1

ATRIA, Anticoagulation and Risk Factors in Atrial Fibrillation; *eGFR,* estimated glomerular filtration rate.
* A total point score for a given patient corresponds with the following risk classes: 0-5 points, low risk; 6 points, moderate risk; 7-15 points, high risk.

HAS-BLED score slightly to accommodate retrospective identification of structured variables in the electronic health record (see Table A.1, in the online appendix).[46]

Manual Chart Review

We undertook a structured manual chart review of the ED provider notes and discharge instructions for patients discharged home without anticoagulation. We identified physician and patient reasons for not starting anticoagulation. We noted also if patient education material on AF/FL, which included a mention of the association of these dysrhythmias with thromboembolic events, was included in the printed discharge instructions. We entered our findings directly into a standardized electronic data collection instrument, modified to its final form after pilot testing. The physician abstractors received training on data collection methods and were not blinded to the study objectives. The principal investigator answered and arbitrated coding questions until consensus was formed, and monitored data collection activities. A random sample of cases (10%) was selected for independent review to assess documentation of reasons for anticoagulation non-prescribing and presence of patient education material on AF/FL at ED discharge.

Outcomes

Our primary outcome was a new oral anticoagulation prescription ordered by either the EP at the index ED discharge or a subsequent provider within 30 days of the index ED visit. We captured all prescription orders of anticoagulants in our comprehensive pharmacy databases. Our secondary outcomes were the reason for withholding anticoagulation documented in the EP's note for patients discharged without anticoagulation and inclusion of AF/FL patient education material in the printed discharge instructions.

Statistical Analysis

We conducted all analyses using SAS statistical software, version 9.31 (Cary, N.C.). A two-tailed p value of less than 0.05 was considered significant. We compared characteristics between those enrolled and not enrolled in the study, as well as groups with and without anticoagulation initiation in the study, using chi-square tests for categorical variables and t-tests or Wilcoxon rank-sum tests for continuous variables. Univariate logistic regression models for the outcome of receipt of anticoagulants within 30 days of the index AF/FL visit identified possible predictors. After running a fully saturated adjusted model, we retained predictors that were significant ($p<0.05$) along with age, gender, and race/ethnicity to generate a final multivariable model estimating odds ratios and 95% confidence intervals. We measured interrater reliability for chart-reviewed variables using both percent agreement and an unweighted kappa statistic.

RESULTS

Among 2,849 identified eligible patients, 1,980 (69.5%) were enrolled by the treating physicians in the parent TAFFY study. Enrolled and non-enrolled patients were comparable in terms of age, gender, comorbidity, and stroke risk scores, except that enrolled patients were more likely to have had a history of prior diagnosed AF/FL (see Table A.2, in the online appendix). For the present analysis, we excluded 906 enrolled patients (45.8%) who were not discharged home directly from the ED or were not KP health plan members at enrollment, 252 patients (23.5%) who were already taking anticoagulation therapy and 510 patients (62.0%) who were not high risk for thromboembolism (ATRIA score <7) (Figure). The remaining 312 AF/FL patients constituted our study cohort. While selected for the study based on their ATRIA score, all study patients were also found to be high risk using the CHA_2DS_2-VASc score (≥2 points).[7] Overall, median age was 80 years (interquartile range, 76 to 85), and 201 (64.4%) cohort members were women.

Oral anticoagulants were prescribed to 128 patients (41.0%) within 30 days of the index ED visit, with 85 patients (27.2%) receiving a new anticoagulant prescription at the time of ED discharge and the remaining 43 patients (13.7%) in the following 30 days. In this sample, warfarin was the only oral anticoagulant prescribed. During the post

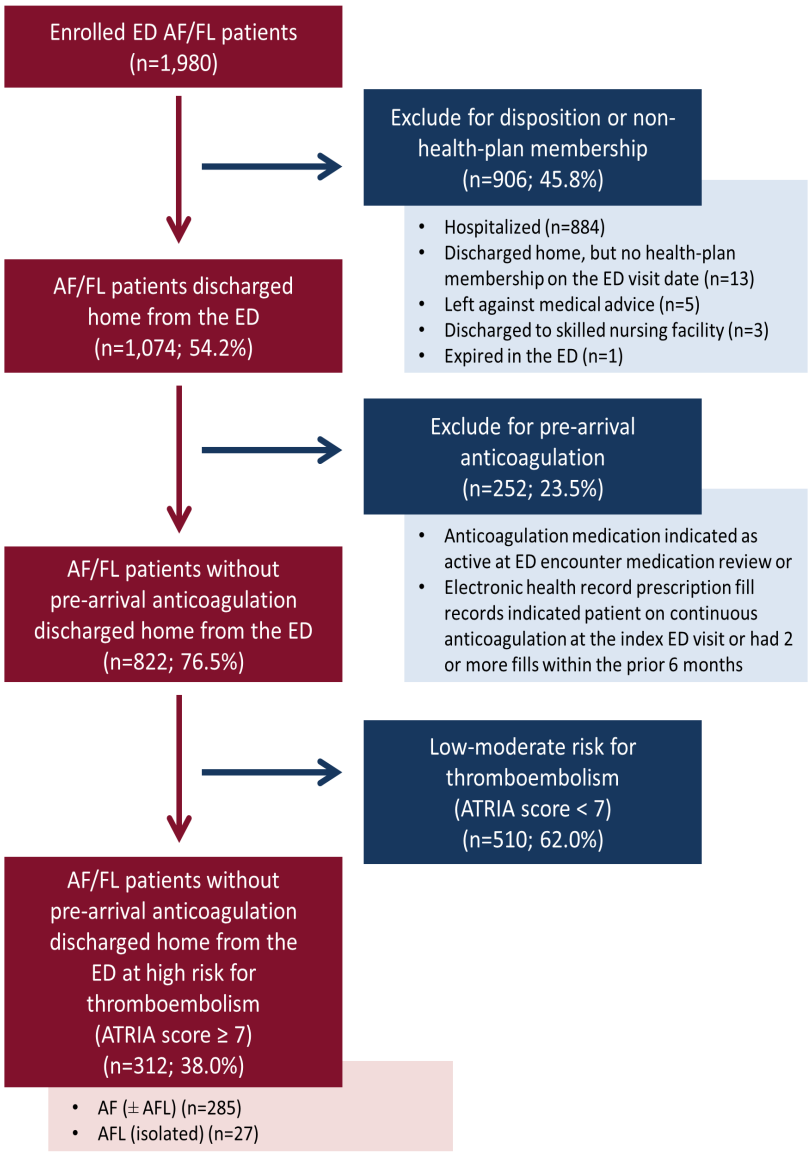

Figure. Patient flow of emergency department (ED) patients with eligible atrial fibrillation or flutter (AF/FL) enrolled in the TAFFY study
TAFFY, Treatment of Atrial Fibrillation and Flutter in the emergencY department; *ATRIA*, Anticoagulation and Risk Factors in Atrial Fibrillation Study.

ED-discharge period, the specialty of the physician prescribing anticoagulation included outpatient internal medicine (n=30), cardiology (n=6), hospital medicine (n=4), and emergency medicine (n=3). Among the 227 patients who left the ED without an oral anticoagulant prescription, 195 (85.9%) had an in-person or telephone encounter with a primary care provider or cardiologist within 30 days.

Forty-three patients (13.8%) were discharged home only on antiplatelet medications: seven were advised to continue their daily aspirin and 36 were prescribed (or advised to begin) new daily antiplatelet agents at the time of discharge (35 aspirin and one clopidogrel).

Characteristics of the cohort stratified by anticoagulation initiation are described in Table 2.

Variables independently associated with increased odds of anticoagulation initiation included younger age, new diagnosis of AF/FL, symptom onset >48 hours prior to evaluation, EP assessment of rhythm pattern as intermittent (not unremitting), receipt of cardiology consultation in the ED, and failure of sinus restoration by time of ED discharge (Table 3).

Among the 227 patients discharged home from the ED without anticoagulation, 139 patients (61.2%) had one or more reasons documented for withholding anticoagulation.

Table 2. Characteristics of atrial fibrillation and flutter patients at high risk for stroke who were discharged home from the emergency department, stratified by anticoagulation initiation.

	Anticoagulation initiation in ED or within 30 days			
Patient characteristics	Total (N=312)	Yes (n=128, 41.0%)	No (n=184, 59.0%)	P-value*
Age at ED visit, years				
Mean (SD)	80.4 (6.8)	78.5 (5.8)	81.8 (7.1)	<0.001
Categorical, n (%)				
65 to 74	48 (15.4)	24 (18.8)	24 (13.0)	0.17
≥75	264 (84.6)	104 (81.2)	160 (87.0)	
Female gender, n (%)	201 (64.4)	75 (58.6)	126 (68.5)	0.07
Race				0.29
White/European	262 (84.0)	105 (82.0)	157 (85.3)	
Asian/Pacific Islander	25 (8.0)	13 (10.2)	12 (6.5)	
Black/African American	16 (5.1)	7 (5.5)	9 (4.9)	
Native Hawaiian/other Pacific Islander	2 (0.6)	1 (0.8)	1 (0.5)	
Other/unknown	7 (2.24)	2 (1.6)	5 (2.7)	
Comorbidities and scores				
History of atrial fibrillation and flutter	137 (43.9)	37 (28.9)	100 (54.3)	<0.001
Hypertension	264 (84.6)	112 (87.5)	152 (82.6)	0.23
Proteinuria	168 (53.8)	69 (53.9)	99 (53.8)	0.99
Diabetes mellitus	83 (26.6)	44 (34.4)	39 (21.2)	0.01
Coronary heart disease	75 (24.0)	40 (31.3)	35 (19.0)	0.01
Estimated GFR <45 ml/min/1.73 m^2 or end-stage renal disease	62 (19.9)	28 (21.9)	34 (18.5)	0.46
Chronic heart failure	44 (14.1)	18 (14.1)	26 (14.1)	0.99
Peripheral artery disease	13 (4.2)	8 (6.3)	5 (2.7)	0.13
Prior ischemic stroke	4 (1.3)	1 (0.8)	3 (1.6)	0.50
ATRIA study stroke risk score				
Mean (SD)	12.5 (3.8)	11.7 (3.3)	13.1 (4.0)	<0.001
Median (IQR)	11.5 (10-16)	11 (10-13)	12 (10.5-17)	
HAS-BLED hemorrhage risk score				
Mean (SD)	2.6 (1.4)	2.4 (1.3)	2.7 (1.4)	0.07
Median (IQR)	2.0 (2-3)	2.0 (2-3)	2.0 (2-4)	
Categorical, n (%)				
Low risk (<3)	179 (57.4)	83 (64.8)	96 (52.2)	0.03
High risk (≥3)	133 (42.6)	45 (35.2)	88 (47.8)	
Rhythm characteristics				
Diagnosis				
Atrial fibrillation (any)	285 (91.3)	110 (85.9)	175 (95.1)	<0.01
Atrial flutter (isolated)	27 (8.7)	18 (14.1)	9 (4.9)	
Recent-onset of rhythm-related symptoms (<48 hours)				
Yes	147 (47.1)	50 (39.1)	97 (52.7)	0.04
No	68 (21.8)	35 (27.3)	33 (17.9)	
Unclear	97 (31.1)	43 (33.6)	54 (29.3)	

ED, emergency department; *GFR*, glomerular filtration rate; *ATRIA*, Anticoagulation and Risk Factors in Atrial Fibrillation; *HAS-BLED*, Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile international normalized ratio, Elderly (>65 years), Drugs or alcohol; *SD*, standard deviation; *IQR*, interquartile range.
*P-values from chi-square likelihood ratio tests for all categorical comparisons. For comparison of means, Student t-tests are reported.

Table 2. Continued.

Patient characteristics	Anticoagulation initiation in ED or within 30 days			
	Total (n=312)	Yes (n=128, 41.0%)	No (n=184, 59.0%)	P-value*
Impression of clinical category				
Intermittent/recurrent	208 (66.7)	88 (68.7)	120 (65.2)	0.01
Chronic/sustained	41 (13.1)	9 (7.0)	32 (17.4)	
Unclear	63 (20.2)	31 (24.2)	32 (17.4)	
Sinus rhythm at discharge	140 (44.9)	48 (37.5)	92 (50.0)	0.03
ED cardiologist consultation	117 (37.5)	64 (50.0)	53 (28.8)	<0.001

ED, emergency department.
*P-values from chi-square likelihood ratio tests for all categorical comparisons. For comparison of means, Student t-tests are reported.

These were categorized as physician concerns and patient concerns (Table 4). The leading physician reasons for withholding anticoagulation were concerns about elevated bleeding risk (including fall risk), deferring the decision to an outpatient provider, and the perception that the restoration of sinus rhythm had significantly reduced or eliminated stroke risk. The leading patient reasons for declining anticoagulation were a preference to continue the discussion of anticoagulation with their outpatient provider and simple refusal, not otherwise specified. Deferring the shared decision-making process to the patient's outpatient provider was the leading reason for withholding anticoagulation when combining physician and patient concerns (43/227; 18.9%).

One hundred thirty-seven (60.3%) patients were given patient education material on AF/FL in their discharge instructions. The three versions of material used by the EPs each included one sentence about the general association between AF/FL and thromboembolic events. The material was not personalized, however, and did not quantify the patient's specific risk (e.g., 4.0% annual stroke risk), nor even mention broader thromboembolic risk categories (low, moderate, high), nor discuss the benefits and risks of stroke prevention therapy.

Using an online random number generator (random.org; Randomness and Integrity Services Ltd., Dublin, Ireland), we identified 23 cases for review by a second abstractor. Percent agreement was the same for presence of both documented reason for non-prescribing and provision of patient education material (22/23; 96.5%). The kappa statistic was 0.91 for each variable.

DISCUSSION

In this multicenter, prospective cohort of non-anticoagulated AF/FL patients at high thromboembolic risk discharged home from the ED, we found that approximately 40% were prescribed oral anticoagulation within 30 days. Furthermore, we observed that younger age, selected rhythm-related characteristics in the ED, and receipt of cardiology consultation were strongly associated with receiving anticoagulation.

About 60% of patients discharged home from the ED without anticoagulation had a reason documented in their electronic health record, a relatively high percentage of documentation compared with a recent, large, inpatient registry.[10] The principal reason for non-prescribing in our study was deferring the shared decision-making process to the patient's outpatient provider (18.9%). Such reasoning is sensible in a setting like ours where patients have ready access to their outpatient physicians and 30-day follow-up is common.[47] Our percentage of deferral was higher than in a similar study of ED anticoagulation prescribing for high-risk AF/FL in Spain (5.6%), though, like our study population, all of their patients also had health coverage.[20] Other leading documented reasons included a perception of increased bleeding risk (e.g., falls) and a perception of reduced stroke risk (e.g., when paroxysmal AF/FL reverted to sinus rhythm prior to ED discharge).

ED Anticoagulation Initiation in the Literature

The incidence of oral anticoagulation initiation for AF/FL patients at high risk for ischemic stroke who are discharged home from the ED has not been well described. Reports range widely, from approximately 10% to 50%. The calculation also varies depending on whether stroke-prone AF/FL patients deemed ineligible for anticoagulation are included in the denominator. A large, 124-center study from Spain by Coll-Vinent et al. in 2011 demonstrated that anticoagulation was initiated at the time of home discharge to 193 of 453 high-risk AF patients (44%), higher than our 27%.[20] The case mix in this study was similar to ours in that patients with all categories of AF were included (e.g., first episode, paroxysmal, persistent, and permanent), but was different in that they excluded patients thought ineligible for anticoagulation, something our study design did not allow. This difference might explain in part why their incidence of initiation

Table 3. Association of variables with 30-day anticoagulation initiation for high-risk patients (ATRIA score ≥7) with atrial fibrillation and flutter discharged home from the emergency department

	Anticoagulation initiation in ED or within 30 days			
	Univariate models		Multivariable model	
Variable	Odds ratio*	95% CI	Adjusted odds ratio*	95% CI
Age, per year	0.93	0.89, 0.96	0.89	0.82, 0.96
Gender				
Female	Reference	--	Reference	--
Male	0.65	0.41, 1.04	1.58	0.91, 2.74
Race				
White	Reference	--	Reference	--
Non-white	1.27	0.69, 2.34	0.85	0.42, 1.74
Clinical characteristics at index ED visit				
Rhythm diagnosis				
AF, any	Reference	--	Reference	--
AFL, isolated	3.18	1.38, 7.33	2.20	0.84, 5.77
AF/FL history				
Prior AF/FL diagnosis	Reference	--	Reference	--
New AF/FL diagnosis	2.93	1.81, 4.73	3.10	1.72, 5.58
Onset of symptoms				
Recent-onset (<48 hrs)	Reference	--	Reference	--
Not recent (≥48 hrs)	2.06	1.15, 3.69	2.31	1.03, 5.21
Unclear	1.54	0.91, 2.62	1.10	0.54, 2.23
AF/AFL categorization				
Chronic/unremitting	Reference	--	Reference	--
Intermittent/recurrent	2.61	1.19, 5.74	4.56	1.65, 12.60
Unclear	3.44	1.42, 8.38	3.43	1.14, 10.34
ED cardiologist consultation				
No	Reference	--	Reference	--
Yes	2.47	1.54, 3.96	1.89	1.10,3.23
ED discharge rhythm				
Sinus rhythm	Reference	--	Reference	--
AF/FL	1.67	1.05, 2.64	2.65	1.35, 5.21
ATRIA stroke risk				
Score, per point increase above 6	0.90	0.84, 0.96	1.10	0.96, 1.26
HAS-BLED hemorrhage risk score				
Score, per point increase	0.86	0.73, 1.02		
Categorical				
Low risk (<3)	Reference	--		
High risk (≥3)	0.59	0.34, 1.01		

ED, emergency department; *AF*, atrial fibrillation; *AFL*, atrial flutter; *AF/FL*, atrial fibrillation or flutter; *ATRIA*, Anticoagulation and Risk Factors in Atrial Fibrillation; *HAS-BLED*, Hypertension, Abnormal renal/liver function, Stroke, Bleeding history or predisposition, Labile international normalized ratio, Elderly (>65 years), Drugs or alcohol; *CI*, confidence interval.

* Reference group includes individuals with no anticoagulation initiation by 30 days after the index ED visit.

Table 4. Documentation of reasons for withholding anticoagulation for high-risk patients with atrial fibrillation and flutter discharged home from the emergency department (n=227).

	N (%)
Reasons for withholding anticoagulation	
Not documented	88 (38.8)
Documented	139 (61.2)
Physician concerns*	86 (37.9)
Bleed risk (including fall risk)	29 (12.8)†
Defer decision to outpatient physician	23 (10.1)
Restoration of sinus rhythm has reduced risk	19 (8.4)
Assents with another physician's recommendation (either in prior notes or during consultation)	15 (6.6)
Perceived to be low risk for stroke, independent of sinus rhythm	6 (2.6)
Already on LMWH or non-aspirin antiplatelet agent	3 (1.3)
Patient concerns*	60 (43.2)
Prefers to discuss further with outpatient provider	20 (8.8)
Declines anticoagulation, no explanation documented	20 (8.8)
Previously discontinued‡	10 (4.4)
Perceived bleed risk	7 (3.0)
Frequent phlebotomy required	3 (1.3)

LMWH, low molecular weight heparin.
*Percentage calculated from cases in which the reason for withholding anticoagulation was documented (n=139). Seven cases included documentation of both physician and patient concerns.
† In 15 of these 29 cases the physician specified that their concern was the risk of falling.
‡ Reasons for previous discontinuation of warfarin were documented in six cases and included intolerance (n=2), bleeding or easy bruising (n=2), allergy (n=1), and non-adherence (n=1).

was higher than what we observed. A more recent, 62-center Spanish study from the same investigators reported a similarly high incidence of de novo anticoagulation prescribing on ED discharge.[32] Two hospitals with the University of British Columbia, Canada, have reported a high baseline incidence (49%; 51/105) of appropriate anticoagulation initiation at ED discharge for high-risk AF/FL patients. As with the Spanish study above, these investigators had excluded ineligible patients.[48]

Other studies have reported lower incidences of anticoagulation initiation. A retrospective cohort study undertaken in 2008 in eight Canadian EDs observed thromboprophylaxis initiation in 21 of 210 patients (18%) with recent-onset AF/FL who were discharged home.[37] A more recent prospective study by Stiell et al. described the treatment of patients with recent-onset AF at six academic Canadian EDs from 2010 to 2012 and found slightly lower rates of untreated high-risk patients leaving the ED with a new anticoagulation prescription (approximately 11%).[12] In a retrospective study of two academic Canadian EDs, Scheuermeyer et al reported that 27% (41/151) of high-risk AF/FL patients were begun on appropriate stroke prevention medications at discharge, and documentation of reasons for withholding thromboprophylaxis was noted in an additional 21 patients.[15]

Patient Age

Our finding that older patients with high-risk AF/FL were less likely to receive an oral anticoagulant prescription than their younger counterparts is consistent with studies demonstrating under-treatment both in the ED[20,49] and in other settings.[50] Thromboprophylaxis is less commonly prescribed to patients over 75 years of age, even though this population likely benefits the most given their higher absolute risk of ischemic stroke compared with intracranial hemorrhage or life-threatening extracranial hemorrhage.[51] Physicians often acknowledge their hesitancy to initiate anticoagulation in the elderly and very elderly,[52] given that these patients often have a high comorbidity burden, associated cognitive disorders and polypharmacy-related challenges. Despite these concerns, there is often a misunderstanding about the net clinical benefit associated with oral anticoagulation in the elderly.[51,53]

Physicians often cite perceived bleeding risk as a primary reason for withholding anticoagulation for AF/FL patients, a finding we also observed.[32,52] Physicians overestimate the risk of intracranial bleeding in patients with high risk for falls. However, there is evidence that patients with AF would need to fall repeatedly throughout the year before the risk of intracranial hemorrhage would outweigh the net benefits of

stroke-prevention from anticoagulation.[54] Of interest, a patient's predicted hemorrhage risk, as measured by the HAS-BLED score, was associated with less anticoagulation prescribing in our population but was of borderline statistical significance (Table 3). The evidence suggests that a high-risk HAS-BLED score per se is not a reason to withhold anticoagulation that is otherwise indicated.[2, 55] In most patients with elevated bleeding risks, the magnitude of gain from stroke reduction far outweighs the small risk of serious bleeding.[56] Bleeding risk scores are best used to identify patients in need of closer follow-up, particularly to address reversible risk factors such as uncontrolled hypertension, concomitant use of non-steroidal anti-inflammatory medications, and excess alcohol.[2, 55]

Rhythm-related Characteristics

Our study found that several rhythm-related characteristics were strongly associated with the likelihood of receiving oral anticoagulation at or shortly after an ED visit for AF/FL. For example, we noted that patients who reverted to sinus rhythm before ED discharge were less likely to receive a prescription for anticoagulation. As indicated from the reasons documented for withholding anticoagulation, EPs significantly varied their estimation of a patient's ischemic stroke risk based on the persistence of AF/FL during the ED stay. Lower rates of anticoagulation also have been seen in patients with paroxysmal AF in other practice settings.[13, 20] Most recently, an analysis of the American College of Cardiology PINNACLE Registry found that patients with paroxysmal AF considered at a moderate to high risk of ischemic stroke were less likely to be prescribed oral anticoagulant therapy and more likely to be prescribed less effective or no therapy for thromboembolism prevention than those with non-paroxysmal AF.[57]

Compared with patients with persistent or permanent AF, those with paroxysmal AF have less frequent and less prolonged episodes of AF (that is, a lower overall "AF burden"), which correlates with a lower incidence of thromboembolism.[58-60] Yet the reduction in stroke risk is not sufficient to lessen the need for thromboprophylaxis.[3, 61] Importantly, consensus-based clinical practice guidelines do not vary their recommendations for thromboprophylaxis based on type of AF, nor do validated stroke risk scores alter their prognosis based on paroxysmal or non-paroxysmal rhythm.[3,7,9,62]

We also found that physicians were less likely to initiate anticoagulation in patients with a history of prior AF/FL and in those whose atrial dysrhythmia was thought by the EP to be chronic and unremitting. This might seem counterintuitive given our finding that patients who left the ED still in AF/FL were more likely to receive thromboprophylaxis. It is possible, however, that ED patients at high risk for stroke with known recurrent or chronic AF/FL had already been advised about anticoagulation options before their index ED visit and previously declined or discontinued anticoagulation in the distant past. Some have attributed this behavior to "clinical inertia," the hesitancy of physicians to alter the current pattern of care initiated by other providers.[63] Nonetheless, further exploration is needed to clarify the underlying reasons for these observations. With today's expanded pharmacopeia for AF/FL stroke prevention, patients who had declined or discontinued warfarin in the past may be open to consider a direct oral anticoagulant, given the several patient-oriented advantages of this class of medications.[62, 64-66]

ED Cardiology Consultation

One novel finding of our study is that EPs were more likely to initiate anticoagulation when consulting cardiology. The reason for this may be multifactorial. Certain patients may have a clinical profile that leads to both cardiology consultation and thromboprophylaxis, or perhaps EPs who consult cardiology are more apt to initiate anticoagulation independent of the consultation. The more likely reason, however, is that cardiologists asked to advise on any facet of ED AF/FL care may raise the question of stroke risk and recommend thromboprophylaxis when indicated.[67] Others have shown that cardiology involvement in the outpatient setting improves rates of stroke prevention treatment in AF patients. The TREAT-AF study found that outpatient cardiology care compared with primary care was associated with higher rates of anticoagulation of AF patients.[68] Anticoagulation rates increase even when a primary care provider referred their AF/FL patients to see a cardiologist but maintained patient oversight themselves.[67]

Post-ED Outpatient Follow-up

The benefits of multispecialty collaboration were seen not just during the patients' ED stay. Of those who were prescribed oral anticoagulation in this study, more than one quarter were given thromboprophylaxis in the outpatient setting, either in the primary care or cardiology clinics. The importance of post-ED follow-up for AF/FL patients at high risk for thromboembolism is also seen by the number of EPs and patients in our study who deferred the anticoagulation decision to allow a fuller discussion of thromboprophylaxis with an outpatient provider (nearly one in five).

Deferring the initiation of anticoagulation in high-risk ED patients, however, may not be without risk. In some settings, a significant proportion of AF patients discharged home from the ED failed to achieve outpatient follow-up in the subsequent 90 days, regardless of insurance status.[24] Moreover, compared with patients who leave the ED with an anticoagulant prescription in hand, those who wait to consult an outpatient provider about stroke prevention have been shown to have a significantly lower frequency of long-term anticoagulation use (76% vs. 36% at one year) and a significant delay in initiation among those eventually treated (mean start time of 205 days following index ED discharge).[69]

When referring patients to outpatient providers for this critical decision, the EP can facilitate anticoagulation initiation by several means: (1) introducing stroke prevention to their AF/FL patients and beginning (or continuing) the educational and shared decision-making process; (2) including stroke prevention material in the patient's discharge instructions; (3) recommending (or even securing) a timely follow-up appointment; and (4) notifying the outpatient provider that stroke prevention may be indicated and that patient education was begun prior to ED discharge.

Opportunities to Improve Care

Our results highlight opportunities for improvement in care. Patients seeking emergency care for their AF/FL may be more open to health-promoting behavioral changes, as has been observed with other medical conditions.[25-30] Initiating stroke-prevention therapy at the time of ED discharge has been shown to be safe and associated with a mortality reduction.[32] Not all EPs, however, see it as their role to initiate anticoagulation when indicated for AF/FL patients.[15,31] Nevertheless, EPs can still play a key role in promoting stroke prevention by risk-stratifying their AF/FL patients, broaching the topic with high-risk patients, adding personalized stroke-risk educational material to the discharge instructions, and encouraging high-risk patients to continue the shared decision-making conversation about thromboprophylaxis with their outpatient provider.

The results of this study raise questions about other ways to increase evidence-based anticoagulation. We identified certain physician misunderstandings that, if corrected, could increase anticoagulation of stroke-prone patients with AF/FL. Physician education should emphasize that patients with AF/FL at high risk for thromboembolism warrant stroke prevention even if their rhythm type is paroxysmal.[3, 7, 9] Also, antiplatelet agents do not provide sufficient protection against ischemic stroke in patients with high-risk AF/FL, though this is commonly believed.[20,70] We observed that about one in eight high-risk AF/FL patients were given or continued on aspirin instead of oral anticoagulation, a high percentage, but lower than that found in a large cardiology clinic-based population of AF patients at moderate to high risk of stroke.[71] Unfortunately, we were not able to distinguish when aspirin was advised as though it were sufficient stroke prevention from cases where the patient refused anticoagulation and was recommended aspirin instead.

Recent U.S. guidelines suggest a very limited role for aspirin in selected AF/FL patients (i.e., those with low predicted risk of stroke);[3] data supporting the use of aspirin monotherapy in patients at high risk of stroke are poor, and there are reports that it may even increase the risk of ischemic stroke in elderly patients.[72] Aspirin is also not safer than oral anticoagulation in patients over 80 years of age with regard to serious bleeding.[73] Recent guidelines recommend that aspirin monotherapy should not be used as stroke prevention in AF/FL with the exception of patients who refuse any form of oral anticoagulation and cannot tolerate a combination of aspirin and clopidogrel.[2, 74]

Though education about these misunderstandings will be vital, education alone may ultimately have little impact on changing physician behavior.[75,76] Several academic medical centers have improved oral anticoagulation rates in stroke-prone AF patients by referring them to an accessible outpatient AF clinic.[77,78] Another recommended approach is the provision of electronic clinical decision support to help physicians in their care for AF/FL patients.[14] To facilitate AF/FL thromboprophylaxis, such a system could calculate a patient's predicted stroke and bleeding risk scores simultaneously at the point of care and provide patient-specific recommendations for treatment. Results of various clinical decision support systems have been mixed.[63, 79-81] The more effective systems have taken a multimodal approach. The Anticoagulant Programme East London, for example, showed improvement in appropriate anticoagulation of outpatients with AF by a combined program of education around agreed-upon guidelines with computer aids to facilitate decision-making as well as patient-specific review and feedback of locally identifiable results.[81] Some clinical researchers are sharing their electronic clinical decision support tools for AF stroke prevention with patients and have found that mobile health technology improved patient knowledge, drug adherence, anticoagulant satisfaction, and quality of life.[82]

Electronic clinical decision support tools have had success in the ED setting when combined with a strong promotional program and could be readily adapted for use in patients with AF/FL.[83-86] A multidisciplinary team at the University of British Columbia designed such an electronic clinical care pathway for ED patients with uncomplicated AF/FL.[48] The pathway included a care map, decision aids, medication orders, management suggestions, and electronic consultation or referral documents, embedded in the computerized physician order entry and integrated electronic health record. Implementation was preceded and accompanied by a standardized educational and promotional program. The pathway increased the incidence of anticoagulation initiation on discharge for high-risk patients by 20.6 percentage points (from 48.6% to 70.2%).[48]

LIMITATIONS

This study had several limitations. The study sample did not include all identified AF/FL patients; however, patient characteristics were highly similar between those who were and were not enrolled, so the impact of potential selection bias is likely limited. Our prospective data collection tool was designed to evaluate a wide range of care-related issues for AF/FL and was not focused on thromboprophylaxis (see above), but we cannot rule out the potential for a Hawthorne effect during the study period. The sample size was modest, which accounts for limited

precision for certain associations, and we cannot rule out missing associations of smaller magnitude that may still be clinically relevant. We did not prospectively capture each patient's relative contraindications to anticoagulation or their treatment preferences, which are two of the leading reasons physicians deviate from guideline recommendations for stroke prevention therapy.[87] This enlarged our denominator of anticoagulant-eligible patients and lowered our percentage of anticoagulant prescribing. We were able to identify some of these contraindications during our retrospective chart review, but these variables were incompletely documented.

This study focused on stroke prevention using warfarin, the only oral anticoagulant on the formulary in our health system until early 2014. Even with the recent availability of direct oral anticoagulants, physicians in our health system continue to initiate warfarin for AF/FL thromboprophylaxis: 40% of new oral anticoagulant prescriptions during the first quarter of 2017 for non-valvular AF/FL (with or without additional anticoagulation indications) across all 21 medical centers were for warfarin. Warfarin continues to be widely used for stroke prevention across North America, Europe, and around the world.[88] In fact, the European Society of Cardiology says it is reasonable to continue warfarin therapy in AF patients with a reassuring time in therapeutic range.[62, 89] It is unclear whether the availability of newer agents will substantively alter physician overestimation of bleeding risk in older patients or underestimation of long-term stroke risk in patients with paroxysmal AF. Additional research will be needed to evaluate whether practice patterns of stroke prevention in AF/FL patients will change with use of direct oral anticoagulants. Studies suggest, however, that suboptimal AF thromboprophylaxis persists despite the availability of direct oral anticoagulants.[90]

Lastly, our study was conducted in a large integrated healthcare delivery system in California among insured patients who, on ED discharge, can receive close monitoring by our pharmacy-led Outpatient Anticoagulation Service and timely follow-up with their primary care providers. These integrated services may influence ED prescribing practices and may not be readily available to patients and providers in other healthcare systems. These distinctions of care may limit the generalizability of our results to other geographic locations and practice settings.

CONCLUSION

In summary, we found that about 40% of non-anticoagulated patients with AF/FL at high risk for stroke who received rhythm-related care in the ED were prescribed evidence-based thromboprophylaxis in the ED or within 30 days. Younger age, ED cardiology consultation, and failure of sinus restoration at time of ED discharge increased the odds of anticoagulation initiation. Reasons for withholding anticoagulation included deferring the decision-making to the outpatient setting, as well as perceptions of high bleed risk (e.g., fall risk) and low stroke risk (e.g., paroxysmal AF/FL). Discharge instructions on AF/FL either lacked personalized stroke risk information or were absent altogether. Opportunities exist to improve stroke prevention interventions in this high-risk population. Multidisciplinary efforts to reduce strokes in high-risk AF/FL patients will need to address physician misunderstandings of anticoagulation risks and benefits and improve patient education.

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REFERENCES

1. Wolf PA, Abbott RD, Kannel WB. Atrial fibrillation as an independent risk factor for stroke: the Framingham Study. *Stroke*. 1991;22(8):983-8.
2. Kirchhof P, Benussi S, Kotecha D, et al. 2016 ESC Guidelines for the management of atrial fibrillation developed in collaboration with EACTS. *Eur Heart J.* 2016;37(38):2893-962.
3. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation*. 2014;130(23):e199-267.
4. Verma A, Cairns JA, Mitchell LB, et al. 2014 focused update of the Canadian Cardiovascular Society Guidelines for the management of atrial fibrillation. *Can J Cardiol*. 2014;30(10):1114-30.
5. You JJ, Singer DE, Howard PA, et al. Antithrombotic therapy for atrial fibrillation: Antithrombotic Therapy and Prevention of Thrombosis, 9th ed: American College of Chest Physicians Evidence-Based Clinical Practice Guidelines. *Chest*. 2012;141(2 Suppl):e531S-75S.
6. Gage BF, Waterman AD, Shannon W, et al. Validation of clinical classification schemes for predicting stroke: results from the National Registry of Atrial Fibrillation. *JAMA*. 2001;285(22):2864-70.
7. Lip GY, Nieuwlaat R, Pisters R, et al. Refining clinical risk stratification for predicting stroke and thromboembolism in atrial fibrillation using a novel risk factor-based approach: the euro heart survey on atrial fibrillation. *Chest*. 2010;137(2):263-72.
8. Hippisley-Cox J, Coupland C, Brindle P. Derivation and validation of QStroke score for predicting risk of ischaemic stroke in primary care and comparison with other risk scores: a prospective open cohort study. *BMJ*. 2013;346:f2573.
9. Singer DE, Chang Y, Borowsky LH, et al. A new risk scheme to predict ischemic stroke and other thromboembolism in atrial fibrillation: the ATRIA study stroke risk score. *J Am Heart Assoc*. 2013;2(3):e000250.
10. Xian Y, O'Brien EC, Liang L, et al. Association of preceding antithrombotic treatment with acute ischemic stroke severity and in-hospital outcomes among patients with atrial fibrillation. *JAMA*. 2017;317(10):1057-67.
11. McGrath ER, Go AS, Chang Y, et al. Use of oral anticoagulant therapy in older adults with atrial fibrillation after acute ischemic stroke. *J Am Geriatr Soc*. 2017;65(2):241-8.
12. Stiell IG, Clement CM, Rowe BH, et al. Outcomes for emergency department patients with recent-onset atrial fibrillation and flutter treated in Canadian hospitals. *Ann Emerg Med*. 2017;69(5):562-71 e2.
13. Palomaki A, Mustonen P, Hartikainen JE, et al. Underuse of anticoagulation in stroke patients with atrial fibrillation - the FibStroke Study. *Eur J Neuro*l. 2016;23(1):133-9.
14. Hess PL, Mirro MJ, Diener HC, et al. Addressing barriers to optimal oral anticoagulation use and persistence among patients with atrial fibrillation: Proceedings, Washington, DC, December 3-4, 2012. *Am Heart J*. 2014;168(3):239-47.e1.
15. Scheuermeyer FX, Innes G, Pourvali R, et al. Missed opportunities for appropriate anticoagulation among emergency department patients with uncomplicated atrial fibrillation or flutter. *Ann Emerg Med.* 2013;62(6):557-65 e2.
16. Ogilvie IM, Newton N, Welner SA, et al. Underuse of oral anticoagulants in atrial fibrillation: a systematic review. *Am J Med.* 2010;123(7):638-45.e4.
17. Hart RG, Pearce LA, Aguilar MI. Meta-analysis: antithrombotic therapy to prevent stroke in patients who have nonvalvular atrial fibrillation. *Ann Intern Med*. 2007;146(12):857-67.
18. Bungard TJ, Ghali WA, Teo KK, et al. Why do patients with atrial fibrillation not receive warfarin? *Arch Intern Med*. 2000;160(1):41-6.
19. Cohen N, Almoznino-Sarafian D, Alon I, et al. Warfarin for stroke prevention still underused in atrial fibrillation: patterns of omission. *Stroke*. 2000;31(6):1217-22.
20. Coll-Vinent B, Martin A, Malagon F, et al. Stroke prophylaxis in atrial fibrillation: searching for management improvement opportunities in the emergency department: the HERMES-AF study. *Ann Emerg Med.* 2015;65(1):1-12.
21. Atzema CL, Austin PC, Miller E, et al. A population-based description of atrial fibrillation in the emergency department, 2002 to 2010. *Ann Emerg Med*. 2013;62(6):570-7.e7.
22. Scott PA, Pancioli AM, Davis LA, et al. Prevalence of atrial fibrillation and antithrombotic prophylaxis in emergency department patients. *Stroke*. 2002;33(11):2664-9.
23. Tran C, Bennell MC, Qiu F, et al. Predictors and clinical outcomes of inpatient versus ambulatory management after an emergency department visit for atrial fibrillation: a population-based study. *Am Heart J*. 2016;173:161-9.
24. Atzema CL, Austin PC, Chong AS, et al. Factors associated with 90-day death after emergency department discharge for atrial fibrillation. *Ann Emerg Med.* 2013;61(5):539-48.e1.
25. McBride CM, Blocklin M, Lipkus IM, et al. Patient's lung cancer diagnosis as a cue for relatives' smoking cessation: evaluating the constructs of the teachable moment. *Psychooncology*. 2017;26(1):88-95.
26. Kronish IM, Ross JS, Zhao H, et al. Impact of hospitalization for acute myocardial infarction on adherence to statins among older adults. *Circ Cardiovasc Qual Outcomes*. 2016;9(4):364-71.
27. Flocke SA, Clark E, Antognoli E, et al. Teachable moments for health behavior change and intermediate patient outcomes. *Patient Educ Couns*. 2014;96(1):43-9.
28. Boudreaux ED, Bock B, O'Hea E. When an event sparks behavior change: an introduction to the sentinel event method of dynamic model building and its application to emergency medicine. *Acad Emerg Med.* 2012;19(3):329-35.
29. Lawson PJ, Flocke SA. Teachable moments for health behavior change: a concept analysis. *Patient Educ Couns*. 2009;76(1):25-30.
30. McBride CM, Puleo E, Pollak KI, et al. Understanding the role of cancer worry in creating a "teachable moment" for multiple risk factor reduction. *Soc Sci Med*. 2008;66(3):790-800.
31. Barrett TW, Marill KA. Anticoagulation for emergency department

patients with atrial fibrillation: is our duty to inform or prescribe? *Ann Emerg Med.* 2013;62(6):566-8.

32. Coll-Vinent B, Martin A, Sanchez J, et al. Benefits of emergency departments' contribution to stroke prophylaxis in atrial fibrillation: the EMERG-AF study (Emergency Department Stroke Prophylaxis and Guidelines Implementation in Atrial Fibrillation). *Stroke*. 2017;48(5):1344-52.
33. Atzema CL, Barrett TW. Managing atrial fibrillation. *Ann Emerg Med*. 2015;65(5):532-9.
34. Atzema CL, Singh SM. Acute Management of Atrial Fibrillation: From Emergency Department to Cardiac Care Unit. *Cardiol Clin.* 2018;36(1):141-59.
35. Oldgren J, Healey JS, Ezekowitz M, et al. Variations in cause and management of atrial fibrillation in a prospective registry of 15,400 emergency department patients in 46 countries: the RE-LY Atrial Fibrillation Registry. *Circulation*. 2014;129(15):1568-76.
36. Atzema CL, Dorian P, Ivers NM, et al. Evaluating early repeat emergency department use in patients with atrial fibrillation: a population-based analysis. *Am Heart J.* 2013;165(6):939-48.
37. Misra P, Lang E, Clement CM, et al. Emergency physician patterns related to anticoagulation of patients with recent-onset atrial fibrillation and flutter. *J Atr Fibrillation*. 2013;5(6):645.
38. Ballard DW, Reed ME, Singh N, et al. Emergency department management of atrial fibrillation and flutter and patient quality of life at one month postvisit. *Ann Emerg Med*. 2015;66(6):646-54.e2.
39. An J, Niu F, Zheng C, et al. Warfarin management and outcomes in patients with nonvalvular atrial fibrillation within an integrated health care system. *J Manag Care Spec Pharm*. 2017;23(6):700-12.
40. Witt DM, Sadler MA, Shanahan RL, et al. Effect of a centralized clinical pharmacy anticoagulation service on the outcomes of anticoagulation therapy. *Chest*. 2005;127(5):1515-22.
41. Rosendaal FR, Cannegieter SC, van der Meer FJ, et al. A method to determine the optimal intensity of oral anticoagulant therapy. *Thromb Haemost*. 1993;69(3):236-9.
42. van den Ham HA, Klungel OH, Singer DE, et al. Comparative performance of ATRIA, CHADS2, and CHA2DS2-VASc risk scores predicting stroke in patients with atrial fibrillation: results from a national primary care database. *J Am Coll Cardiol*. 2015;66(17):1851-9.
43. Aspberg S, Chang Y, Atterman A, et al. Comparison of the ATRIA, CHADS2, and CHA2DS2-VASc stroke risk scores in predicting ischaemic stroke in a large Swedish cohort of patients with atrial fibrillation. *Eur Heart J*. 2016;37(42):3203-10.
44. Pisters R, Lane DA, Nieuwlaat R, et al. A novel user-friendly score (HAS-BLED) to assess 1-year risk of major bleeding in patients with atrial fibrillation: the Euro Heart Survey. *Chest.* 2010;138(5):1093-100.
45. Caldeira D, Costa J, Fernandes RM, et al. Performance of the HAS-BLED high bleeding-risk category, compared to ATRIA and HEMORR2HAGES in patients with atrial fibrillation: a systematic review and meta-analysis. *J Interv Card Electrophysiol.* 2014;40(3):277-84.
46. Wang SV, Rogers JR, Jin Y, et al. Use of electronic healthcare records to identify complex patients with atrial fibrillation for targeted intervention. *J Am Med Inform Assoc*. 2017;24(2):339-44.
47. Atzema CL, Yu B, Ivers NM, et al. Predictors of obtaining follow-up care in the province of Ontario, Canada, following a new diagnosis of atrial fibrillation, heart failure, and hypertension in the emergency department. *CJEM*. 2017:1-15.
48. Barbic D, DeWitt C, Harris D, et al. Implementation of an emergency department atrial fibrillation and flutter pathway improves rates of appropriate anticoagulation, reduces length of stay and thirty-day revisit rates for congestive heart failure. *CJEM*. 2017:1-9.
49. Laguna P, Martn A, del Arco C, et al. Risk factors for stroke and thromboprophylaxis in atrial fibrillation: what happens in daily clinical practice? The GEFAUR-1 study. *Ann Emerg Med.* 2004;44(1):3-11.
50. Suarez Fernandez C, Formiga F, Camafort M, et al. Antithrombotic treatment in elderly patients with atrial fibrillation: a practical approach. *BMC Cardiovasc Disord*. 2015;15:143.
51. Singer DE, Chang Y, Fang MC, et al. The net clinical benefit of warfarin anticoagulation in atrial fibrillation. *Ann Intern Med.* 2009;151(5):297-305.
52. Pugh D, Pugh J, Mead GE. Attitudes of physicians regarding anticoagulation for atrial fibrillation: a systematic review. *Age Ageing*. 2011;40(6):675-83.
53. Lip GY, Lane DA. Stroke prevention with oral anticoagulation therapy in patients with atrial fibrillation--focus on the elderly. *Circ J.* 2013;77(6):1380-8.
54. Man-Son-Hing M, Nichol G, Lau A, et al. Choosing antithrombotic therapy for elderly patients with atrial fibrillation who are at risk for falls. *Arch Intern Med*. 1999;159(7):677-85.
55. Lip GY, Lane DA. Bleeding risk assessment in atrial fibrillation: observations on the use and misuse of bleeding risk scores. *J Thromb Haemost.* 2016;14(9):1711-4.
56. Friberg L, Benson L, Lip GY. Balancing stroke and bleeding risks in patients with atrial fibrillation and renal failure: the Swedish Atrial Fibrillation Cohort study. *Eur Heart J*. 2015;36(5):297-306.
57. Hsu JC, Chan PS, Tang F, et al. Differences in anticoagulant therapy prescription in patients with paroxysmal versus persistent atrial fibrillation. *Am J Med*. 2015;128(6):654.e1- e10.
58. Ganesan AN, Chew DP, Hartshorne T, et al. The impact of atrial fibrillation type on the risk of thromboembolism, mortality, and bleeding: a systematic review and meta-analysis. *Eur Heart J.* 2016;37(20):1591-602.
59. Link MS, Giugliano RP, Ruff CT, et al. Stroke and mortality risk in patients with various patterns of atrial fibrillation: results from the ENGAGE AF-TIMI 48 trial (Effective Anticoagulation With Factor Xa Next Generation in Atrial Fibrillation-Thrombolysis in Myocardial Infarction 48). *Circ Arrhythm Electrophysiol.* 2017;10(1). pii: e004267.
60. Takabayashi K, Hamatani Y, Yamashita Y, et al. Incidence of stroke or systemic embolism in paroxysmal versus sustained atrial fibrillation: the Fushimi Atrial Fibrillation Registry. *Stroke*. 2015;46(12):3354-61.
61. Lilli A, Di Cori A, Zaca V. Thromboembolic risk and effect of oral anticoagulation according to atrial fibrillation patterns: A systematic

review and meta-analysis. *Clin Cardiol*. 2017;40(9):641-7.
62. Diener H-C, Aisenberg J, Ansell J, et al. Choosing a particular oral anticoagulant and dose for stroke prevention in individual patients with non-valvular atrial fibrillation: part 1. *Eur Heart J*. 2017;38(12):852-9.
63. Eckman MH, Lip GY, Wise RE, et al. Impact of an atrial fibrillation decision support tool on thromboprophylaxis for atrial fibrillation. *Am Heart J*. 2016;176:17-27.
64. Contreras Muruaga MDM, Vivancos J, Reig G, et al. Satisfaction, quality of life and perception of patients regarding burdens and benefits of vitamin K antagonists compared with direct oral anticoagulants in patients with nonvalvular atrial fibrillation. *J Comp Eff Res.* 2017;6:(4)303-12.
65. Diener H-C, Aisenberg J, Ansell J, et al. Choosing a particular oral anticoagulant and dose for stroke prevention in individual patients with non-valvular atrial fibrillation: part 2. *Eur Heart J*. 2017;38(12):860-8.
66. Lopez-Lopez JA, Sterne JAC, Thom HHZ, et al. Oral anticoagulants for prevention of stroke in atrial fibrillation: systematic review, network meta-analysis, and cost effectiveness analysis. *BMJ*. 2017;359:j5058.
67. Choudhry NK, Soumerai SB, Normand SL, et al. Warfarin prescribing in atrial fibrillation: the impact of physician, patient, and hospital characteristics. *Am J Med*. 2006;119(7):607-15.
68. Turakhia MP, Hoang DD, Xu X, et al. Differences and trends in stroke prevention anticoagulation in primary care vs cardiology specialty management of new atrial fibrillation: The Retrospective Evaluation and Assessment of Therapies in AF (TREAT-AF) study. *Am Heart J*. 2013;165(1):93-101.e1.
69. Atzema CL, Austin PC, Chong AS, et al. The long-term use of warfarin among atrial fibrillation patients discharged from an emergency department with a warfarin prescription. *Ann Emerg Med.* 2015;66(4):347-54.e2.
70. Frankel DS, Parker SE, Rosenfeld LE, et al. HRS/NSA 2014 Survey of atrial fibrillation and stroke: gaps in knowledge and perspective, opportunities for improvement. *J Stroke Cerebrovasc Dis.* 2015;24(8):1691-700.
71. Hsu JC, Maddox TM, Kennedy K, et al. Aspirin instead of oral anticoagulant prescription in atrial fibrillation patients at risk for stroke. *J Am Coll Cardiol.* 2016;67(25):2913-23.
72. Sjalander S, Sjalander A, Svensson PJ, et al. Atrial fibrillation patients do not benefit from acetylsalicylic acid. *Europace*. 2014;16(5):631-8.
73. van Walraven C, Hart RG, Connolly S, et al. Effect of age on stroke prevention therapy in patients with atrial fibrillation: the atrial fibrillation investigators. *Stroke*. 2009;40(4):1410-6.
74. Lau YC, Lip GY. Acetylsalicylic acid for stroke prevention in atrial fibrillation: a conspiracy that needs to end? *Europace*. 2014;16(5):619-20.
75. Davis DA, Thomson MA, Oxman AD, et al. Changing physician performance. A systematic review of the effect of continuing medical education strategies. *JAMA*. 1995;274(9):700-5.
76. Mostofian F, Ruban C, Simunovic N, et al. Changing physician behavior: what works? *Am J Manag Care*. 2015;21(1):75-84.
77. Angaran P, Mariano Z, Dragan V, et al. The Atrial Fibrillation Therapies after ER visit: Outpatient Care for Patients with Acute AF - The AFTER3 Study. *J Atr Fibrillation*. 2015;7(5):1187.
78. Elmouchi DA, VanOosterhout S, Muthusamy P, et al. Impact of an emergency department-initiated clinical protocol for the evaluation and treatment of atrial fibrillation. *Crit Pathw Cardiol*. 2014;13(2):43-8.
79. Arts DL, Abu-Hanna A, Medlock SK, et al. Effectiveness and usage of a decision support system to improve stroke prevention in general practice: A cluster randomized controlled trial. *PLoS One*. 2017;12(2):e0170974.
80. Bajorek BV, Magin PJ, Hilmer SN, et al. Optimizing stroke prevention in patients with atrial fibrillation: a cluster-randomized controlled trial of a computerized antithrombotic risk assessment tool in Australian general practice, 2012-2013. *Prev Chronic Dis.* 2016;13:E90.
81. Robson J, Dostal I, Mathur R, et al. Improving anticoagulation in atrial fibrillation: observational study in three primary care trusts. *Br J Gen Pract*. 2014;64(622):e275-81.
82. Guo Y, Chen Y, Lane DA, et al. Mobile Health Technology for Atrial Fibrillation Management Integrating Decision Support, Education, and Patient Involvement: mAF App Trial. *Am J Med.* 2017;130(12):1388-96.e6.
83. Dayan PS, Ballard DW, Tham E, et al. Use of Traumatic Brain Injury Prediction Rules With Clinical Decision Support. *Pediatrics*. 2017;139(4). pii: e20162709.
84. Ballard DW, Vemula R, Chettipally UK, et al. Optimizing clinical decision support in the electronic health record. clinical characteristics associated with the use of a decision tool for disposition of ed patients with pulmonary embolism. *Appl Clin Inform*. 2016;7(3):883-98.
85. Vinson DR, Ballard DW, Mark DG, et al. Impact of electronic clinical decision support on initial site of care for emergency department patients with acute pulmonary embolism [abstract]. *Ann Emerg Med.* 2016;68:S54.
86. Vinson DR, Morley JE, Huang J, et al. The accuracy of an electronic pulmonary embolism severity index auto-populated from the electronic health record: setting the stage for computerized clinical decision support. *Appl Clin Inform.* 2015;6(2):318-33.
87. Arts DL, Voncken AG, Medlock S, et al. Reasons for intentional guideline non-adherence: a systematic review. *Int J Med Inform*. 2016;89:55-62.
88. Huisman MV, Rothman KJ, Paquette M, et al. The changing landscape for stroke prevention in AF: findings From the GLORIA-AF Registry Phase 2. *J Am Coll Cardiol.* 2017;69(7):777-85.
89. Camm AJ, Lip GY, De Caterina R, et al. 2012 focused update of the ESC Guidelines for the management of atrial fibrillation: an update of the 2010 ESC Guidelines for the management of atrial fibrillation. Developed with the special contribution of the European Heart Rhythm Association. *Eur Heart J*. 2012;33(21):2719-47.
90. Alamneh EA, Chalmers L, Bereznicki LR. Suboptimal use of oral anticoagulants in atrial fibrillation: has the Introduction of direct oral anticoagulants improved prescribing practices? *Am J Cardiovasc Drugs*. 2016;16(3):183-200.

Just Missing the Mark: Discharging High-risk Atrial Fibrillation / Flutter without Thromboprophylaxis

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Atrial fibrillation and flutter (AF) is a pervasive disease affecting 6.1 million people in the United States.[1] Each year it is responsible for more than 750,000 hospitalizations and 130,000 deaths.[2,3] In contrast to overall declining death rates for cardiovascular disease,[4] AF as the "primary or contributing cause of death has been rising for more than two decades."[3] The annual economic burden of AF is six billion dollars; medical costs per AF patient are about $8,707 higher than for non-AF individuals.[3]

Thrombotic embolism of the cerebral circulation, or stroke, is the principal risk of AF and ranges from less than 2% to greater than 10% annually.[5-8] AF is the cause of 100,000-125,000 embolic strokes each year, of which 20% are fatal.[9] Anticoagulation to prevent these embolic events is standard of care unless contraindicated.[9] However, it is not without risk, as even minor trauma can cause substantial and potentially life-threatening bleeding. Given that AF is the most common arrhythmia among the elderly,[1,2,3] balancing these competing risks is challenging.

Anticoagulation for AF is most commonly accomplished with a vitamin K antagonist, warfarin. However, its use requires patient education, medication compliance, dietary consistency, and close monitoring. CHA_2DS_2-VASc, ATRIA, HAS-BLED, ORBIT, and $HEMORR_2HAGES$ are just some of the decision-support tools available to objectively weigh the risk of stroke and life-threatening bleeding from therpy.[10-15] Newer, novel oral anticoagulant agents (NOAC) provide a benefit/risk profile that may surpass warfarin, especially when considering initiation in the emergency department (ED).[16-18]

In this issue of *WestJEM*, Smith and colleagues present a prospective observational evaluation of anticoagulation prescribing practices in non-valvular AF. Patients presenting to one of seven Northern California EDs with AF at high risk for stroke were eligible unless admitted, not part of Kaiser Permanente of Northern California (KPNC), or already prescribed anticoagulation. During the 14-month study there were no departmental policies governing the initiation of anticoagulation in AF patients.

The authors report 27.2% of the 312 at high risk for stroke received a new anticoagulant at ED discharge, and only 40% were prescribed oral anticoagulation within 30 days of the index ED visit. Anticoagulation was more likely to be initiated in the ED if the patient was younger (age < 80), had persistent AF at discharge, or when cardiology was consulted during the index visit. Furthermore, only 60.3% of patients were given patient education material on AF in their discharge instructions.[19]

Critics of Smith et al. will take issue with their inclusion criteria that required participation in KPNC. By definition, all members of KPNC are insured; they also have guaranteed access to timely primary care follow-up and are of higher socioeconomic means than the general population.[20] Many of the factors that contribute to successful anticoagulation therapy – diet stability, monitoring of renal function, education and intervention of modifiable risk factors, smoking cessation, and fall risk – can all be assessed by a primary care physician and addressed with shared decision-making ensured in the KPNC system.[21]

While these limitations are acknowledged by the authors and narrow the generalizability of these findings, Smith and colleagues demonstrate the challenges of addressing ongoing chronic disease in the ED and highlight the complex decision-making required. AF patients without insurance in the U.S. lack reliable access to primary care, and emergency physicians (EPs) likely under-prescribe anticoagulation therapy due to an abundance of caution. EPs are poorly equipped to determine the burden of AF (i.e., is this isolated AF or recurrent and how often is the patient in it) or the origin of the arrhythmia (i.e., is it valvular?). Lacking the objective data to quantify these thromboembolic risk factors of AF, EPs are reluctant to initiate thromboprophylaxis, despite its known benefits, in light of the well-demonstrated risk for life-threatening bleeding.[22]

However, the risk is largely misperceived. Recent findings from the Spanish EMERG-AF trial demonstrate that initiating this therapy in the ED is at least as safe as in other settings

(i.e., in the outpatient clinic or during an inpatient stay) and has clear mortality benefit at one year. Furthermore, that benefit (i.e., stroke prevention) does not come at the expense of reduced effectiveness (i.e., more episodes of major bleeding) over the course of one-year follow-up.[23]

In addition to highlighting the challenges of prescribing anticoagulation in the ED setting, Smith et al. also illustrate the opportunity for EPs to prevent future strokes in the setting of known AF. This opportunity is likely larger than reported considering the limitations of this investigation (i.e., enrollment predicated upon KPNC participation). Thankfully, there are clear guidelines to assist EPs based upon validated methods of risk-stratification.[24,25] Furthermore, of those patients receiving anticoagulation therapy in the first 30 days, more than half were initiated in the ED. While these subjects likely represent the least complex decision-making, these results also suggest some prescribing inertia; anticoagulation was continued by the primary care physician because it has already been initiated in the ED.

Despite these limitations, Smith and colleagues demonstrate an immense target for EPs to improve stroke risk for at least 60% of AF patients discharged from the ED. Coupled with other evidence demonstrating that such practice is efficacious, safe, and cost effective, Smith makes a compelling case that thromboprophylaxis should be initiated in all but the most complex AF patients who will likely be admitted. EDs should develop policies to assure that AF patients can receive anticoagulation therapy on discharge. These local policies could include decision pathways that rely on guidelines, decision-support tools, and account for insurance status. As EPs, we should embrace the responsibility to provide thromboprophylaxis regardless of the likelihood of primary care follow-up. To defer that decision ignores the role emergency medicine plays in providing for the public health in the U.S., and frankly misses the mark.

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REFERENCES

1. Wolf PA, Abbott Rd, Kannel WB. Atrial fibrillation: a major contributor to strike in the elderly. The Framingham Study. *Arch Internal Med.* 1987;147(9):1561-4.
2. Go AS, Hylek EM, Phillips KA, et al. Prevalence of diagnosed atrial fibrillation in adults: national implications for rhythm management and stroke prevention: the AnTicoagulation and risk factors in atrial fibrillation (ATRIA) Study. *JAMA*. 2001;285(18):2370-5.
3. Centers for Disease Control and Prevention. Atrial Fibrillation Fact Sheet. Available at: https://www.cdc.gov/dhdsp/data_statistics/fact_sheets/fs_atrial_fibrillation.htm. Accessed February 17, 2018.
4. Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics—2017 update: a report from the American Heart Association. *Circulation*. 2017;135(10):e146-e603.
5. Atrial Fibrillation Investigators. Risk factors for stroke and efficacy of antithrombotic therapy in atrial fibrillation. *Arch Intern Med*. 1994;154(13):1449-57.
6. Stroke Prevention Atrial Fibrillation III Writing Committee. Patients with nonvalvular atrial fibrillation at low risk of stroke during treatment with aspirin: Stroke Prevention in Atrial Fibrillation III Study. *JAMA.* 1998;279(16):1273-7.
7. Stroke Prevention in Atrial Fibrillation Investigators. Predictors of thromboembolism in atrial fibrillation, I: clinical features of patients at risk. *Ann Intern Med.* 1992;116(1):1-5.
8. van Latum JC, Koudstaal PJ, Venables GS, et al. Predictors of major vascular events in patients with a transient ischemic attack or minor ischemic stroke and with nonrheumatic atrial fibrillation. *Stroke.* 1995;26:801-6.
9. Reiffel JA. Atrial fibrillation and stroke: epidemiology. *Am J Med*. 2014;127(4):e15-6.
10. Olesen JB, Lip GY, Hansen ML, et al. Validation of risk stratification schemes for predicting stroke and thromboembolism in patients with atrial fibrillation: a nationwide cohort study. *BMJ.* 2011;342:d124.
11. Boriani G, Botto GL, Padeletti L, et al. Improving Stroke Risk Stratification Using the $CHADS_2$ and CHA_2DS_2-VASc Risk Scores in Patients with Paroxysmal Atrial Fibrillation by Continuous Arrhythmia Burden Monitoring. *Stroke*. 2011;42(6):1768-70.
12. Fang MC, Go AS, Chang Y, et al. Comparsion of risk stratification schemes to predict thromboembolism in people with nonvalvular atrial fibrillation. *J AM Coll Cardiol.* 2008;51(8):810-5.
13. Van den Ham, H, Klungel O, Singer DE, Leufkens HGM, Van Staa TP. Comparative performance of ATRIA, $CHADS_2$, and CHA_2DS_2-VASc Risk Scores Predicting Stroke in Patients with Atrial Fibrillation. *J Am Coll Cardiol*. 2015;66(17):1851-9.
14. Apostolakis S, Lane DA, Guo Y, et al. Performance of the Hemorr(2) Hages, ATRIA, and HAS-BLED bleeding risk-prediction scores in patients with atrial fibrillation undergoing anticoagulation: The AMADEUS (evaluating the use of SR34006 compared to Warfarin or acenocoumarol in patients with atrial fibrillation) study. *J Am Coll Cardiol.* 2912;60(9):861-7.
15. Senoo K, Proietti M, Lane DA, et al. Evaluation of the HAS-BLED,

ATRIA, and ORBIT Bleeding Risk Scores in Patients with Atrial Fibrillation Taking Warfarin. *Am J Med*. 2016;129(6):600-7.

16. Almutairi AR, Zhou L, Gellad WF, et al. Effectiveness and safety of non-vitamin K antagonist oral Anticoagulants for atrial fibrillation and Venous Thromboembolism: A Systemic Review and Meta-analyses. *Clin Ther*. 2017;39(7):1456-1478.e36.
17. Friberg L, Oldgren J. Efficacy and safety of non-vitamin K antagonist oral anticoagulants compared with warfarin in patients with atrial fibrillation. *Open Heart.* 2017;4(2):e000682.
18. Patel P, Pandya J, Goldberg M. NOACs vs warfarin for stroke prevention in NOnvalvular atrial fibrillation. *Cureus.* 2017;9(6):e1395.
19. Vinson DR, Warton ME, Mark DG, et al. Thromboprophylaxis for Patients with High-risk Atrial Fibrillation and Flutter Discharged from the Emergency Department. *West J Emerg Med*. 2018;19(2)X-X.
20. Feachem RGA, Sekhri NK, White KL. "Getting more for their dollar: a comparison of the NHS with California's Kaiser PermanenteCommentary: Funding is not the only factor Commentary: Same price, better care Commentary: Competition made them do it." *BMJ*. (2002):135-143.
21. Panneerselvam S, Baglin C, Lefort W, et al. Analysis of risk factors for over-anticoagulation in patients receiving long-term warfarin. *Br J Hematol.* 1998;103(2):422-4.
22. Cotton BA, McCarthy JJ, Holcomb JB. Acutely injured patients on dabigatran. *N Engl J Med.* 2011;365(21):2039-40.
23. Coll-Vinent B, Martín A, Sánchez J, et al. Benefits of Emergency Departments' Contribution to Stroke Prophylaxis in Atrial Fibrillation. *Stroke*. 2017;48(5):1344-52.
24. Diener HC, Aisenberg J, Ansell J,et al. Choosing a particular oral anticoagulant and dose for stroke prevention in individual patients with non-valvular atrial fibrillation: part 1. *Eur Heart J*. 38(12):852-9.
25. January CT, Wann LS, Alpert JS, et al. 2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation*. 2014;130(23):e199-267.

Radial Arterial Lines Have a Higher Failure Rate than Femoral

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Introduction: Arterial lines are important for monitoring critically ill patients. They are placed most commonly in either femoral or radial sites, though there is little evidence to guide site preference.

Methods: This is an ambispective, observational, cohort study to determine variance in failure rates between femoral and radial arterial lines. This study took place from 2012 to 2016 and included all arterial lines placed in adult patients at a single institution. Causes of line failure were defined as inaccuracy, blockage, site issue, or accidental removal. The primary outcome was line failure by location. Secondary outcomes included time to failure and cause of failure.

Results: We evaluated 272 arterial lines over both arms of the study. Fifty-eight lines eventually failed (21.32%). Femoral lines failed less often in both retrospective (5.36% vs 30.71%) and prospective (5.41% vs. 25.64%) arms. The absolute risk reduction of line failure in the femoral site was 20.2% (95% confidence interval [3.7 - 36.2%]). Failures occurred sooner in radial sites compared to femoral. Infection was not a significant cause of removal in our femoral cohort.

Conclusion: Femoral arterial lines fail much less often then radial arterial lines. If placed preferentially in the femoral artery, one line failure would be prevented for every fourth line. [West J Emerg Med. 2018;19(2)364-371.]

INTRODUCTION

Arterial lines are important for monitoring and providing care to critically ill patients. Not only do they allow for rapid access to blood, but they also allow a provider continuous access to the patient's blood pressure, which enables minute titration of vasoactive medications. Traditionally there are two locations for arterial line placement: femoral and radial arteries. The choice between sites is often made according to the provider's preference with very little evidence guiding this decision.[1] Although initial beliefs that arterial lines are immune to infection are certainly unfounded,[2,3,4] there is evidence that the infection risk is proportionally similar to their central venous counterparts regarding location.[5,6]

New evidence has shown that femoral, central venous catheter infection risk is likely overestimated in the modern era of sterile placement and surveillance.[7,8] It has also been shown repeatedly that central arterial monitoring provides different information from both peripheral and non-invasive monitoring.[9,10,11] Older studies have shown that the femoral artery is superior to the radial artery for blood pressure monitoring, but these results come from a different era of medicine when placement technique was different and the landscape of monitoring was not what it is today.[12] It is therefore important to reinvestigate femoral artery access in today's environment. Line failure adds significant and unnecessary costs to the treatment of critically ill patients, including financial costs (supplies), time

(additional procedure), and health (risk of additional procedure to patient as well as time without critical monitoring). In the present study, we attempt to determine if one site is more prone to failure.

Population Health Research Capsule

What do we already know about this issue?
Arterial lines are placed predominantly in the radial and femoral arteries with little known about the site selection effect on patient outcomes.

What was the research question?
Is there a difference in failure rates between arterial lines placed in the radial artery compared with the femoral artery?

What was the major finding of the study?
Femoral Arterial lines failed at a significantly reduced rate as compared to their radial counterparts.

How does this improve population health?
If arterial monitoring is expected for significant amount of time then choosing a site which is less prone to failure leads to improved monitoring and less need for line replacement.

METHODS

We performed an ambispective, observational, cohort study to determine variance in failure rates between femoral and radial arterial lines. This study took place at a single center, a county teaching hospital with 12 adult ICU beds, and was approved by our institutional review board. Any patient with an arterial line placed anywhere in our hospital (in the intensive care unit [ICU], emergency department [ED], and operating rooms) met our inclusion criteria. Providers at our site were not using ultrasound for arterial line placement routinely, so this metric was not evaluated.

Although the specific indication for arterial line placement was not captured in our study, it is customary at our institution to place arterial lines for either ongoing titration of vasopressor agents or expected repeated evaluation of the management of patients with ventilatory support. Our institution uses the Arrow RA-04020 quick kit for radial arterial lines, which is a 20-gauge, 4.25 cm catheter. The Arrow select kit (ASK-04510-UMP) is used for femoral lines, which is also a 20-gauge catheter, though 12 cm in length. All patients in our study were admitted to an ICU bed and were therefore of high acuity. Exclusion criteria were patient age < 18 years old and line removal before 24 hours.

We performed the retrospective arm of this study using the hospital billing database. Records from every patient who received and was successfully billed for an arterial line between January 2012 and June 2015 in our hospital were included. Research assistants (RAs), who were blinded to the study hypothesis (though educated on what an arterial line is), were provided a training presentation on how to extract relevant information from the electronic health record (EHR), including patient's age, line insertion time, line removal time, and whether line removal was due to failure. We compiled their results into a database, and a pilot quality inprovement study was initially performed on every 20th patient in the study. The two principal investigators then reviewed the data to ensure that data acquisition was accurate between all RAs, demonstrating reliable inter-observer agreement regarding insertion and removal dates and classification of line failure. After confirming that our proposed method of data acquisition was precise, the RAs performed the complete review on the total cohort and the acquired data was kept in a spreadsheet without analysis until the prospective portion of the study was completed.

The prospective arm of the study took place from June 2015 to March 2016. RAs obtained information on every adult patient in whom an arterial line was placed in our hospital during the enrollment period. To ensure capture of all patients, RAs would observe each ICU bed and ED resuscitation bay for new arterial lines three times daily. They compiled an ongoing list of known lines, noting the time of insertion, location of the line (radial vs. femoral), patient age, and patient comorbidities. If the arterial line was found to have been removed, the RAs would document the time of removal and determine why the line had been removed (or if the patient had died), noting whether it was considered a failure and if it was replaced. The RAs obtained this information from nursing flow sheets or nursing interview at the time of their evaluation. Causes of failure included the following: 1) inaccuracy (if a patient was still on vasoactive medications or there was signal dampening or a large discrepancy between noninvasive blood pressure cuff and arterial line), 2) blockage (line would not draw or ABGs still routinely drawn at the time of removal), 3) site issue (hematoma, swelling, concern for infection or neuropathy), and 4) accidental removal (as documented by nursing).

We hypothesized a 2x greater failure rate of radial arterial lines compared to femoral amounting to a 50% reduction in

failure rate by placing the line in the femoral artery. We postulated a 60% radial and 40% femoral distribution of line placement, based on observance of local practice. We calculated that 128 patients would provide sufficient power to detect the hypothesized failure rate if lines were split evenly between the two sites. We therefore planned to enroll 200 patients as the actual distribution was not known a priori. We chose an ambispective design as the EHR made retrospective data acquisition easy, allowing for greater power to the study. We subsequently used the prospective data to help validate our retrospective findings.

RESULTS

In total, we evaluated 272 arterial lines over both the prospective and retrospective arms of our study, with 58 lines leading to failure for a combined total failure rate of 21.32%. Comorbidities between the two cohorts were similar, as shown in the Table. Our retrospective arm screened 304 arterial lines; however, only 196 (140 radial and 56 femoral) met criteria for analysis over the three-and-a-half years (Figure 1). The radial cohort had 43 failures (30.71%) and the femoral cohort had three failures (5.36%), for an absolute risk reduction for failure of 25.4% (95% CI [13.7 - 34.2%]) if the femoral site was chosen (Figure 2).

The prospective arm had 76 total lines, which included 39 radial and 37 femoral. The radial cohort had 10 failures (25.64%) and the femoral cohort had two failures (5.41%) (Figure 3). This similarly provided an absolute risk reduction of 20.2% (95% confidence interval [CI] [3.7 – 36.2%]) in failure rate if a femoral line was placed instead of a radial arterial line. This outcome was consistent between the retrospective and prospective arms of the trial and led to a number needed to treat (preference of femoral line over radial) of 4.1 patients to prevent one line failure.

Secondary outcomes evaluated include time to failure and cause of failure. Combined data showed the median time to failure for radial lines as two days compared to femoral lines having a median time to failure of four days. From the prospective data, the primary causes of failure for the radial lines were accidental removal (40%), a line not drawing (30%), and inaccurate readings (30%). There were no radial lines removed due to "site issue" (which would include infection) in our prospective arm; however, such issues were responsible for 15% of radial removals in our retrospective arm. Conversely, accidental removal accounted for only 5% of all removals in the retrospective cohort of radial lines but 40% of failures in the prospective arm. In the femoral cohort, site issues and inaccuracies were the causes of two of the removals, and inability to draw was the cause for removal in a single patient. Accidental removal did not occur in the femoral cohort.

Mortality data was only monitored in the prospective arm and included only patients with an arterial line in place at the time of death or patients who died shortly after line removal as we did not follow patients beyond line removal. There were 11 deaths in the femoral cohort, with none occurring in patients with prior femoral line failures. There were seven deaths in the radial cohort, with three of those occurring in patients with prior radial line failures. Of the three deaths attributed to patients with radial line failures, one of these failed lines was replaced in the other radial artery (failed due to inaccuracies), one was replaced in a femoral artery (failed due to accidental removal), and one was not replaced (failed due to accidental removal).

DISCUSSION

To our knowledge, this is the first study to compare failure rates by arterial line site in the last 35 years. Soderstrom et al. in 1982 also showed differences in "placement duration" and "longevity" when comparing arterial line sites, with results favoring the femoral site. Their data was similar to ours in that it showed a femoral failure rate of 10.6% compared to 26.4% for radial sites, with failures occurring on average 3.5 days sooner in their radial cohort.[12] Our data likewise demonstrate that femoral arterial lines fail at a significantly lower rate than radial arterial lines (5.38% compared to 29.61%). Despite making up 34% of the lines placed, they accounted for only 8.6%

Table. Comorbidities across cohorts in a study comparing failure rates by arterial line site

	Radial	(%)	Femoral	(%)	P
Comorbidities	N = 179	-	N = 93	-	
Alcohol use	21	(11.73%)	10	(10.75%)	0.810
Chronic kidney disease	4	(2.23%)	5	(5.38%)	0.171
Congestive heart failure	9	(5.03%)	5	(5.38%)	0.904
Coronary artery disease	11	(6.15%)	7	(7.53%)	0.667
Diabetes	32	(17.88%)	15	(16.13%)	0.712
Hypertension	46	(25.70%)	22	(23.66%)	0.711

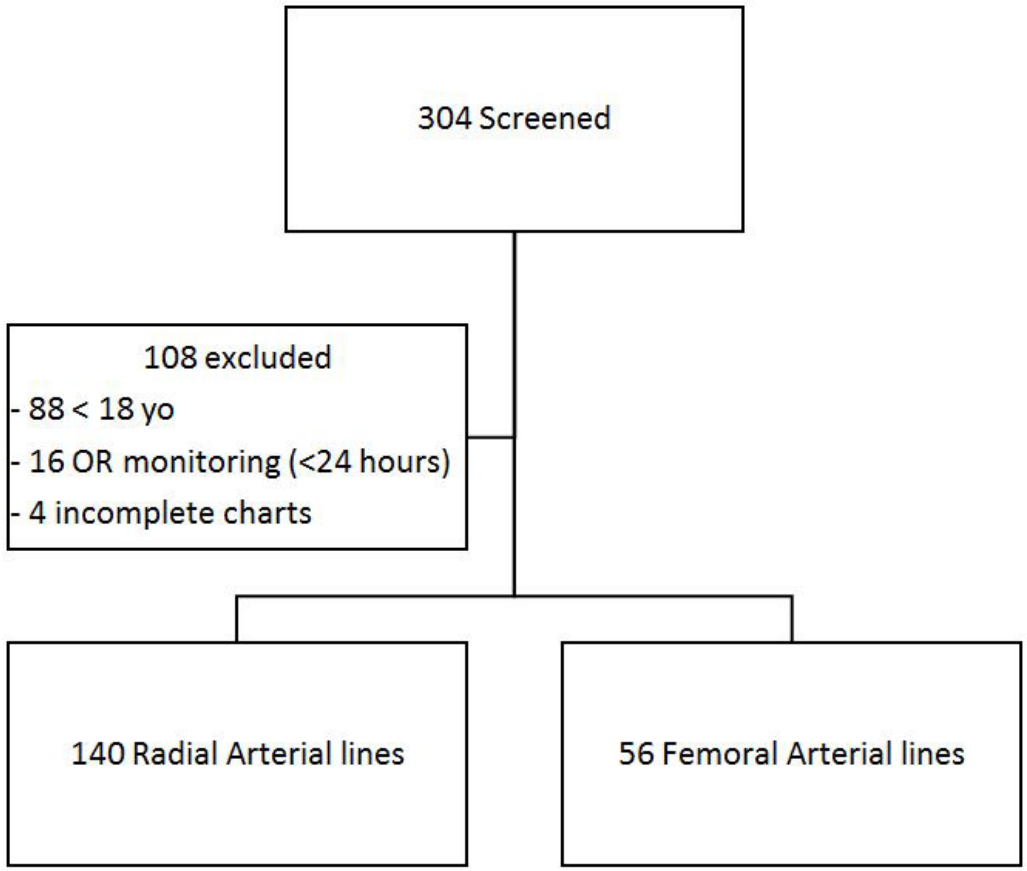

Figure 1. Retrospective patient selection for comparison of radial vs. femoral arterial lines.

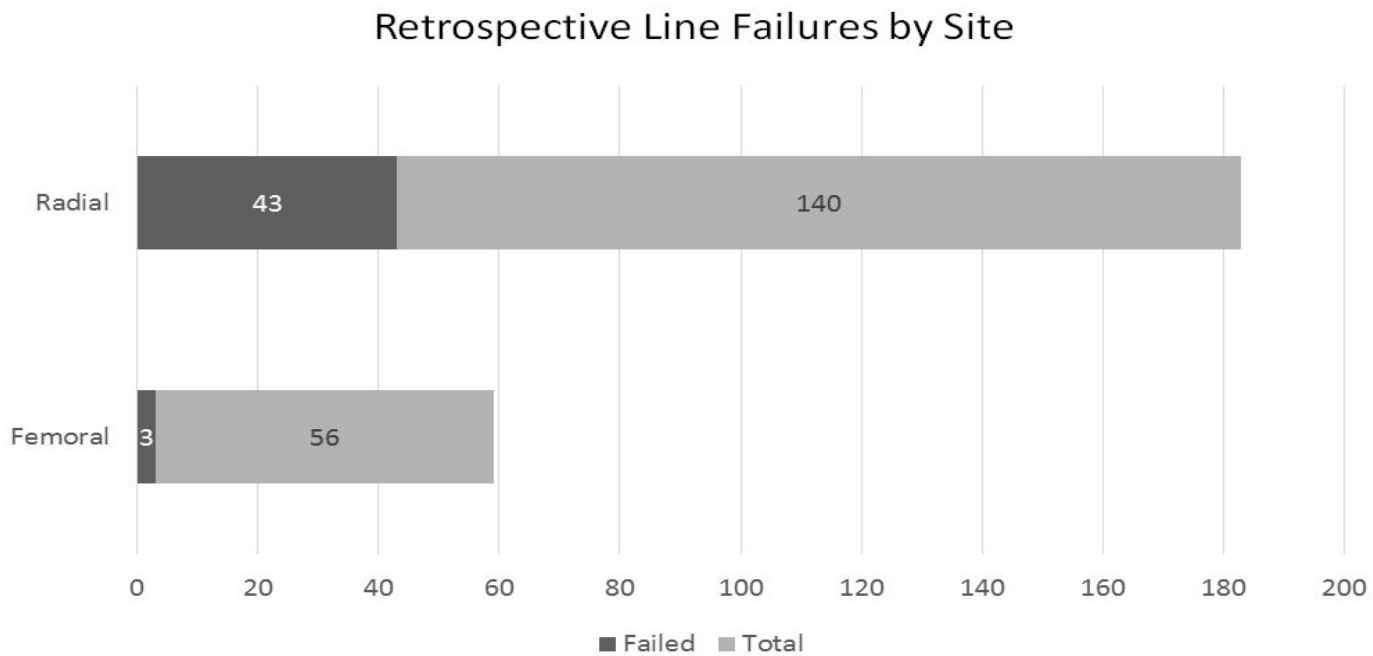

Figure 2. Arterial line failure by site from retrospective data. Femoral lines failed 5.36% of the time (3 of 56) as compared to radial lines, which failed 30.17% of the time (43 of 140).

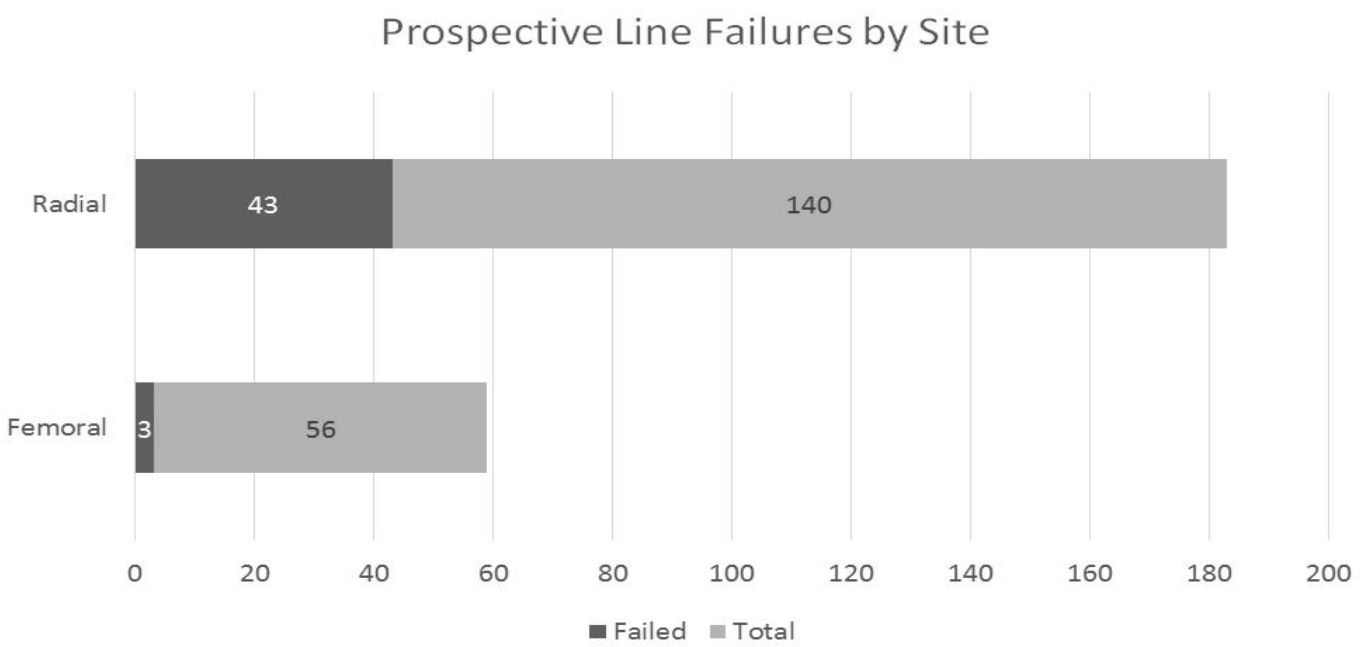

Figure 3. Arterial line failure by site from prospective data. Femoral lines failed 5.41% of time (2 of 37) as compared to radial lines, which failed 25.64% of the time (10 of 39).

of the lines that failed (Figure 4). This difference was consistent in both the retrospective and prospective arms of the study, exhibiting agreement between the two data groups. This gives a number needed to treat of only four patients: four patients preferentially receiving a femoral arterial line prevents one premature line failure.

We believe that no meaningful conclusion can be drawn from the data regarding mortality, as we did not follow patients beyond removal of their arterial lines. Additionally, the comorbidity data is likely incomplete given the low prevalence of classical diseases in this critically ill population. This is likely due to limitations of our retrospective review, including incomplete charting and a lack of emphasis on this data during collection.

This study was also not designed to evaluate the reason for a provider's site preference. At the institutional level, radial lines are preferred over femoral, and this likely instilled selection bias, though to what extent is unclear. If radial lines are preferred by default, then femoral lines might have been placed in cases where there were radial site issues or in patients with higher acuity. Femoral lines might also have been placed after multiple radial attempts failed, or even after a placed radial line failed in the first 24 hours, which would not have been caught by our study (as lines less than 24 hours were excluded). These factors should have selected for a sicker population in the femoral cohort, though this did not lead to increased line failure rates. An alternative argument could be made that because the femoral cohort were sicker, they may have gotten more attention by nursing staff and thus better line care (Hawthorne effect). The possibility of this effect is mitigated, however, by the prospective arm: in this phase nursing staff was aware of the study and yet the line failure rates remained consistent to the retrospective data in each site.

The length of time in which the lines failed also favors femoral line placement. Of the failed arterial lines, the average times of failure for the femoral and radial cohorts were four and two days after placement, respectively. Still, not all radial lines in our study failed within two days, with some radial lines lasting 17 days; however, it is impossible to know which lines are going to fail in advance, and our data indicates that radial lines on average fail earlier in the course.

Although we would have liked to draw conclusions as to why lines failed, our study with only 58 total failures was not adequately powered to draw meaningful conclusions in this area. The ambispective design also makes it difficult to compare causes of failure between the two groups due to the ambiguity of etiology in the retrospective charting. We attempted to account for this in the prospective arm by having the RAs determine the cause of removal from the nursing staff that had direct care of the patient. Our data between the two groups is comparable in this respect, adding strength to our retrospective methods. Furthermore, the length difference between the arterial

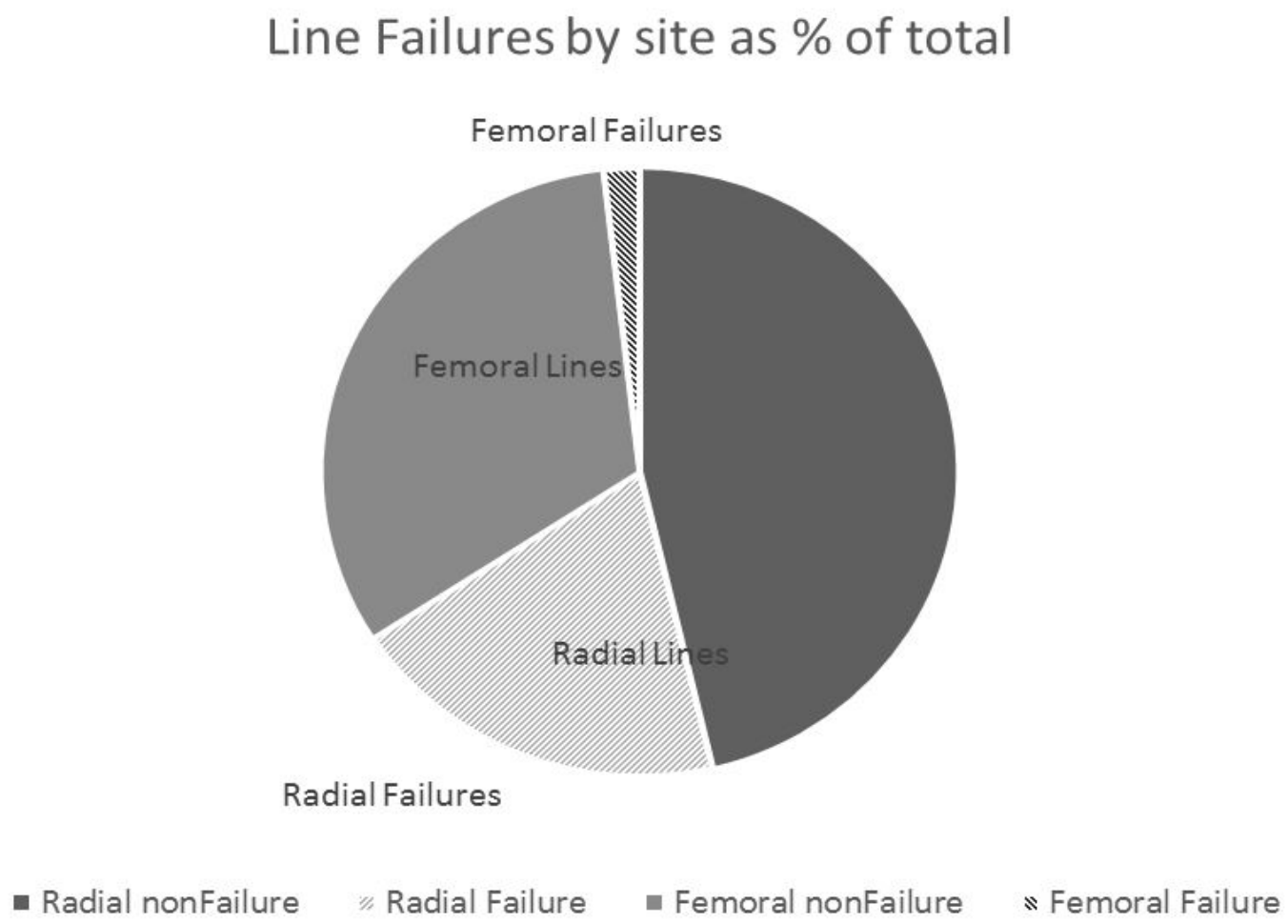

Figure 4. Arterial line failure as % of total, with hashed areas representing failure rates. Femoral failure rates are proportionally much smaller than their radial counterparts.

lines could have an effect on line longevity, but this does not change the fact that femoral lines failed less often. Longer, wider catheters in the radial artery are likely to increase complications, given the increasing risk for ischemia at this site.

Our study suggests that femoral lines were well tolerated with minimal infectious risk. Only one of 93 femoral arterial lines were removed for "site issues". Note that in designing this study, we wanted to be broad in our attribution of "infection" and thus specified a broader category of "site issue" (rather than "infection") as a cause of line failure. In retrospect, it would be favorable to define why this one patient's line was removed (e.g., was it due to hematoma, infection, or some other cause?). This particular line failed after six days and was replaced with another femoral line.

Patients who died early in their disease course may not have had enough time for the line to fail, and this could have led to dilution of the failure rates among sites. Additionally, lines that were not adequate at insertion or were tenuous would increase the number of failures inappropriately as they were likely to get replaced quickly. The retrospective cohort is at greatest risk of being affected by these confounders as providers were unlikely to add additional billing codes for lines replaced rapidly in the same day. We attempted to control for both issues by only including lines surviving greater than 24 hours. The prospective data matching the retrospective rates also gives confidence that we monitored true failure rates.

LIMITATIONS

This was a single-center study performed at a county teaching hospital with only 12 adult ICU beds, which partially accounts for the small volume of patients over the four-year period of the study. Additionally, our retrospective arm relies on a billing database, which

certainly does not capture all lines placed during this period. Several factors would contribute to loss of capture, though we suspect, based on observed practice, that lack of appropriate billing code assignment and documentation of placement in individual procedure notes accounted for the majority of lost lines in the database. The prospective arm remedies this in that RAs observed every bed that might have held a patient with an arterial line three times daily. We believe this is why there were 76 patients captured in the nine months of the prospective arm (8.4 patients/month), and only 196 patients captured in the 42 months of the retrospective arm (4.6 patients/month). The external validity of our study may be limited due to the size of our hospital and ICU; however, we would argue that these are in fact the locations where line failures can be the most detrimental, straining a system already stretched thin.

Given the observational nature of our study, we were not immune to selection bias and it is impossible to determine why one site was chosen over another site by each individual provider. We noticed that more often, patients were given a femoral line as a rescue from a radial line failure, and thus the lines may have been placed at times when the patient's illness was further along and possibly improving. However this still would not account for the extended time to failure seen in the femoral cohort. Line site preference did change (from 28% femoral placement during the retrospective arm of the study to 49% femoral placement during the prospective arm), which may be due to a change in local culture, a change in perception of femoral line risk given new literature, more complete capture of all lines placed, or even a Hawthorne effect (though this effect is unlikely as many line placements in this portion of the study were performed by providers unaware of the study). It is also likely that many lines were not captured in our retrospective arm as stated above. A better understanding of the differences between the patient groups (demographics, diagnosis, and true mortality rates), as well as the reasons why a site was chosen, was not captured in our study but would be interesting to study in another, larger trial.

CONCLUSION

These data show that femoral lines fail far less often than radial arterial lines and when they do fail, it occurs later in the patient's treatment. Further study should endeavor to confirm these findings across multiple centers and practice styles, including at larger institutions and with the use of ultrasound for placement. If it is in fact determined that arterial line failure rates could be reduced from almost 30% to 5% simply by privileging femoral over radial sites, that would lead to significant gains in patient care in terms of less time unmonitored, less exposure to risk, and lower cost to the healthcare system.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

REFERENCES

1. Frezza EE, Mezghebe H. Indications and complications of arterial catheter use in surgical or medical intensive care units: analysis of 4932 patients. *Am Surg.* 1998;64(2):127-31.
2. Thomas F, Burke JP, Parker J, et al. The risk of infection related to radial vs femoral sites for arterial catheterization. *Crit Care Med.* 1983;11(10):807-12.
3. Lucet JC, Bouadma L, Zahar JR, et al. Infectious risk associated with arterial catheters compared with central venous catheters. *Crit Care Med*. 2010;38(4):1030-35.
4. O'Horo J, Maki D, Krupp A, et al. Arterial Catheters as a source of bloodstream infection: a systematic review and meta analysis. *Crit Care Med*. 2014;42(6):13343-9.
5. Traoré O, Liotier J, Souweine B. Prospective study of arterial and central venous catheter colonization and of arterial and central venous catheterrelated bacteremia in intensive care units. *Crit Care Med.* 2005;33(6):1276-80.
6. Koh DB, Gowardman JR, Rickard CM, et al. Prospective study of peripheral arterial catheter infection and comparison with concurrently sited central venous catheters. *Crit Care Med* 2008;36(2)397-402.
7. Marik PE, Flemmer M, Harrison W. The risk of catheterrelated bloodstream infection with femoral venous catheters as compared to subclavian and internal jugular venous catheters: a systematic review of the literature and metaanalysis. *Crit Care Med.* 2012;40(8):2479-85.
8. Parienti JJ, Mongardon N, Mégarbane B, et al. 3SITES Study Group. Intravascular complications of central venous catheterization by insertion site. *N Engl J Med.* 2015;373(13):1220-9.
9. Dorman T, Breslow MJ, Lipsett PA, et al. Radial artery pressure monitoring underestimates central arterial pressure during vasopressor therapy in critically ill surgical patients. *Crit Care Med*. 1998;26(10):1646-9.
10. Galluccio ST, Chapman MJ, Finnis ME. Femoralradial arterial

pressure gradients in critically ill patients. *Crit Care Resusc.* 2009;11(1):348.

11. Kim S, Lilot M, Kulraj SS, et al. Accuracy and precision of continuous noninvasive arterial pressure monitoring compared with invasive arterial pressure: a systematic review and meta-analysis. *Anesthesiology*. 2014;120(5):1080-97.

Evaluation of a Novel Handoff Communication Strategy for Patients Admitted from the Emergency Department

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Introduction: Miscommunication during inter-unit handoffs between emergency and internal medicine physicians may jeopardize patient safety. Our goal was to evaluate the impact of a structured communication strategy on the quality of admission handoffs.

Methods: We conducted a mixed-methods, pre-test/post-test study at a 560-bed academic health center with 60,000 emergency department (ED) patient visits per year. Admission-handoff best practices were integrated into a modified SBAR format, resulting in the Situation, Background, Assessment, Responsibilities & Risk, Discussion & Disposition, Read-back & Record (SBAR-DR) model. Physician handoff conversations were recorded and transcribed for the 60 days before (n=110) and 60 days after (n=110) introduction of the SBAR-DR strategy. Transcriptions were scored by two blinded physicians using a 16-item scoring instrument. The primary outcome was the composite handoff quality score. We assessed physician perceptions via a post-intervention survey.

Results: The composite quality score improved in the post-intervention phase (7.57 + 2.42 vs. 8.45 + 2.51, p=.0085). Three of the 16 individual scoring elements also improved, including time for questions (70.6% vs. 82.7%, p=.0344) and confirmation of disposition plan (41.8% vs. 62.7%, p=.0019). The majority of emergency and internal medicine physicians felt that the SBAR-DR model had a positive impact on patient safety and handoff efficiency.

Conclusion: Implementation of the SBAR-DR strategy resulted in improved verbal handoff quality. Agreement upon a clear disposition plan was the most improved element, which is of great importance in delineating responsibility of care and streamlining ED throughput. Future efforts should focus on nurturing broader physician buy-in to facilitate institution-wide implementation. [West J Emerg Med. 2018;19(2)372-379.]

INTRODUCTION

Patient care handoffs are a potentially vulnerable time for patient safety.[1-5] Sub-optimal handoff communication is a common cause of medical errors[6] and malpractice claims.[7, 8] Handoff research has primarily focused on communication within a specialty or unit, such as those occurring at shift change. Recently, there has been increased focus on inter-unit handoffs, which occur when patients are transitioned between services, departments, or institutions.[9] The inter-unit admission handoff between emergency physicians (EP) and inpatient providers is a

particularly important example. The emergency department (ED) admission process involves changes in the healthcare team and physical location of the patient.[10] Unstructured communication, inter-disciplinary conflict, patient throughput pressures, and uncertain assignment of responsibilities may further impede safe care transitioning from the ED to inpatient setting.[9-13] Survey studies have found that one-third of physicians know of adverse patient events related to the admission handoff process.[10, 13]

Standardized handoff communication tools have been shown to improve outcomes for inter-unit handoffs,[6] but they have not been widely implemented for admission handoffs. A survey of 750 physicians at 10 sites found that only 18% of EPs and internal medicine (IM) physicians used a standardized admission-handoff tool and only one-third of residents received handoff training.[14] Although many handoff mnemonics exist in the literature,[15-17] Situation, Background, Assessment, and Recommendation (SBAR) is the most commonly used,[18] and is promoted by regulatory and professional organizations, including the Agency for Healthcare Research and Quality[19] and Institute for Healthcare Improvement.[20]

In 2012 Beach et. al. published best practice recommendations for ED-to-inpatient handoff communication, including style, form and content. They suggested synchronous, two-way, closed-loop communication, with the goal of constructing a shared mental model of patient care between EPs and IM providers. Rather than rote recitation of data, it was suggested the content of handoff communication should focus on clinical judgment, diagnostic uncertainty, the patient's clinical trajectory, pending tasks, and any patient- or system-level considerations that may impact care.[21]

A study in 2016 found that a standardized method of handoff for patients admitted to a geographically isolated, 35-bed community hospital from the ED resulted in fewer physician-reported "defective" handoffs;[22] however, it is unknown if these findings are applicable to larger academic health centers that have unique complexities, including multiple admitting services with variable processes and trainees at various levels of training.[13] The goal of this study was to pilot test a standardized process to improve admission handoff communication between EPs and IM physicians by integrating best-practice recommendations with a modified SBAR format, resulting in the Situation, Background, Assessment, Responsibilities & Risks, Discussion & Disposition, Read-back & Record (SBAR-DR) model. We hypothesized use of SBAR-DR would improve the quality of inter-unit handoff communication for patients admitted from the ED.

Population Health Research Capsule

What do we already know about this issue?
Inter-unit handoff from the ED to the inpatient setting is a vulnerable time for patient safety, but little research has investigated strategies to improve this process.

What was the research question?
How would a structured communication strategy impact the quality of handoffs between emergency physicians and internal medicine physicians?

What was the major finding of the study?
The admission handoff quality score improved following the intervention (7.6 vs. 8.5, p=.0085).

How does this improve population health?
Improving handoff practices has the potential to improve the care of the 12 million people/ year admitted to the hospital from the ED.

METHODS

Design and Setting

We conducted a mixed-methods, pre/post-study of admission handoff quality in conjunction with the implementation of the SBAR-DR strategy for admission handoff communication between EPs and IM physicians. The intervention took place at a 560-bed, Midwestern academic health center. The ED is a certified Level I trauma center with 60,000 patient visits per year, 15,000 inpatient admissions per year, and an emergency medicine (EM) residency program with 27 trainees. The IM service includes teaching and non-teaching teams, which admit approximately 6,000 patients per year, 60% of which are through the ED. The IM residency program has approximately 80 house officers. Prior to the intervention, there was no institutional standardized verbal or written handoff strategy. The project team consisted of resident and faculty physicians from EM and IM, as well as an educational expert specializing in training and performance improvement.

Verbal Handoff

The research team conducted iterative rounds of analysis to integrate admission handoff best practices[21] into a modified SBAR format,[23] resulting in the SBAR-DR model. Within each section there was clearly defined clinical information and communication guidance (Figure 1). For example, physicians were instructed to discuss severity of illness based on a three-tier system,[24] ask clarifying questions, come to explicit agreement on the disposition plan, and use closed-loop communication. The transfer of patient care responsibility from EP to IM physician was linked to placement of an

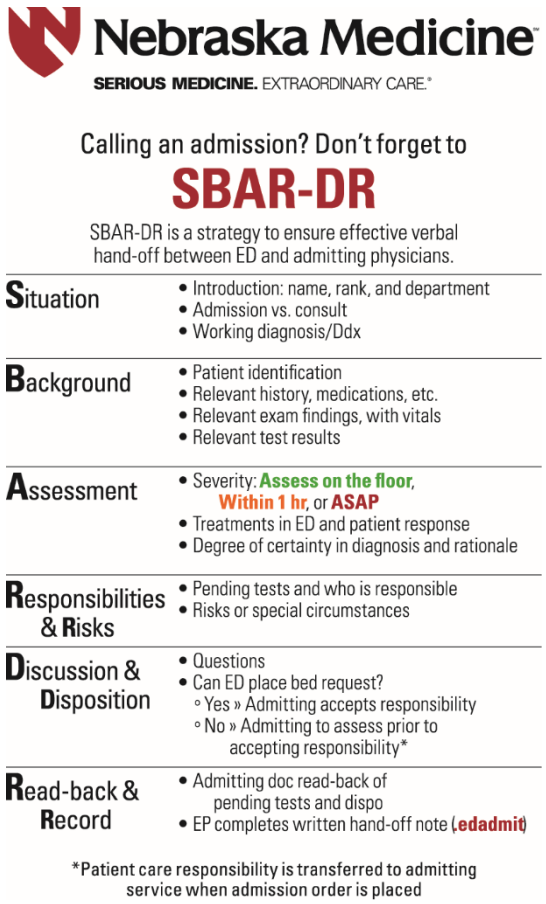

Figure 1. Situation, Background, Assessment, Responsibilities & Risks, Discussion and Disposition, Read-back & Record (SBAR-DR) format for admission handoffs.

admission order, so as to remove ambiguity. Finally, EPs were asked to create a written handoff with the electronic health record (EHR) using an admission handoff template, further described below.

Written Handoff Template

An admission handoff template was created within the EHR to supplement verbal handoff. The template was designed as an editable macro that could quickly be imported into the EP note. The template included headings for working diagnosis, description of the ED course, and a drop-down menu to list potential risks to patient care (e.g., prolonged boarding times). Data on pending tests and medications administered were automatically imported into the template. A definitive assignment of care responsibilities was documented at the end of the note, along with pager numbers for the appropriate admitting service to facilitate communication with ED nursing and ancillary staff. The EP completed the handoff note immediately after completion of the verbal admission handoff.

Education

The research team developed an educational session that included a discussion of admission handoff best practices, a review of internal handoff data, and introduction to the verbal and written elements of the SBAR-DR model. The training included review and group discussion of two videos, one demonstrating poor handoff communication and one demonstrating high-quality communication using SBAR-DR.[25] Resident and faculty physicians in EM and IM underwent training at required meetings in the two weeks prior to the introduction of the SBAR-DR process. Each session took approximately 30 minutes to complete. To reinforce the training, badge and pocket cards illustrating the SBAR-DR format were given to all participants. SBAR-DR posters were placed in the ED near recorded phone lines and in IM physician work rooms where they typically received admission handoff calls.

Data Collection

Handoff recordings

Admission handoff conversations were recorded from two labeled ED telephone lines using a HIPAA-compliant online recording program for 60 days prior to (January 21 – March 21, 2015) and 60 days following (April 9 – June 7, 2015) the implementation of the SBAR-DR process. Participants were emailed consent cover letters prior to the start of the intervention to notify them that their calls could be recorded.

Calls from the recorded phone lines were initially screened based on length of call and excluded if less than 25 seconds. The remaining calls were reviewed three times by a member of the research team (RB), and were excluded if they did not concern an inpatient admission, involved admitting services other than IM, or the screener deemed the recording quality did not allow accurate evaluation (e.g., unintelligible or prematurely cut off). Eligible calls underwent stratified random sampling to achieve the pre-determined sample size. (See below.) We used sample stratification to ensure that the distribution of EP training level within the cohort of eligible calls was similar to the distribution in the final pre-/post-intervention samples. Recordings were de-identified and transcribed verbatim by a hospital-approved, independent third party.

Transcription Scoring

We created a 16-point scoring instrument reflecting the best practice recommendations used in creating SBAR-DR.[21] Each element was scored as "communicated" or "not communicated," based upon pre-defined requirements (Appendix). The scoring instrument was pilot tested on 15 sample cases, with revisions made based upon scorers' feedback until consensus was reached.

Admission handoff transcripts were randomly assigned and independently scored by one of three dyads. Each of the dyads

were comprised of one EP and one IM physician of similar training level to minimize the potential for undue influence. The dyads were blinded to physician- and patient-identifying information and whether the transcription was from the pre- or post-intervention group. Scoring disagreements were settled by consensus via in-person conference of dyad members.

The primary outcome was the composite admission handoff score (0-16 points), which was determined by summing the "communicated" elements of the transcribed verbal handoffs. Secondary outcomes included frequency of individual handoff elements; a global rating based on an anchored, five-point scale; and average length of handoff calls.

Survey

We developed a post-intervention survey to assess EPs' and IM physicians' perceptions of the SBAR-DR strategy. Questions focused on patient safety and efficiency using a five-point, Likert-like scale. Before distribution, the survey was pilot tested for clarity and face-validity by two EPs and three IM physicians. A consent cover letter and link to an anonymous online survey was sent to eligible participants via their university email accounts. Participants who reported they had not participated in an ED admission handoff during the study period were excluded from the analysis.

Analysis

Unpublished pilot data demonstrated that handoff scoring elements were communicated 30% of time. Anticipating a 25% absolute improvement,[6] we determined that to achieve a 90% power with a significance level of 5% or less would require 87 pre-intervention and 87 post-intervention handoffs. Our estimation that up to 20% of calls might meet exclusion criteria during the scoring phase resulted in a final sample size of 110 pre- and 110 post-intervention admission handoffs.

We compared mean composite admission handoff quality scores and global rating scores using a t-test. Individual scoring elements were compared using chi-square tests. We calculated percent agreement and kappa statistics to determine inter-rater reliability for scoring elements. For the composite quality score and global rating scale, a general linear model was fit that included fixed-effect terms for time period (pre- or post-), EP training level, and the interaction of time period by training level. Type III tests were performed and, if significant, were followed by analysis of all possible pairwise comparisons of interest.

We calculated descriptive statistics for physician survey responses and handoff template use within the EHR. The method in which the written note was coded did not allow for analysis beyond descriptive terms and only produced data in the form of general use counts. Statistical calculations were completed using IBM SPSS v 22 and PC SAS version 9.4. We considered p-values of <0.05 statistically significant. This research project was approved for exempt status by the local institutional review board (#729-14-EX).

RESULTS

Approximately 14,400 calls took place on the recorded phone lines over the study period, with 20% lasting >25 seconds (Figure 2). After review, 332 calls (175 pre- and 157 post-intervention) met inclusion criteria, with 220 used in the final analysis (110 pre- and 110 post-intervention). Table 1 displays the handoff characteristics and admission-handoff quality scoring before and after introduction of SBAR-DR. For the primary outcome, there was a significant increase in composite quality score in the post-intervention recordings (mean 7.57 ± 2.42 vs. 8.45 ± 2.51, p=0.009). Individual content areas that showed improvement included opportunities to ask questions (70.6% vs. 82.7% p=0.034), agreement about disposition plan (41.8% vs. 62.7% p=0.002), and adherence to the SBAR-DR format (17.2% vs. 29.1% p= 0.038). There was a trend towards significance for stating severity of illness (7.3% vs 14.5% p=0.084), and use of closed-loop communication (27.3% vs. 38.2% p=0.085).

The inter-rater agreement for SBAR-DR scoring elements was moderate (0.41-0.60) to substantial (0.61-0.80) as measured by Cohen's kappa.[26] There was no significant difference in the global rating scale (2.95 +/- 0.85 vs. 3.09 +/- 0.85. p= 0.236). The mean handoff duration was longer in the post-intervention phase (2:15 minutes vs. 2:28 minutes, p=0.016). When analyzing scores based on EP training level, Postgraduate year 3 residents demonstrated significant improvement in composite quality scores (7.2, standard deviation [SD] 2.3 vs. 9.0, SD 2.3, p<0.01) and global rating score (2.8, SD 0.8 vs. 3.2, SD0.7, p=0.02). There were no statistically significant changes within other levels of training. The written handoff template was used for 51% of eligible admissions during the study period (329/642 admissions).

The post-intervention survey response rate was 50% for EPs (19/38) and 66% for IM physicians (20/30). Table 2 illustrates physicians' perceptions of the SBAR-DR model. Overall, the majority of EPs and IM physicians felt that using SBAR-DR had a positive impact on patient safety and efficiency compared to prior handoff strategies.

DISCUSSION

We found that the introduction of a standardized handoff process for patients being admitted from the ED to hospital setting resulted in improvements in verbal handoff quality. The driver of improvement was primarily due to improvements in opportunities for questions and reaching unambiguous agreement regarding patient disposition. Interactive questioning during handoffs is recommended by regulatory agencies[27] and practice guidelines.[21] Not only does this support clarifications and error-correction, but it also facilitates anticipatory guidance, reframing of the clinical picture, and creation of a shared mental model of patient care.[28]

Explicit agreement in disposition plan was also an important improvement. Uncertain assignment of responsibility is a known barrier to safe care transitions.[10, 13] EPs and IM physicians are

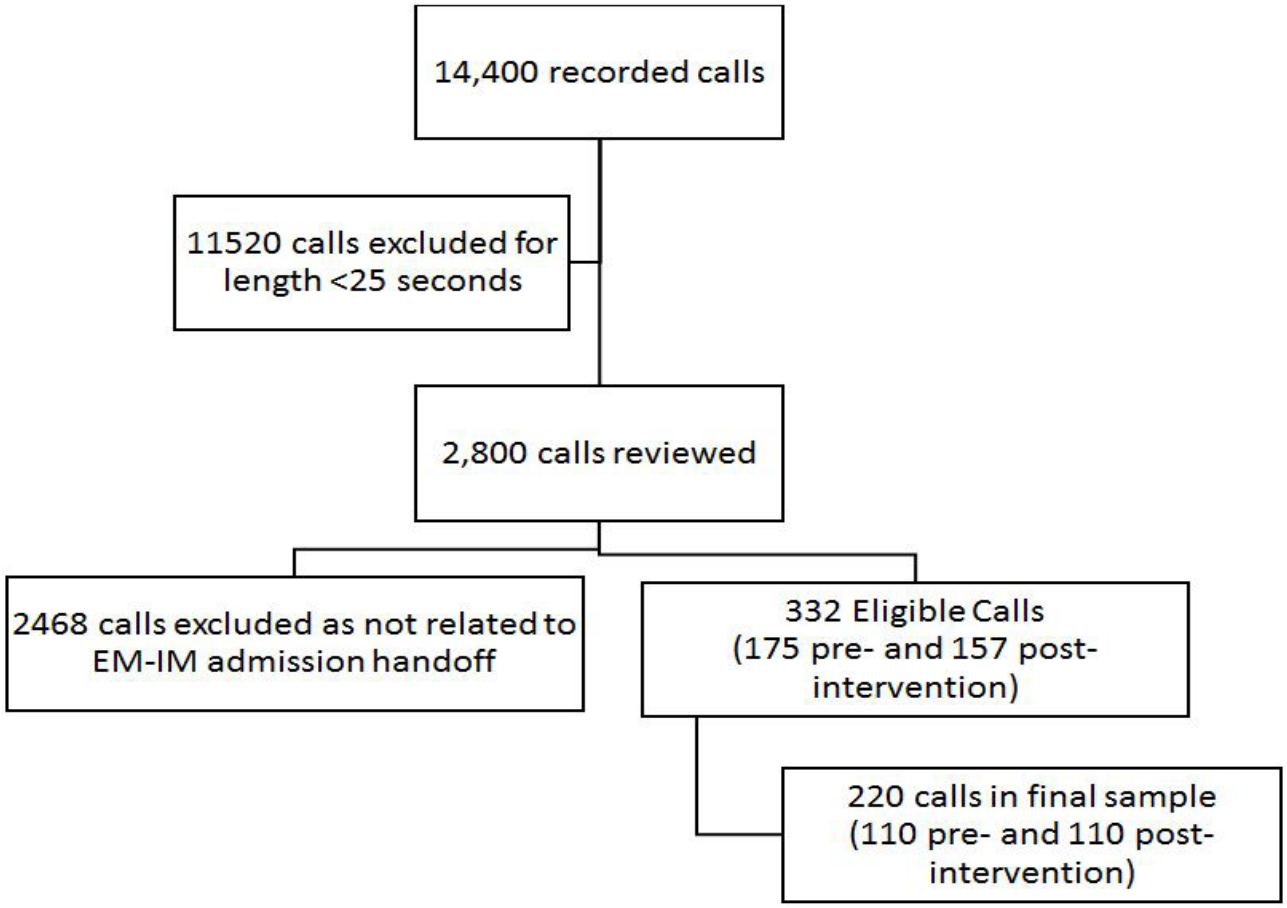

Figure 2. Study flow diagram for evaluation of admission-handoff recordings between emergency physicians and internal medicine physicians during the 120-day study period.

often uncertain when patient care is definitively transferred, especially for a patient boarding in the ED. This leaves the patient in limbo, during which time nursing and ancillary staff do not know where to direct concerns about changes in clinical trajectory or care needs. As part of our intervention, we explicitly tied the disposition decision and assignment of patient care, in which the admitting team assumed responsibility when an admission order was placed. This decision was then clearly delineated in the handoff template, where it was visible to all members of the patient care team.

As a result of using the SBAR-DR strategy, over half of surveyed physicians reported personally experiencing improved patient safety during the 60-day study period. Although the absolute improvement in quality scores was modest (approximately 12% improvement above baseline), the intervention resulted in the communication of approximately 100 pieces of additional information, any of which had the potential to improve the handoff process.

A recent survey of EM residency programs in the U.S. found poor adherence to standardized ED-to- inpatient handoff practices,[29] and our study was no exception. In the post-intervention period, the SBAR-DR format was used for only 30% of verbal handoffs and the written template was used for 50%. The reason for this was likely multifactorial and related to both methodological and cultural barriers. Although the pilot study involved the institution's largest admitting service, EPs performed admission handoffs with other admitting teams not included in the study. Having to shift between different handoff strategies may have limited EPs' ability to acclimatize and integrate SBAR-DR into their daily practice. The adoption of the written handoff note also may have been hindered by the additional charting time required. Additionally, having fewer senior EM residents in the post-intervention cohort may have negatively impacted our post-intervention scores, as we found this group showed significant improvement in both handoff quality score and global rating scale. This supports prior research, which has found that residents' ability to integrate handoff information may improve with experience.[30]

Additionally, handoff practices are an engrained part of a

Table 1. Characteristics and content communication frequency before and after introduction of SBAR-DR* admission handoff strategy.

Content	Before (n=110)	After (n=110)	p-value	Inter-rater Agreement (%)	Kappa Statistic
Characteristics					
EM level of training			0.061		
Faculty	11 (10%)	12 (11%)		NA	NA
PGY 3	56 (51%)	37 (34%)		NA	NA
PGY 2	15 (14%)	18 (16%)		NA	NA
PGY 1	28 (25%)	43 (39%)		NA	NA
Duration of handoff (min)	2:15	2:28	0.016		
SBAR-DR quality scoring					
Situation					
Reason for call, admission vs. consult	79 (71.8%)	82 (74.5%)	0.648	91.4	0.78
Working diagnosis	104 (94.5%)	105 (95.4%)	0.7571	93.6	0.43
Background					
Patient history	86 (78.2%)	82 (74.5%)	0.5256	88.2	0.68
Physical exam findings	39 (35.4%)	32 (29.1%)	0.3128	88.6	0.74
Test results	91 (82.7%)	95 (86.4%)	0.4556	92.3	0.68
Assessment					
Severity of illness	8 (7.3%)	16 (14.5%)	0.0836	91.4	0.55
Treatments performed in the ED	61 (55.4%)	71 (64.5%)	0.1688	91.4	0.82
Patient's response to treatments in the ED	39 (35.4%)	43 (39.1%)	0.577	93.2	0.85
Degree of certainty in working diagnosis	84 (76.4%)	85 (77.3%)	0.8731	76.8	0.45
Risks and recommendations					
Pending tests or tasks	26 (23.6%)	35 (31.8%)	0.1753	90.9	0.75
Assignment of responsibility for pending tests or tasks	7 (6.4%)	12 (10.9%)	0.2301	92.7	0.52
Patient-specific risks that may impact care	39 (35.4%)	38 (34.5%)	0.8876	87.7	0.72
Discussion and disposition					
Opportunity for questions	77 (70.6%)	91 (82.7%)	0.0344	88.2	0.68
Disposition plan agreement	46 (41.8%)	69 (62.7%)	0.0019	88.2	0.76
Read-back					
Use of closed-loop communication	30 (27.3%)	42 (38.2%)	0.0847	86.8	0.68
SBAR-DR format followed	19 (17.3%)	32 (29.1%)	0.0378	87.3	0.63
Composite handoff quality score	7.57 (SD 2.42)	8.45 (SD 2.51)	0.0085	NA	NA
Global rating scale	2.955 + 0.850	3.091 + 0.852	0.236	68.2	0.61

SBAR-DR, Situation, Background, Assessment, Responsibilities & Risks, Discussion and Disposition, Read-back & Record; *PGY*, post-graduate year; *SD*, standard deviation, *ED*, emergency department; *EM*, emergency medicine.

specialty's culture. Although our study group included faculty and resident physician champions from IM and EM, we may not have fostered adequate buy-in from practicing providers to change practice routines. As institutions implement changes to inter-unit handoffs and care transitions, they need to address cultural complacency and build coalitions among affected members of the healthcare team.[31] Possible solutions include inter-disciplinary communication training, which could give physicians an opportunity to practice standardized handoffs with one another, while also mitigating future conflicts via improved inter-personal engagement.[11] Endorsement from senior physician leadership could also facilitate provider buy-in and adherence. Finally, the Joint Commission Center for Transforming Healthcare's Targeted Solutions Tool® has shown

Table 2. Survey results of emergency and internal medicine physicians' perceptions of the SBAR-DR* handoff strategy.

SBAR-DR strategy used for verbal handoff	Helpful	No effect don't know	Harmful
How did SBAR-DR impact patient safety compared to prior handoff strategies?	61.6%	38.5%	0%
How did SBAR-DR impact efficiency of care compared to prior handoff strategies?	53.8%	35.9%	10.3%
What was the overall impact of SBAR-DR compared to prior handoff strategies?	61.5%	33.3%	5.2%
When the written handoff template was used during admission handoff, how did it impact patient safety compared to prior handoff strategies?	41%	56.4%	2.6%
Have you experienced a situation in which you feel patient safety was positively impacted because the SBAR-DR handoff strategy was used?	Yes 54.8%		No 45.2%

SBAR-DR, Situation, Background, Assessment, Responsibilities & Risks, Discussion and Disposition, Read-back & Record

promise in improving handoff communication by facilitating targeted needs assessment of local handoff practices, data collection, and quality improvement intervention.[32]

LIMITATIONS

The study had several limitations. Implementation was conducted at a single institution, so results may not be generalizable to other settings. The pre/post study design cannot exclude the possibility that factors other than the intervention may have influenced the results. Since we scored written transcripts, we may have missed certain cues, such as voice inflection and tone, which can be important in verbal communication. Additionally, we used a novel scoring instrument, as we were unable to find a published, psychometrically- tested assessment instrument. Our scoring system was strict in its definitions of "communicated," which may have biased results toward the null. Finally, the method in which the written note was coded in the EHR did not allow for analysis beyond descriptive counts.

CONCLUSION

We found that introduction of a standardized admission-handoff process resulted in improved verbal handoff quality and that physicians felt it facilitated better patient safety and efficiency. Improvements may have been limited by inconsistent application of the SBAR-DR format. Future areas of study could include the institution-wide implementation of the SBAR-DR model to avoid the use of competing handoff strategies and efforts to better engage practicing physicians prior to implementation.

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REFERENCES

1. Horwitz LI, Moin T, Krumholz HM, et al. Consequences of inadequate sign-out for patient care. *Arch Intern Med*. 2008;168(16):1755-60.
2. Ong MS, Coiera E. A systematic review of failures in handoff communication during intrahospital transfers. *Jt Comm J Qual Patient Saf*. 2011;37(6):274-84.
3. Kitch BT, Cooper JB, Zapol WM, et al. Handoffs causing patient harm: A survey of medical and surgical house staff. *Jt Comm J Qual Patient Saf*. 2008;34(10):563-70.
4. Arora V, Johnson J, Lovinger D, et al. Communication failures in patient sign-out and suggestions for improvement: A critical incident analysis. *Qual Saf Health Care*. 2005;14(6):401-7.
5. Denson JL, Jensen A, Saag HS, et al. Association between end-of-rotation resident transition in care and mortality among hospitalized patients. *JAMA*. 2016;316(21):2204-13.
6. Starmer AJ, Spector ND, Srivastava R, et al. Changes in medical errors after implementation of a handoff program. *N Engl J Med*. 2014;371(19):1803-12.
7. Kachalia A, Gandhi TK, Puopolo AL, et al. Missed and delayed diagnoses in the emergency department: A study of closed

malpractice claims from 4 liability insurers. *Ann Emerg Med*. 2007;49(2):196-205.
8. Singh H, Thomas EJ, Petersen LA, et al. Medical errors involving trainees: a study of closed malpractice claims from 5 insurers. *Arch Intern Med*. 2007;167(19):2030-2036.
9. Hilligoss B and Cohen MD. The unappreciated challenges of between-unit handoffs: negotiating and coordinating across boundaries. *Ann Emerg Med*. 2013;61(2):155-160.
10. Horwitz LI, Meredith T, Schuur JD, et al. Dropping the baton: a qualitative analysis of failures during the transition from emergency department to inpatient care. *Ann Emerg Med*. 2009;53(6):701-10.e4.
11. Chan T, Bakewell F, Orlich D, et al. Conflict prevention, conflict mitigation, and manifestations of conflict during emergency department consultations. *Acad Emerg Med*. 2014;21(3):308-13.
12. Apker J, Mallak LA, Gibson SC. Communicating in the "gray zone": perceptions about emergency physician hospitalist handoffs and patient safety. *Acad Emerg Med*. 2007;14(10):884-94.
13. Smith CJ, Britigan DH, Lyden E, et al. Interunit handoffs from emergency department to inpatient care: a cross-sectional survey of physicians at a university medical center. *J Hosp Med*. 2015;10(11):711-7.
14. Kessler C, Scott NL, Siedsma M, et al. Interunit handoffs of patients and transfers of information: a survey of current practices. *Ann Emerg Med*. 2014;64(4):343-9.e5.
15. Starmer AJ, O'Toole JK, Rosenbluth G, et al. Development, implementation, and dissemination of the I-PASS handoff curriculum: a multisite educational intervention to improve patient handoffs. *Acad Med*. 2014;89(6):876-84.
16. Gopwani PR, Brown KM, Quinn MJ, et al. SOUND: A structured handoff tool improves patient handoffs in a pediatric emergency department. *Pediatr Emerg Care*. 2015;31(2):83-7.
17. Chu ES, Reid M, Schulz T, et al. A structured handoff program for interns. *Acad Med*. 2009;84(3):347-52.
18. Riesenberg LA, Leitzsch J, Little BW. Systematic review of handoff mnemonics literature. *Am J Med Qual*. 2009;24(3):196-204.
19. Agency for Healthcare Research and Quality. TeamSTEPPS. Available at: http://www.ahrq.gov/teamstepps/index.html. Accessed on December 20, 2016.
20. Institute for Healthcare Improvement. SBAR technique for communication: A situational briefing model. Available at: http://www.ihi.org/resources/pages/tools/sbartechniqueforcommunicationasituationalbriefingmodel.aspx. Accessed on December 20, 2016.
21. Beach C, Cheung DS, Apker J, et al. Improving interunit transitions of care between emergency physicians and hospital medicine physicians: A conceptual approach. *Acad Emerg Med*. 2012;19(10):1188-95.
22. Benjamin MF, Hargrave S, Nether K. Using the targeted solutions tool(R) to improve emergency department handoffs in a community hospital. *Jt Comm J Qual Patient Saf*. 2016;42(3):107-18.
23. Lenert LA, Sakaguchi FH, Weir CR. Rethinking the discharge summary: A focus on handoff communication. *Acad Med*. 2014;89(3):393-8.
24. Starmer AJ, Spector ND, Srivastava R, et al. I-PASS, a mnemonic to standardize verbal handoffs. *Pediatrics*. 2012;129(2):201-4.
25. University of Nebraska Department of Emergency Medicine Research. SBAR-DR communication videos. Available at: http://www.unmc.edu/emergency/research/research-projects.html. Accessed on January 30, 2017.
26. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med*. 2005;37(5):360-3.
27. World Health Organization and Joint Commission. Communication during patient handovers. *Patient Safety Solutions*. 2007;1(3):1-4.
28. Cohen MD, Hilligoss PB. Handoffs in hospitals: A review of the literature on information exchange while transferring patient responsibility or control. Available at: http://deepblue.lib.umich.edu/handle/2027.42/61498. Accessed on May 24, 2017.
29. Lee S, Jordan J, Hern HG, et al. Transition of care practices from emergency department to inpatient: survey data and development of algorithm. *West J Emerg Med*. 2017;18(1):86-92.
30. Brannen ML, Cameron KA, Adler M, et al. Admission handoff communications: clinician's shared understanding of patient severity of illness and problems. *J Patient Saf*. 2009;5(4):237-42.
31. Kotter J. *Leading Change*. Boston, MA: Harvard Business Review Press; 1996.
32. Joint Commission Center for Transforming Healthcare. Targeted solutions tool for hand-off communications. Available at: http://www.centerfortransforminghealthcare.org/projects/detail.aspx?Project= 1. Accessed on January 5, 2017.

Cannabinoid Hyperemesis Syndrome: Public Health Implications and a Novel Model Treatment Guideline

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Introduction: Cannabinoid hyperemesis syndrome (CHS) is an entity associated with cannabinoid overuse. CHS typically presents with cyclical vomiting, diffuse abdominal pain, and relief with hot showers. Patients often present to the emergency department (ED) repeatedly and undergo extensive evaluations including laboratory examination, advanced imaging, and in some cases unnecessary procedures. They are exposed to an array of pharmacologic interventions including opioids that not only lack evidence, but may also be harmful. This paper presents a novel treatment guideline that highlights the identification and diagnosis of CHS and summarizes treatment strategies aimed at resolution of symptoms, avoidance of unnecessary opioids, and ensuring patient safety.

Methods: The San Diego Emergency Medicine Oversight Commission in collaboration with the County of San Diego Health and Human Services Agency and San Diego Kaiser Permanente Division of Medical Toxicology created an expert consensus panel to establish a guideline to unite the ED community in the treatment of CHS.

Results: Per the consensus guideline, treatment should focus on symptom relief and education on the need for cannabis cessation. Capsaicin is a readily available topical preparation that is reasonable to use as first-line treatment. Antipsychotics including haloperidol and olanzapine have been reported to provide complete symptom relief in limited case studies. Conventional antiemetics including antihistamines, serotonin antagonists, dopamine antagonists and benzodiazepines may have limited effectiveness. Emergency physicians should avoid opioids if the diagnosis of CHS is certain and educate patients that cannabis cessation is the only intervention that will provide complete symptom relief.

Conclusion: An expert consensus treatment guideline is provided to assist with diagnosis and appropriate treatment of CHS. Clinicians and public health officials should identity and treat CHS patients with strategies that decrease exposure to opioids, minimize use of healthcare resources, and maximize patient safety. [West J Emerg Med. 2018;19(2)380–386.]

INTRODUCTION

Cannabis is the most widely used illicit substance in the United States. In 2014, 22.2 million Americans 12 years of age and older reported current cannabis use.[1] The rapidly changing political landscape surrounding cannabis use has the potential to increase these numbers dramatically. Twenty-nine states and the District of Columbia have legalized medicinal use of cannabis.[2] In addition, as of 2017 California, seven other states and the District of Columbia have legalized recreational use of marijuana.[3] The incidence of CHS and other marijuana-related emergency department (ED) visits has increased significantly in states where marijuana has been legalized.[4] A study published in 2016 evaluating the effects of cannabis legalization on EDs in the state of Colorado found that visits for cyclic vomiting—which included CHS in this study—have doubled since legalization.[5]

Despite the syndrome's increasing prevalence, many physicians are unfamiliar with its diagnosis and treatment. CHS is marked by symptoms that can be refractory to standard antiemetics and analgesics.[6,7] Notwithstanding increasing public health concerns about a national opioid epidemic and emerging guidelines advocating non-opioid alternatives for management of painful conditions, these patients are frequently treated with opioids.[6,8,9] In light of the public health implications of a need to reduce opioid use when better alternatives exist, this paper describes the current state of knowledge about CHS and presents a novel model treatment guideline that may be useful to frontline emergency physicians and other medical providers who interface with these patients. The expert consensus process used to develop the model guideline is also described.

Population Health Research Capsule

What do we already know about this issue?
Recurrent patient presentations for abdominal pain with nausea/vomiting associated with chronic cannabinoid use may represent cannabinoid hyperemesis syndrome (CHS).

What was the research question?
Investigators sought to create a consensus guideline for rapid identification and opioid-sparing treatment of patients with CHS.

What was the major finding of the study?
Researchers created a concise expert consensus CHS guideline focusing on avoiding opioid analgesia and unnecessary work-ups.

How does this improve population health?
The CHS treatment guideline will assist frontline clinicians to reduce use of unnecessary healthcare resources and promote safe prescribing to help mitigate contributing to the opioid crisis.

CANNABINOID HYPEREMESIS SYNDROME

CHS is a condition defined by symptoms including significant nausea, vomiting, and abdominal pain in the setting of chronic cannabis use.[7] Cardinal diagnostic characteristics associated with CHS include regular cannabis use, cyclic nausea and vomiting, and compulsive hot baths or showers with resolution of symptoms after cessation of cannabis use. Cyclical vomiting syndrome (CVS) is a related condition consisting of symptoms of relentless vomiting and retching. While CHS patients present with similar symptoms to those with CVS, associated cannabis use is required to make the diagnosis.

CHS patients present to the ED with non-specific symptoms that are similar to other intra-abdominal conditions. These patients command substantial ED and hospital resources. In a small multicenter ambispective cohort study by Perrotta et al., the mean number of ED visits and hospital admissions for 20 suspected CHS patients identified over a two-year period was 17.3 ± 13.6 and 6.8 ± 9.4 respectively.[10] These patients frequently undergo expensive and non-diagnostic abdominal imaging studies. In the Perrotta study, the mean number of abdominal computed tomography scans and abdominal/pelvic ultrasounds per patient was 5.3 ± 4.1 and 3.8 ± 3.6 respectively. In addition to a contribution to ED crowding by unnecessary prolonged stays to perform diagnostic testing, patients are exposed to potential side effects of medications, peripheral intravenous lines, and procedures such as endoscopies and abdominal surgeries.[7,11,12] While treating physicians often administer opioid analgesics and antiemetics, symptom relief is rarely achieved with this strategy. In fact, there is evidence to suggest opioids may exacerbate symptoms.[6,7]

PATHOPHYSIOLOGY OF CHS

The pathophysiology of CHS is unclear.[7] Paradoxically, there are long-recognized *antiemetic* effects of cannabis, thus leading to its approved use for treatment of nausea and vomiting associated with chemotherapy and appetite stimulation in HIV/AIDS patients. The factors leading to the development of CHS among only a portion of chronic marijuana users are not well understood. Basic science research has identified two main cannabinoid receptors: CB_1 and CB_2, with CB_1 receptors primarily in

the central nervous system, and CB_2 receptors primarily in peripheral tissues. This categorization has recently been challenged and researchers have identified CB_1 receptors in the gastrointestinal tract.[7,9] Activity at the CB_1 receptor is believed to be responsible for many of the clinical effects of cannabis use, including those related to cognition, memory, and nausea/vomiting.[13] Scientists hypothesize that CHS may be secondary to dysregulation of the endogenous cannabinoid system by desensitization or downregulation of cannabinoid receptors.[14,15] Some investigators have postulated that disruption of peripheral cannabinoid receptors in the enteric nerves may slow gastric motility, precipitating hyperemesis.[16,17]

Relief of CHS symptoms with very hot water (greater than 41°C) has highlighted a peripheral tissue receptor called $TRPV_1$, a G-protein coupled receptor that has been shown to interact with the endocannabinoid system, but is also the only known capsaicin receptor.[13,18] This has led some to advocate for the use of topical capsaicin cream in the management of acute CHS.[18-21]

PRESENTATION AND DIAGNOSIS

A systematic review of CHS by Sorensen et al.[7] identified major diagnostic characteristics in patients with CHS as the following:

- History of regular cannabis use for over a year (74.8%)
- At least weekly cannabis use (97.4%)
- Severe nausea and vomiting (100%)
- Abdominal pain (85.1%)
- Vomiting that recurs in a cyclic pattern over months (100%)
- Resolution of symptoms after stopping cannabis (96.8%)
- Compulsive hot baths/showers with symptom relief (92.3%)
- Male predominance (72.9%)

Sorensen et al. identified seven diagnostic frameworks, with significant overlap among characteristics listed by the various authors; however, there was no specific mention of how many of the above features are required for diagnosis. Those with the highest sensitivity include at least weekly cannabis use for greater than one year, severe nausea and vomiting that recurs in cyclic patterns over months usually accompanied by abdominal pain, resolution of symptoms after cannabis cessation, and compulsive hot baths/showers with symptom relief. Clinicians should consider other causes of abdominal pain, nausea and vomiting to avoid misdiagnosis.

Abdominal pain is classically generalized and diffuse in nature. CHS is primarily associated with inhalation of cannabis, though it is independent of formulation and can be seen with incineration of plant matter (traditional smoking), vaporized formulations (e-cigarettes), waxes or oils, and synthetic cannabinoids. At the time of this writing, there have been no reported cases associated with edible marijuana. Episodes generally last 24-48 hours, but may last up to 7-10 days. Patients who endorse relief with very hot water will sometimes report spending hours in the shower.[11,12] Many of these patients will have had multiple presentations to the ED with previously negative workups, including laboratory examinations and advanced imaging.[10] Clinicians should assess for the presence of CHS in otherwise healthy, young, non-diabetic patients presenting with a previous diagnosis of gastroparesis.

Laboratory test results are frequently non-specific. If patients present after a protracted course of nausea and vomiting, there may be electrolyte derangements, ketonuria, or other signs of dehydration. Mild leukocytosis is common. If patients deny cannabis use but suspicion remains high, a urine drug screen should be considered. Imaging should be avoided, especially in the setting of a benign abdominal examination, as there are no specific radiological findings suggestive of the diagnosis.

PROCESS TO DEVELOP CHS TREATMENT GUIDELINE

Recognizing the public health concerns surrounding the opioid epidemic and the increasing frequency of ED presentations of CHS, the San Diego Emergency Medicine Oversight Commission in collaboration with the County of San Diego Health and Human Services Agency and San Diego Kaiser Permanente Division of Medical Toxicology established an expert consensus panel to create a guideline to unite the regional ED community in the treatment of CHS. The goal of the guideline is to raise awareness of how to recognize and treat CHS, which will allow providers to avoid opioids, radiation, and invasive procedures for CHS patients. Expert panel members engaged in an iterative process to provide evidence-based input into the draft guideline until complete consensus was achieved. The results of this initiative are presented here (Figure).

TREATMENT OF CHS

Per the expert consensus guideline, once the diagnosis of CHS has been made and there is a low suspicion for other acute diagnoses, treatment should focus on symptom relief and education on the need for cannabis cessation. Capsaicin is a readily available topical preparation that is reasonable to employ as first line treatment.[18,20] While this recommendation is made based on very limited data including a few small case series, capsaicin is inexpensive, has a low risk side-effect profile, makes mechanistic sense, and is well tolerated.[20,22] Conversely, there are no data demonstrating efficacy of opioids for CHS. Capsaicin 0.075% can be applied to the abdomen or the backs of the arms. If the patients can identify regions of their bodies where hot water provides symptom relief, those areas should be prioritized for capsaicin application. Patients should be advised that capsaicin may be uncomfortable initially, but then should rapidly mimic the relief that they receive with hot showers. Additionally patients

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These are guidelines, not established protocols, and are intended to assist clinicians in the management of cannabinoid hyperemesis syndrome (CHS). Clinicians should consider other causes of abdominal pain, nausea and vomiting to avoid misdiagnosis. Further research is evolving on this syndrome.

■ Pathophysiology

- **Cannabinoid hyperemesis syndrome (**CHS) is a syndrome of cyclic vomiting associated with cannabis use.
- The pathophysiology of CHS is not yet fully understood.
- Diagnostic characteristics: regular cannabis use for any duration of time (100%), including at least weekly cannabis use (97.4%), cyclic nausea and vomiting (100%), and abdominal pain (85.1%). There is a male predominance (72.9%); resolution of symptoms occurs after cannabis cessation (96.8%); compulsive hot showers/baths provide symptom relief (92.3%).
- Chronic, heavy marijuana use can result in a paradoxical reaction to the long-recognized anti-emetic effects of cannabinoids.
- There are two main cannabinoid receptors: CB_1 and CB_2.
    - CB_1 receptors are found primarily in the central nervous system, while CB_2 receptors are found primarily in the peripheral system, including the GI tract.
    - Cannabinoid receptors regulate and fine-tune neurotransmitter release.
- Hyperemesis may be secondary to brainstem effects or enteric neuron effects.
- Chronic cannabinoid exposure causes downregulation of the endocannabinoid receptors in animal models.
- Peripheral cannabinoid receptors in the enteric nerves may slow gastric motility.
- $TRPV_1$ is a G-protein coupled receptor known to interact with the endocannabinoid system as well as being the only known receptor for capsaicin.
    - This receptor is activated by heat (temperature greater than 41°C), as well as capsaicin.
    - This may correspond with the clinical relief of symptoms by hot showers/baths.

■ Diagnosis

- *Presentation:* Abdominal pain, nausea, vomiting
    - Pain generalized and diffuse in nature
- *Cannabis Use:* Heavy, chronic, daily cannabinoid use
    - Plant matter, vapes, waxes, synthetics
    - No reported cases with only edibles
- Multiple ED visits for abdominal pain and vomiting with negative work-up
- *Course of Illness:*
    - Episodes typically last 24-48 hours, but can last as long as 7-10 days.
    - Symptoms may return with re-exposure.

Figure. Cannabinoid hyperemesis syndrome expert consensus treatment guideline.
°C, degrees Celsius; *CHS*, cannabinoid hyperemesis syndrome; *ED*, emergency department; *GI*, gastrointestinal; *IM*, intramuscular; *IV*, intravenous; *ODT*, orally disintegrating tablet; *OTC*, over the counter; *PO*, orally; *TID*, three times a day; *TRPV1*, transient receptor potential (vanilloid) cation channel 1; *UDS*, urine drug screen.

  - Relief occurs with hot showers or baths.
  - Condition resolves with cannabis cessation.
- *Screening:* Synthetic cannabinoids (Spice) is not detected on urine drug screen (UDS).

■ **Management**

- **Cannabis cessation is the only standard treatment in the current literature**.
  - **Avoid opioids (to avoid opioid addiction**).
  - If low suspicion for emergent etiologies or known/confirmed CHS, **avoid** advanced imaging, radiation, and invasive procedures.
- Supportive therapy includes:
  - IV fluids for dehydration
  - Antiemetics: Ondansetron 4-8 mg IV/PO/ODT, Promethazine 12.5 mg IV, Metoclopramide 10 mg IV
  - Benzodiazepines: Lorazepam 1 mg IV, Diazepam 5-10 mg IV
  - Diphenhydramine 25-50 mg IV
  - Antipsychotics: Haloperidol 5 mg IV/IM, Olanzapine 5mg IV
- Hot showers are beneficial, but caution patients regarding burns from hot water.
- Apply capsaicin cream (available OTC) topically to abdomen or back of arms TID:
  - **Caution**: use gloves, wash hands thoroughly after application, and discontinue use if patient develops significant skin irritation or chemical burns;
  - **Caution** near faces, eyes, nipples, perineum - can use occlusive dressings to cover and protect these areas (but do not cover capsaicin with occlusive dressings or use on broken skin);
  - 0.075% concentration (may cause initial discomfort);
  - Can be used as first-line treatment in cases of clear diagnosis.
- Provide education, reassurance, and referral to cessation programs.
- Use clear documentation in the medical record for possible future visits:
  - Document the word "Cannabis" or "Marijuana" in the diagnosis.

References

1. Sorensen CH, DeSanto K, Borgelt L, et al. Cannabinoid hyperemesis syndrome: diagnosis, pathophysiology, and treatment - a systematic review. *J Med Toxicol*. 2017;13(1):71-87.
2. Lapoint JM. Cannabinoids. In: Hoffman RS, Howland M, Lewin NA, Nelson LS, Goldfrank LR. eds. Goldfrank's Toxicologic Emergencies*,* 10e*.* New York, NY: McGraw-Hill; 2015.
3. Darmani NA. Cannabinoid-induced hyperemesis: a conundrum—from clinical recognition to basic science mechanisms. *Pharmaceuticals.* 2010;3(7):2163-77.
4. Simonetto DA, Oxentenko AS, Herman ML, et al. Cannabinoid hyperemesis: a case series of 98 patients. *Mayo Clin Proc.* 2012;87:114–9.
5. Lapoint J. Capsaicin cream for treatment of cannabinoid hyperemesis syndrome. American College of Medical Toxicology Annual Scientific Meeting abstracts. Abstract 51. 2014. Available at http://www.acmt.net/Abstracts_41-60.html#fiftyone.

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Figure. Continued.
°C, degrees Celsius; *CHS*, cannabinoid hyperemesis syndrome; *ED*, emergency department; *GI*, gastrointestinal; *IM*, intramuscular; *IV*, intravenous; *ODT*, orally disintegrating tablet; *OTC*, over the counter; *PO*, orally; *TID*, three times a day; *TRPV1*, transient receptor potential (vanilloid) cation channel 1; *UDS*, urine drug screen.

must be counseled to avoid application near the face, eyes, genitourinary region, and other areas of sensitive skin, not to apply capsaicin to broken skin, and not to use occlusive dressings over the applied capsaicin. Patients can be discharged home with capsaicin, advising application three or four times a day as needed. If capsaicin is not readily available, but there is a shower available in the ED, patients can be advised to shower with hot water to provide relief. Educate patients to use caution to avoid thermal injury, as there are reports of patients spending as long as four hours at a time in hot showers.[11]

Other possible therapeutic interventions include administration of antipsychotics such as haloperidol 5 mg IV/IM or olanzapine 5 mg IV/IM or ODT, which have been described to provide complete symptom relief in case reports.[23,24] Conventional antiemetics, including antihistamines (diphenhydramine 25-50 mg IV), serotonin antagonists (ondansetron 4-8 mg IV), dopamine antagonists (metoclopramide 10 mg IV), and benzodiazepines can be used, though reports of effectiveness are mixed.[7,9] Provide intravenous fluids and electrolyte replacement as indicated. Avoid opioids if the diagnosis of CHS is certain.

Clinicians should inform patients that their symptoms are directly related to continued use of cannabis. They should further advise patients that immediate cessation of cannabis use is the only method that has been shown to completely resolve symptoms. Reassure patients that symptoms resolve with cessation of cannabinoid use and that full resolution can take anywhere from 7-10 days of abstinence.[7] Educate patients that symptoms may return with re-exposure to cannabis. Provide clear documentation in the medical record to assist colleagues with confirming a diagnosis, as these patients will frequently re-present to the ED.

CONCLUSION

The incidence of cannabinoid hyperemesis syndrome in patients presenting to U.S. emergency departments is increasing. Awareness of the syndrome, along with education regarding diagnostic criteria and treatment options, may help avoid increased costs of and potential harms from testing for other conditions while providing more targeted and definitive treatment for CHS patients. Furthermore, lengths of stay are reduced when unnecessary testing is avoided. As highlighted by the public health opioid crisis, emergency physicians have a responsibility to prescribe opioids only for conditions where they would benefit patients.[25] A novel CHS treatment guideline is presented to assist frontline clinicians with managing this increasingly common condition.

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REFERENCES

1. Results from the 2014 national survey on drug use and health: summary of national findings. Available at: http://www.samhsa.gov/data. Accessed 4 April, 2017.
2. State medical marijuana laws. *National Conference of State Legislatures*. Available at: http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx. Accessed 14 August, 2017.
3. 10 things to know about legal pot. *CNN Money*. Available at: http://money.cnn.com/2017/04/19/news/legal-marijuana-420/index.html. Accessed 14 August, 2017.
4. Kim HS, Monte AA. Colorado cannabis legalization and its effect on emergency care. *Ann Emerg Med.* 2016;68(1):71-5.
5. Kim HS, Anderson JD, Saghafi O, et al. Cyclic vomiting presentations following marijuana liberalization in Colorado. *Acad Emerg Med*. 2015;22(6):694-9.
6. Galli JA, Sawaya RA, Friedenberg FK. Cannabinoid hyperemesis syndrome. *Curr Drug Abuse Rev.* 2011;4(4):241-9.
7. Sorensen CJ, DeSanto K, Borgelt L, et al. Cannabinoid hyperemesis syndrome: diagnosis, pathophysiology, and treatment - a systematic review. *J Med Toxicol.* 2017;13(1):71-87.
8. America's heroin and opioid abuse epidemic. *United States House Committee on Oversight and Government Reform*. Available at: https://oversight.house.gov/hearing/americas-heroin-and-opioid-abuse-epidemic. Accessed 24 April, 2017.
9. Richards JR, Gordon BK, Danielson AR, et al. Pharmacologic treatment of cannabinoid hyperemesis syndrome: a systematic review. *Pharmacotherapy.* 2017;37(6):725-34.
10. Perrotta G, Miller J, Stevens T, et al. Cannabinoid hyperemesis: relevance to emergency medicine (abstract 542). Society for Academic Emergency Medicine Annual Meeting. Vol 19. 2012:S286-287.
11. Chang YH, Windish DM. Cannabinoid hyperemesis relieved by compulsive bathing. *Mayo Clin Proc.* 2009;84(1):76-8.
12. Patterson DA, Smith E, Monahan M, et al. Cannabinoid hyperemesis and compulsive bathing: a case series and

paradoxical pathophysiological explanation. *J Am Board Fam Med.* 2010;23(6):790-3.

13. Lapoint JM. Cannabinoids. In: Hoffman RS, Howland M, Lewin NA, et al., eds. Goldfrank's Toxicologic Emergencies. 10 ed. New York, NY: McGraw-Hill; 2015.
14. Darmani NA. The cannabinoid CB1 receptor antagonist SR 141716A reverses the antiemetic and motor depressant actions of WIN 55, 212-2. *Eur J Pharmacol.* 2001;430(1):49-58.
15. Lundberg DJ, Daniel AR, Thayer SA. Delta(9)-Tetrahydrocannabinol-induced desensitization of cannabinoid-mediated inhibition of synaptic transmission between hippocampal neurons in culture. *Neuropharmacology.* 2005;49(8):1170-7.
16. Krowicki ZK, Moerschbaecher JM, Winsauer PJ, et al. Delta9-tetrahydrocannabinol inhibits gastric motility in the rat through cannabinoid CB1 receptors. *Eur J Pharmacol.* 1999;371(2-3):187-96.
17. McCallum RW, Soykan I, Sridhar KR, et al. Delta-9-tetrahydrocannabinol delays the gastric emptying of solid food in humans: a double-blind, randomized study. *Aliment Pharmacol Ther.* 1999;13(1):77-80.
18. Lapoint J. Capsaicin cream for treatment of cannabinoid hyperemesis syndrome (abstract 51). Paper presented at: American College of Medical Toxicology Annual Scientific Meeting, 2014.
19. Burillo-Putze G, Llorens P, Roman F. Use of capsaicin cream in cannabis hyperemesis syndrome. *J Emerg Med.* 2017;52(5):760.
20. Dezieck L, Hafez Z, Conicella A, et al. Resolution of cannabis hyperemesis syndrome with topical capsaicin in the emergency department: a case series. *Clin Toxicol (Phila).* 2017;55(8):908-13.
21. Waterson Duncan R, Maguire M. Capsaicin topical in emergency department treatment of cannabinoid hyperemesis syndrome. *Am J Emerg Med.* [Epub ahead of print] Jun 21 2017.
22. Pelissier F, Claudet I, Gandia-Mailly P, et al. Use of capsaicin cream in cannabis hyperemesis syndrome. *J Emerg Med.* May 2017;52(5):760-1.
23. Hickey JL, Witsil JC, Mycyk MB. Haloperidol for treatment of cannabinoid hyperemesis syndrome. *Am J Emerg Med.* 2013;31(6):1003 e1005-1006.
24. Witsil JC, Mycyk MB. Haloperidol, a novel treatment for cannabinoid hyperemesis syndrome. *Am J Ther.* 2017;24(1):e64-e67.
25. Understanding the epidemic. *Centers for Disease Control and Prevention*. Available at: https://www.cdc.gov/drugoverdose/epidemic/index.html. Accessed 24 April, 2017.

Optimal Implementation of Prescription Drug Monitoring Programs in the Emergency Department

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The opioid epidemic is the most significant modern-day, public health crisis. Physicians and lawmakers have developed methods and practices to curb opioid use. This article describes one method, prescription drug monitoring programs (PDMP), through the lens of how to optimize use for emergency departments (ED). EDs have rapidly become a central location to combat opioid abuse and drug diversion. PDMPs can provide emergency physicians with comprehensive prescribing information to improve clinical decisions around opioids. However, PDMPs vary tremendously in their accessibility and usability in the ED, which limits their effectiveness at the point of care. Problems are complicated by varying state-to-state requirements for data availability and accessibility. Several potential solutions to improving the utility of PDMPs in EDs include integrating PDMPs with electronic health records, implementing unsolicited reporting and prescription context, improving PDMP accessibility, data analytics, and expanding the scope of PDMPs. These improvements may help improve clinical decision-making for emergency physicians through better data, data presentation, and accessibility. [West J Emerg Med. 2018;19(2)387–391.]

INTRODUCTION

Due to the growing opioid epidemic in the U.S., there is widespread interest in using prescription drug monitoring systems (PDMP) to curb prescription drug abuse. PDMPs are statewide databases used by physicians, pharmacists, and law enforcement to obtain data about controlled-drug prescriptions, with the goal of detecting substance-use disorders, drug-seeking behaviors, and reducing patient risks of adverse drug events. While almost all U.S. states have PDMPs, they vary in design and implementation.[1] In this paper, we review the history, evidence, and adoption of best practice guidelines in state PDMPs with a focus on how to best deploy PDMPs in emergency departments (ED). Specifically, we analyze the current PDMP model and provide recommendations for PDMP developers and EDs to help meet the informational needs of ED providers with the goal of better detection and prevention of prescription drug abuse.

THE OPIOID CRISIS AND THE EMERGENCY DEPARTMENT

The U.S. accounts for roughly 80% of opioid use worldwide, and misuse – such as the recreational use of opioids – is a significant problem.[2] Every 19 minutes in the U.S. someone dies from an unintentional drug overdose, the majority from opioids.[3] From 1997 to 2007 the average milligram (mg)-per-year use of prescription per person of opioids in the U.S. increased 402%, from 74 mg to 369 mg. Meanwhile, an estimated seven million people above the age of 12 use opioids and other prescription medications for non-therapeutic purposes annually.[3,4] These non-medical uses of opioids are linked to 700,000 ED visits yearly.[3]

Along with treating the consequences of opioid-related illness and overdose, EDs are often a location used by some patients as a source for opioid prescriptions.[4] With limited time and no prior patient relationship, emergency physicians (EP)

must make quick decisions balancing the provision of sufficient pain management against the potential for abuse and/or misuse. It is sometimes difficult to detect who might be seeking to misuse opioids. In one study, "classic" drug-seeking behaviors were relatively ineffective in identifying high-risk patients.[3]

A Brief History of PDMPs and Their Effectiveness

PDMPs have been available for nearly 80 years. The first state PDMP was established in California (1939), followed by Hawaii (1943), Illinois (1961), Idaho (1967), New York (1970), Pennsylvania (1972), Rhode Island (1978), Texas (1981), and Michigan (1988).[5] Early PDMPs were paper-based, recordkeeping systems used primarily to provide reports to law enforcement.[5] By 1990 electronic key-punch databases enabled easier data dissemination via PDMPs, and pharmacists and clinicians began to use them.[5] In 1996 the pharmaceutical OxyContin™ was introduced; simultaneously, illicit prescription drugs doubled from 1994-1998.[5] In response, Congress signed the Harold Rogers Prescription Monitoring Program grant into law in 2002, providing the first guidelines and funding for states to develop PDMPs.[5] Since then, 49/50 states have now adopted PDMPs. (Missouri is the only exception).[6]

Since the inception of PDMPs, studies have assessed their impact on opioid prescribing and overdoses. Overall, the literature has been mixed. Some studies have found no relationship between PDMP implementation and outcomes; however, most studies evaluated paper- or faxed-based systems, with physicians receiving information days to weeks after the initial request.[4,7] In one such study, 21% of the PDMPs evaluated were within their first years of operation or had only recently come online.[4] This is significant because in states with new PDMPs, (Maine, New Mexico and Wyoming [which became operational in 2004-2005]), many physicians were not accessing or using data.[4] This point is exemplified through Virginia's PDMP, which was established in 2007 and was initially paper based.[8] After moving to electronic and real-time reporting, data requests exponentially increased from 74,342 in 2009 to 433,450 in 2010.[8]

Another factor limiting the effectiveness of PDMPs is that each state has different policies and requirements for providers to use them. Few states mandate prescriber use and in those states that do not mandate use, compliance varies greatly.[7] In this context, it is logical to assume that if prescribers do not access PDMP data, they cannot be effective.

VARIATION IN PDMP DESIGN AND IMPLEMENTATION

A clear factor that leads to variation in observed effectiveness is that PDMPs are not all designed in the same way, particularly when it comes to their accessibility. Most are representative of separate and distinct technological and political environments at the time of their creation.[5] According to the National Alliance for Model State Drug Laws study in late 2012, 38 state PDMPs are operated by a state health agency and six are operated under the aegis of law enforcement agencies.[9] Additionally, 45 states monitor schedule II-IV controlled substances, 34 states grant authority to monitor schedule V substances, and 13 allow additional monitoring of drugs not listed on Drug Enforcement Administration schedules.[9] Moreover, while several states require physicians to access patient PDMP data before prescribing controlled substances, the majority of states allow for voluntary participation among physicians.[9] Finally, 25 states provide unsolicited, automatic reports of suspicious activity directly to law enforcement but only three (Delaware, Louisiana, and West Virginia) automatically send reports to multiple facilities including law enforcement, licensing boards, pharmacies, and prescribers.[9]

However, states have looked to update and reformat their PDMPs to better address the opioid crisis. For example, with funding from the Core State Violence and Injury Prevention Program, Oregon reformatted its PDMP to provide more appropriate data to its EPs.[10] Under this new funding, PDMPs were designed to track schedule II-VI drugs prescribed within Oregon as well as providing physicians with access to the PDMP data of bordering states.[10] Furthermore, pharmacies within Oregon were required to report prescription data within 72 hours of opioid dispensing.[10] Such interstate sharing and tracking of all scheduled drugs has shown to provide safer patient care. Since implementation, Oregon has reported a 38% decrease in the rate of prescription opioid overdose as well as a 58% reduction in deaths related to methadone use.[11] As sharing hubs such as those in Oregon, Michigan, Indiana and Ohio are established, EPs may be better equipped to successfully identify drug-seeking behavior.

PDMP design also leads to great variation in usability. For example, some information displayed is not always relevant or organized in a way that allows for EPs to answer specific clinical questions that fit into ED workflow. In some systems, frequent extraneous information is obtained simultaneously.[2] Excessive data forces providers to search for relevant information, squandering valuable time.

Furthermore, clinician training on how to use and interpret PDMPs is often limited. Users are often left wading through mountains of patient data seeking to piece together a complete picture. One study surveyed physicians and nurses from diverse specialties after PDMP use and found that practitioners lacked guidance on data interpretation.[12] In EDs time is a valuable resource and, unfortunately, the complexity of some PDMPs limits their usability. For example, in the current structure, PDMPs have experienced growing compliance issues secondary to their difficulty of use. In certain states, physicians are required to register with their PDMP via a notarized medical license and government identification.[13] Password protocols exacerbate issues with PDMP accessibility. Often physicians are required to meet

excessive requirements for password security only to find that within a short time their password has expired and the process starts over. Passwords often cannot match previous entries and involve multiple erroneous key elements to meet required fields. Working in a fast-paced ED, having to frequently create and update complicated passwords quickly transforms these safeguards into a barrier to use.

Finally, not all PDMPs track all schedule drugs. Schedule II drugs such as opioids have largely been the focus of PDMPs, but other drugs categorized in alternative schedules also have the potential for abuse. In 2011, for example, ED visits for benzodiazepine abuse, a schedule IV drug, was nearly equal to visits for opioids.[14] ED records have demonstrated a strong association with benzodiazepine abuse and opioid abuse.[15] Despite this potential for additional abuse, only 34 PDMPs monitor schedule II-V drugs.[16] To address many of the usability limitations with PDMPs in EDs, we suggest several ways to optimize their implementation.

Integration into ED Electronic Health Records

First, working to integrate the PDMPs with electronic health records (EHR) is a key to effectively using PDMPs. Currently, while clinicians are working in their hospital's EHR system, most have to open a web-browser and log in to a separate, secure page with a separate username and password that is often a time-consuming process, further deterring the widespread use of the PDMP data. In the interest of time, physicians instead often resort to using prior EHR data to make determinations about possible drug seeking. Considering that EHR data is typically not shared between facilities, physicians base decisions on significantly smaller sample sizes. Indiana became the first state to merge an EHR with the PDMP. The integration was found to be highly effective with 58% of physicians prescribing fewer opioids or smaller quantities after the implementation of the PDMP data.[17] Furthermore, integration of these systems could allow for improvements through unsolicited reporting "alerts" on the EHR for accessing physicians.[18] These alerts could be used much like a "sepsis alert," indicating a questionable prescription history of a patient immediately, allowing clinicians to further investigate if needed.[18]

Unsolicited Reporting

Unsolicited reporting is a powerful tool through which PDMPs can automatically send alerts for drug-seeking behavior meeting a specific threshold to the appropriate authority. Such quantitative thresholds have already been implemented in several states with some success. In Virginia, thresholds for individuals receiving 10 prescriptions from 10 providers (10x10) or (15x15) within a six-month period were used.[19] Subsequent periodic analysis of the data for automatic, unsolicited reporting showed a steady decrease in the number of individuals meeting thresholds, correlating to a decrease in likely diversion and abuse.[19] Such automated reporting does come with risk as such policies raise concerns about patients being labeled an addict or postponing necessary treatment.[18] In addition, physicians treating cancer patients or those requiring long-term opioid management have expressed concern for their reputation and licensure.[18] However, in the context of the newly-approved National Quality Forum measures for limiting opioid prescribing, PDMPs can take such measures into consideration and would likely have an inverse effect by ensuring that guidelines are followed and patients are treated safely.[20]

Providing Context for Opioid Prescriptions Through Data Analytics

Data analytics and data visualization may be ways to help contextualize opioid prescriptions for the busy EP. For example, by linking prescriptions to a particular diagnosis physicians may greatly reduce the guesswork involved for prescription behavior. At a glance, a patient with multiple prescriptions for both short- and long-acting, opioid pain medications may appear to be an opioid abuser. However, by tethering an explanatory diagnosis to such prescriptions, after investigation this patient could be found to have an extensive chronic pain condition warranting multiple prescriptions. Therefore, fewer mental resources may be required to rule out opioid abuse, reducing the potential for misinterpreting data and in turn provide quicker and better-informed emergency care.

Expanding the Accessibility to PDMPs Within the ED

Another common complaint from attending physicians is the restriction allowing use of PDMPs only by licensed and practicing attending physicians, and excluding resident physicians. By allowing resident physicians access to PDMP information, the clinical care team could be more efficient particularly in academic settings where residents make many clinical decisions. In addition, allowing other providers who work in the ED, such as nurses and technicians, access to PDMP data may further amplify their effectiveness and use as a screening instead of a confirmation tool.

Expanding the Scope of PDMPs

PDMPs have an extensive capability for tracking drug-seeking behavior and contacting the appropriate authorities such as prescribers, pharmacies, licensing boards or law enforcement. However, given that abuse is not limited to opioid misuse, but includes benzodiazepines and other schedule drugs as well, it is logical to assume that by extending PDMP records to include tracking of all scheduled drugs, PDMPs can have a greater impact against multiple forms of doctor shopping, drug abuse and diversion.

Models of Well-designed PDMPs

Despite the issues highlighted above, some PDMPs studies still suggest a positive trend between their use and

subsequent decreases in opioid and prescription-drug abuse. While opioid prescription overdose and abuse steadily increased from 2002-2010, by 2011 opioid prescriptions declined and consequently opioid overdose-related deaths fell and abuse plateaued.[21] As more modern PDMP systems came online in conjunction with this decline, they are thought to have played a role in by reducing prescriptions in circulation and providing local governments with better resources to identify illicit activity. Furthermore, in Kentucky, Tennessee, New York and Ohio, early adopters of mandated PDMP use have shown preliminary results significant for a reduction in opioid prescribing as well as declines in multiple providers prescribing or in doctor shopping.[7] Meanwhile, a 2016 study found a reduction on average of 1.12 fewer, opioid-related overdose deaths per 100,000 cases annually by implementing a PDMP program.[7] Finally, another 2016 study showed that from 2003-2009, states without PDMPs experienced a steady increase in opioid exposures of 1.9% per quarter annually, while states with PDMPs in place experienced increases of only 0.2%.[2]

CONCLUSION

EDs and their providers are on the front lines of the opioid crisis, treating significant portions of the surrounding community. As a result, their clinical decision-making has effects throughout their community, and improving the effectiveness of the PDMP in the ED has the potential to curb drug abuse and diversion. Yet PDMPs are currently complicated by myriad different strategies with varying state-to-state requirements and a lack of interconnectivity, which limit their usability and use. Several potential solutions exist to enhance PDMPs in the ED including integrating PDMPs with EHRs, implementing unsolicited reporting and prescription context, improving PDMP accessibility and data analytics, and expanding the scope of PDMPs.

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REFERENCES

1. Gugelmann H, Perrone J, Nelson L. Windmills and pill mills: can PDMPs tilt the prescription drug epidemic? *J Med Toxicol.* 2012;8(4):378-86.
2. Marco CA, Venkat A, Baker EF, et al. Prescription drug monitoring programs: ethical issues in the emergency department. *Ann Emerg Med.* 2016;68(5):589-98.
3. Grover CA, Elder JW, Close RJ, et al. How frequently are "classic" drug-seeking behaviors used by drug-seeking patients in the emergency department? *West J Emerg Med.* 2012;13(5):416-21.
4. Kerlikoqsky G, Jones C, Labelle R, et al. Prescription drug monitoring programs - lack of effectiveness or a call to action? *Pain Med.* 2011;12(5):687-9.
5. Clark T, Eadie J, Knue P, et al. Prescription drug monitoring programs: an assessment of the evidence for best practices. The Pew Charitable Trusts. Available at: http://www.pewtrusts.org/~/media/assets/0001/pdmp_update_1312013.pdf. Accessed on November 22, 2017.
6. PDMP training & technical assistance center: status of prescription drug monitoring programs. Available at: http://www.pdmpassist.org/pdf/PDMPProgramStatus2014.pdf. Accessed on November 27, 2017.
7. Murthy, VH. Facing addiction in America: The Surgeon General's Report on Alcohol, Drugs, and Health. Washington (DC): *US Department of Health and Human Services*; 2016 Nov.
8. Virginia Prescription Monitoring Program 2010 Statistics. Available at: https://www.dhp.virginia.gov/dhp_programs/pmp/docs/ProgramStats/2010PMPStatsDec2010.pdf. Accessed on November 28, 2017.
9. Deyo RA, Irvine J, Millet L, et al. Measures such as interstate cooperation would improve the efficacy of programs to track controlled drug prescriptions. *Health Aff (Millwood).* 2013;32(3):603-13.
10. Oregon Prescription Drug Monitoring Program. (2017). Available at: on http://www.orpdmp.com/. Accessed November 27, 2017.
11. Opioid Information: State Successes. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/drugoverdose/policy/successes.html. Accessed on November 21, 2017.
12. Hildebran C, Cohen DJ, Irvine JM, et al. How clinicians use prescription drug monitoring programs: a qualitative inquiry. *Pain Med.* 2014;15(7):1179-86.
13. Hammer J. Enhancing Access to Prescription Drug Monitoring Programs Using Health Information Technology: Work Group Recommendations. Available at: https://www.healthit.gov/sites/default/files/work_group_document_integrated_paper_final_0.pdf. Accessed on December 2, 2017.
14. Drug Abuse Warning Network. Highlights of the 20011 Drug Abuse Warning Network (DAWN) Findings on Drug-Related Emergency Department visits. Substance Abuse and Mental Health Services Administration: Available at: https://www.samhsa.gov/data/sites/default/files/DAWN127/DAWN127/sr127-DAWN-highlights.pdf. Accessed on December 1, 2017.
15. Admissions Reporting Benzodiazepine and Narcotic Pain Reliever Abuse at Treatment Entry. Substance Abuse and Mental Health Services Administration. Available at: https://www.samhsa.gov/data/sites/default/file/BenzodiazepineAndNarcoticPainRelieverAbuse/

BenzodiazepineAndNarcoticPainRelieverAbuse/BenzodiazepineAndNarcoticPainRelieverAbuse.htm. Accessed on November 30, 2017.

16. Prescription Drug Monitoring Programs. American Academy of Family Physicians. Available at: https://www.aafp.org/dam/AAFP/documents/advocacy/prevention/risk/BKG-PDMPs-103017.pdf. Accessed on December 5, 2017.
17. Connecting for Impact: Linking Potential Prescription Drug Monitoring Programs (PDMPs) to Patient Care Using Health IT. Available at: https://www.healthit.gov/PDMP. Accessed on November 1, 2017.
18. Elder, J. Pines J. Taking PDMPs Up a Notch. Available at: http://epmonthly.com/article/taking-pdmps-notch/. Accessed on November 5, 2017.
19. Virginia Prescription Monitoring Program 2010 Statistics. Virginia Department of Health Professions. Available at: www.dhp.virginia.gov/dhp_programs/pmp/docs/ProgramStats/2010PMPStatsDec2010.pdfAccessed on November 1, 2017.
20. New National Quality Partners Action Team Focuses on Opioid Prescribing. National Quality Forum. Available at: http://www.qualityforum.org/New_NQF_Initiative_Focuses_on_Opioid_Prescribing.aspx. Accessed on December 1, 2017.
21. Ling W, Mooney L, Hillhouse M. Prescription opioid abuse, pain and addiction: Clinical issues and implications. *Drug Alcohol Rev.* 2011;30(3):300-5.

By Default: The Effect of Prepopulated Prescription Quantities on Opioid Prescribing in the Emergency Department

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Introduction: Opioid prescribing patterns have come under increasing scrutiny with the recent rise in opioid prescriptions, opioid misuse and abuse, and opioid-related adverse events. To date, there have been limited studies on the effect of default tablet quantities as part of emergency department (ED) electronic order entry. Our goal was to evaluate opioid prescribing patterns before and after the removal of a default quantity of 20 tablets from ED electronic order entry.

Methods: We performed a retrospective observational study at a single academic, urban ED with 58,000 annual visits. We identified all adult patients (18 years or older) seen in the ED and discharged home with prescriptions for tablet forms of hydrocodone and oxycodone (including mixed formulations with acetaminophen). We compared the quantity of tablets prescribed per opioid prescription 12 months before and 10 months after the electronic order-entry prescription default quantity of 20 tablets was removed and replaced with no default quantity. No specific messaging was given to providers, to avoid influencing prescribing patterns. We used two-sample Wilcoxon rank-sum test, two-sample test of proportions, and Pearson's chi-squared tests where appropriate for statistical analysis.

Results: A total of 4,104 adult patients received discharge prescriptions for opioids in the pre-intervention period (151.6 prescriptions per 1,000 discharged adult patients), and 2,464 post-intervention (106.69 prescriptions per 1,000 discharged adult patients). The median quantity of opioid tablets prescribed decreased from 20 (interquartile ration [IQR] 10-20) to 15 (IQR 10-20) ($p<0.0001$) after removal of the default quantity. While the most frequent quantity of tablets received in both groups was 20 tablets, the proportion of patients who received prescriptions on discharge that contained 20 tablets decreased from 0.5 (95% confidence interval [CI] [0.48-0.52]) to 0.23 (95% CI [0.21-0.24]) ($p<0.001$) after default quantity removal.

Conclusion: Although the median number of tablets differed significantly before and after the intervention, the clinical significance of this is unclear. An observed wider distribution of the quantity of tablets prescribed after removal of the default quantity of 20 may reflect more appropriate prescribing patterns (i.e., less severe indications receiving fewer tabs and more severe indications receiving more). A default value of 20 tablets for opioid prescriptions may be an example of the electronic medical record's ability to reduce practice variability in medication orders actually counteracting optimal patient care. [West J Emerg Med. 2018;19(2)392-397.]

INTRODUCTION

Painful conditions make up 42% of all emergency department (ED) visits.[1] With the increasing focus on analgesia by The Joint Commission's pain management standards and emphasis on analgesia in patient satisfaction surveys, it is no surprise that medical use of opioids and opioid analgesic prescriptions has been increasing since the early 1990s.[2-8] Unfortunately, there has also been an increase in prescription opioid abuse and misuse, with a rise in opioid-related events including increases in opioid-related ED visits, inpatient hospitalizations, and opioid overdose deaths.[9-14] Unintentional overdose has now surpassed motor vehicle collisions as the leading cause of injury and death in the United States for adults aged 25–64 years, and the majority of all unintentional poisonings are related to opioids.[15, 16]

Not surprisingly, opioid prescribing has come under increasing scrutiny in recent years including in the ED. The American College of Emergency Physicians Clinical Policy – Critical Issues in the Prescribing of Opioids for Adult Patients in the Emergency Department – states, "Although relieving pain and reducing suffering are primary emergency physician responsibilities, there is a concurrent duty to limit the personal and societal harm that can result from prescription drug misuse and abuse."[17] While the percentage of U.S. ED visits with opioids prescribed increased from 20.8% to 31.0% between 2001-2010, studies have shown that the majority of opioid prescriptions from the ED are a low pill count (mean of 15 tablets) and are almost exclusively (99%) immediate-release formulations and significantly less likely to be high dose or consist of a large quantity compared to those from office-based practices.[18-20]

Regardless, with a recent study showing that opioid-naive ED patients prescribed opioids for acute pain are at increased risk for additional opioid use at one year, the ED is an important site for the study of opioid-prescribing patterns.[21] Adding to this body of literature, a recent article in the *New England Journal of Medicine* showed that opioid-prescribing habits vary widely between providers in the same ED and patients who receive treatment of "high-intensity" opioid prescribers had higher rates of long-term opioid use.[22]

Recent interventions for decreasing opioid prescribing have focused on prescription drug monitoring programs and creation of opioid-prescribing guidelines.[17, 23-26] Opioid-prescribing guidelines have been shown to reduce rates of opioids prescribed for both minor and chronic complaints in acute care settings.[27, 28] Most recommendations on safe opioid prescribing for the ED recommend a maximum of three- to five-day courses of opioid medications.[23, 29]

With the increasing prevalence of electronic medical records (EMR) and electronic order-entry systems has come an increasing interest in the ability to standardize clinical workflows in an effort to reduce medication-related errors.[30-33] To date, no study has assessed the effect of default tablet quantities as part of electronic order entry on emergency physicians' prescribing patterns. Our primary objective was to evaluate opioid-prescribing patterns before and after removal of the default quantity of 20 tablets for opioid prescriptions in the EMR.

Population Health Research Capsule

What do we already know about this issue?
ED opioid prescribing patterns have received increasing attention. Focus has included reducing the frequency of opioid use and alternatives to opioids for pain control.

What was the research question?
What effect would removal of a default opioid prescription quantity (20 tablets) have on ED opioid- prescribing patterns?

What was the major finding of the study?
We observed a decreased median quantity of tablets per prescription and a wider distribution in the number of tablets prescribed.

How does this improve population health?
Having providers input tablet quantities when prescribing opioids may lead to more thoughtful prescribing of opioids than having a default quantity pre-entered in the electronic medical record.

METHODS

Study Design

We conducted a retrospective observational study using a computer-generated dataset of consecutive patients from a single, academic, urban ED with approximately 58,000 annual visits. We followed the STROBE checklist for observational trials reporting results.[34] This study was deemed exempt by the institutional review board as the data was originally collected for a quality improvement retrospective chart review.

Study Setting and Population

We identified all adult patients (18 years and older) seen in a single, university-based, academic ED who were discharged home with prescriptions for tablet forms of hydrocodone and oxycodone and their acetaminophen-containing combination formulations. Patients were included only if they were discharged from the ED.

Measurements

We examined all opioid prescriptions provided to discharged patients between 1/1/2013 and 11/3/14. The variable reviewed was opioid tablet number. We compared the quantity of tablets prescribed before and after the electronic order-entry prescription default quantity of 20 tablets was removed. This intervention was enacted on 1/17/2014. No specific messaging was given to providers to avoid influencing prescribing patterns.

Data Analysis

We used two-sample Wilcoxon rank-sum test, two-sample test of proportions, and Pearson's chi-squared test to compare the number of tablets prescribed before and after the removal of the default and proportion of 20 tab prescriptions. Data analysis was conducted using STATA version 14.0© (College Station, TX).

RESULTS

A total of 4,104 adult patients received discharge prescriptions for opioids in the 54 weeks pre-intervention, and 2,464 in the 43 weeks post-intervention period. The median quantity of opioid tablets prescribed before and after removal of the default quantity was 20 (interquartile ratio [IQR] 10-20) to 15 (IQR 10-20) respectively (two sample Wilcoxon rank-sum $p<0.0001$). The most frequent quantity of tablets received in both groups was 20 tablets; however, the proportion of patients receiving 20 tablets reduced from 0.5 (95% confidence interval [CI] [0.48-0.52]) to 0.23 (95%CI 0.21-0.24) after default quantity removal ($p<0.001$) (Table 1, Figure).

DISCUSSION

Our primary objective was to evaluate opioid-prescribing patterns after removal of default quantity of 20 tablets in the EMR. When the default quantity was in place, the majority of prescriptions provided were for this exact quantity (20 tablets), suggesting that prescribing behavior is strongly influenced by a default quantity prepopulated in the EMR. After removing the default, the number of prescriptions provided for this quantity (20) decreased, and the median number of tablets prescribed with each prescription had a statistically significant reduction. Removing the default quantity requires that physicians choose the number of tablets they will prescribe.

Had our primary objective been to achieve a more significant reduction in quantity provided, we could have changed to a smaller default value of 10 or 12 tablets and evaluated the impact of this change. However, the increased variation of tablet quantity prescriptions observed after removal of the default may reflect more appropriate prescribing patterns—a smaller quantity of analgesia tablets needed for less severe pain or pain expected to resolve quickly and greater quantities for more severe pain or pain expected to be prolonged. In many clinical scenarios it may be beneficial to avoid variation among practicing clinicians in a single ED, such as in the treatment of an acute myocardial infarction or sepsis. Having a default opioid quantity in the EMR, while demonstrated to successfully reduce variation in clinical practice patterns, may not be optimal for patient care. This would reflect a case where variation of prescribing patterns may be more appropriate than standardization. A "one-size-fits-all" approach to opioid prescribing and ignoring variable durations and severities of acute pain syndromes will predictably result in undertreatment for some patients and overtreatment for others.

The total number of prescription for opioids was also noted to have decreased during the study period. In the pre-intervention period, there were 151.6 prescriptions for opioids per 1,000 discharged adult patients compared to 106.69 per 1,000 in the post-intervention period. This may reflect random variation or purposeful decline in opioid prescribing influenced by the significant attention recently brought on by the "opioid epidemic." The providers were not notified of removal of the default quantity; therefore, it is less likely that the intervention itself influenced the decrease in number of prescriptions. The data on prescribing patterns from the ED in recent years are limited, and it is unknown if there has been a widespread decline in prescribing patterns over this same time period.

LIMITATIONS

This was a single-center study, potentially limiting its generalizability. However, a recent study on prescribing patterns from the ED demonstrates that the median number of pills prescribed was 15 in an observational, multi-centered cohort study across 19 U.S. EDs.[19] These findings are similar to our department's average tablets prescribed. Our analysis was limited to adult patients; we did not assess prescribing patterns for pediatric patients.

Table 1. Number of opioid-containing analgesic prescriptions by tablet number groupings (and percentage of total prescriptions) before and after removal of default quantity of 20 tablets.

Tablet number group	Pre	Post	Total
< 20	1,723 (42.9%)	1,685 (68.4%)	3,408 (52.6%)
20	2,007 (50.0%)	562 (22.8%)	2,569 (39.7%)
> 20	284 (7.1%)	217 (8.8%)	501 (7.7%)
Total	4,014	2,464	6,478

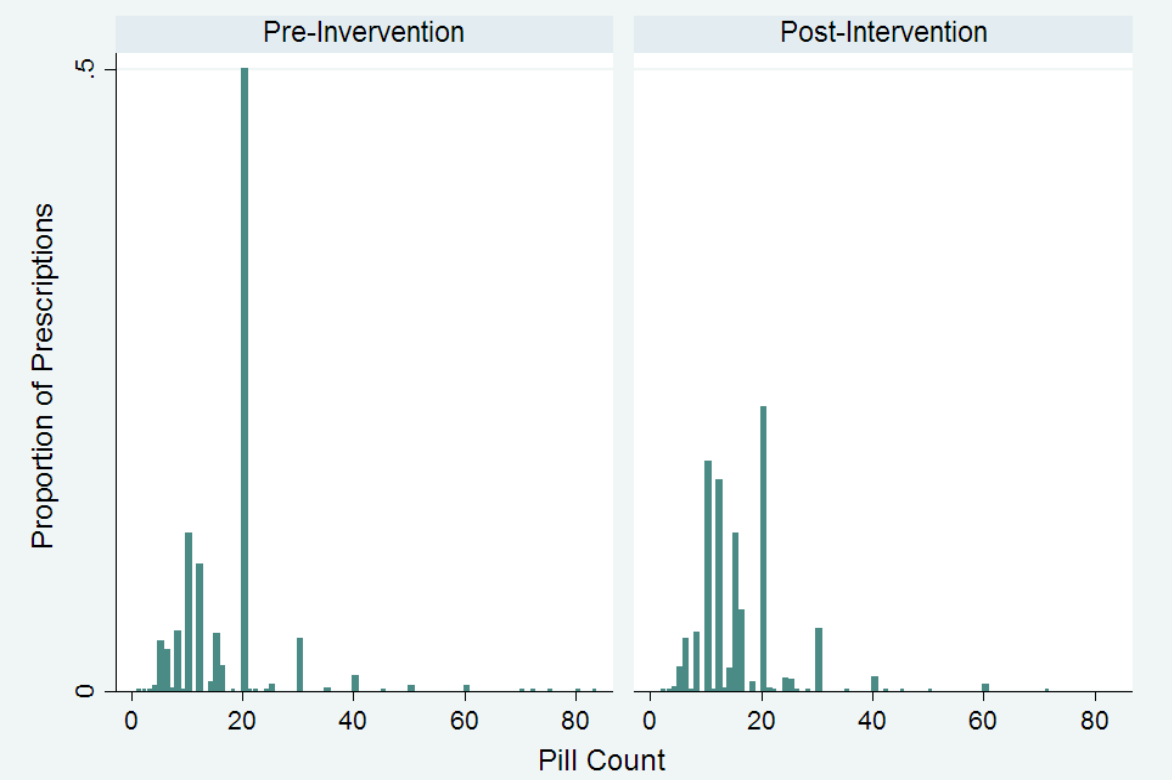

Figure. Histogram demonstrating number of tablets prescribed as a fraction of overall prescribed, opioid-containing analgesics before and after removal of default quantity of 20 tablets

As a retrospective analysis, unmeasured confounders may have influenced our analysis. Factors that were not studied may have influenced opioid prescribing patterns. These include the physician's perception of pain intensity, the age of the patient, the provider's experience level, and the diagnosis at the time of discharge. Furthermore, it is unknown whether the increased variation post-intervention really represents true individual prescribing variation. Further evaluation would be required to analyze each individual provider's prescribing patterns before and after the intervention to determine whether they each exhibited the same increase in variability as the entire group or if, after removal of the default quantity, each provider relied on his/her own individual default quantity for each patient regardless of painful condition.

Other potential explanations for the findings observed were not studied directly. One potential confounder is a change in the patient population or ED providers during the study period, which may have influenced prescribing habits. Comparing patient acuity in the period before and after the intervention demonstrates similar Emergency Severity Index scores and admission rates (Table 2). This suggests similar patient characteristics in the pre- and post-intervention period. The total number of Level I and II trauma activations and ED visits for adult patients was lower in the post-intervention period as expected, given the duration of the post-intervention period was shorter. Pain scores and injury severity scores may have differed and were not studied.

Although it appears that prescribing patterns may have been more appropriate after elimination of default quantity, this assumption was not directly tested. Changes in provider mix may also account for differences in opioid prescribing during the post-intervention period. Although this was not studied directly, there was minimal turnover among the provider group during the study period with a total of one hire and two departures of full-time faculty (total number of 30 faculty) during the combined time periods. Further studies would be needed to determine which factors influence physician-prescribing patterns of opioid analgesics for specific, painful conditions including analysis of pain scores.

CONCLUSION

We demonstrated that prescription quantities for pain medications are influenced by EMR default quantities. Having a default quantity of opioid analgesics prepopulated in the EMR resulted in a large portion of patients receiving that exact quantity. Eliminating the default quantity of tablets altered prescribing patterns for clinicians, which resulted in wider variability in quantity of tablets prescribed. This may reflect more appropriate prescribing patterns for painful conditions. It is important to continue to study physician-prescribing patterns and to find strategies to prevent or reduce opioid abuse and

Table 2. Characteristics of ED patient encounters in the time periods before and after removal of a default quantity of 20 tablets for opioid prescriptions.

Measure	Pre (1/1/13 – 1/16/14)	Post (1/17/14 – 11/3/2014)
Mean ESI Score	2.92	2.93
Median ESI Score	3	3
Admit Rate	30.6% (15,543/50,828)	29.6% (12,611/42,549)
Adult Admit Rate	33.2% (13,463/40,535)	31.8% (10,804/33,899)
Level I Traumas	298	281
Level II Traumas	1,684	1,312
Adult Patients	40,535	33,899
Total ED Visits	50,828	42,549

ESI, Emergency Severity Index; *ED*, emergency department

overdose among patients while also ensuring appropriate pain control when using these high-risk medications.

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REFERENCES

1. Pletcher MJ, Kertesz SG, Kohn MA, et al. Trends in opioid prescribing by race/ethnicity for patients seeking care in US emergency departments. *JAMA*. 2008;299(1):70-8.
2. Phillips DM. JCAHO pain management standards are unveiled. Joint Commission on Accreditation of Healthcare Organizations. *JAMA*. 2000;284(4):428-9.
3. Lanser P, Gesell S. Pain management: the fifth vital sign. *Healthc Benchmarks*. 2001;8(6):68-70, 62.
4. Manchikanti L, Fellows B, Ailinani H, et al. Therapeutic use, abuse, and nonmedical use of opioids: a ten-year perspective. *Pain Physician*. 2010;13(5):401-35.
5. Gilson AM, Ryan KM, Joranson DE, et al. A reassessment of trends in the medical use and abuse of opioid analgesics and implications for diversion control: 1997-2002. *J Pain Symptom Manage*. 2004;28(2):176-88.
6. Joranson DE, Ryan KM, Gilson AM, et al. Trends in medical use and abuse of opioid analgesics. *JAMA*. 2000;283(13):1710-4.
7. Novak S, Nemeth WC, Lawson KA. Trends in medical use and abuse of sustained-release opioid analgesics: a revisit. *Pain Med*. 2004;5(1):59-65.
8. Zacny J, Bigelow G, Compton P, et al. College on Problems of Drug Dependence taskforce on prescription opioid non-medical use and abuse: position statement. *Drug Alcohol Depend*. 2003;69(3):215-32.
9. Tadros A, Layman SM, Davis SM, et al. Emergency visits for prescription opioid poisonings. *J Emerg Med*. 2015;49(6):871-7.
10. Martins SS, Sampson L, Cerda M, et al. Worldwide Prevalence and trends in unintentional drug overdose: a systematic review of the literature. *Am J Public Health*. 2015;105(11):e29-49.
11. Paulozzi LJ, Budnitz DS, Xi Y. Increasing deaths from opioid analgesics in the United States. *Pharmacoepidemiol Drug Saf*. 2006;15(9):618-27.
12. Coben JH, Davis SM, Furbee PM, et al. Hospitalizations for poisoning by prescription opioids, sedatives, and tranquilizers. *Am J Prev Med*. 2010;38(5):517-24.
13. Piercefield E, Archer P, Kemp P, et al. Increase in unintentional medication overdose deaths: Oklahoma, 1994-2006. *Am J Prev Med*. 2010;39(4):357-63.
14. Warner M, Chen LH, Makuc DM, et al. Drug poisoning deaths in the United States, 1980-2008. *NCHS Data Brief*. 2011;(81):1-8.
15. Centers for Disease Control and Prevention (CDC). Vital signs: overdoses of prescription opioid pain relievers-- United States, 1999--2008. *MMWR Morb Mortal Wkly Rep*. 2011;60(43):1487-92.
16. 10 leading causes of injury deaths by age group highlighting unintentional injury deaths, United States - 2014. Centers for Disease Control and Prevention website. Available at: https://www.cdc.gov/injury/images/lc-charts/leading_causes_of_injury_deaths_unintentional_

injury_2014_1040w740h.gif. Accessed on December 12, 2016.
17. Cantrill SV, Brown MD, Carlisle RJ, et al. Clinical policy: critical issues in the prescribing of opioids for adult patients in the emergency department. *Ann Emerg Med*. 2012;60(4):499-525.
18. Mazer-Amirshahi M, Mullins PM, Rasooly I, et al. Rising opioid prescribing in adult U.S. emergency department visits: 2001-2010. *Acad Emerg Med*. 2014;21(3):236-43.
19. Hoppe JA, Nelson LS, Perrone J, et al. Opioid prescribing in a crosssection of US emergency departments. *Ann Emerg Med*. 2015;66(3):253-9.e1.
20. Menchine MD, Axeen S, Plantmason L, et al. Strength and dose of opioids prescribed from US emergency departments compared to office practices: implications for emergency department safe-prescribing guidelines. *Ann Emerg Med*. 2014;64(45).
21. Hoppe JA, Kim H, Heard K. Association of emergency department opioid initiation with recurrent opioid use. *Ann Emerg Med*. 2015;65(5):493-9.e4.
22. Barnett ML, Olenski AR, Jena AB. Opioid-prescribing patterns of emergency physicians and risk of long-term use. *N Engl J Med*. 2017;376(7):663-73.
23. Weiner SG, Perrone J, Nelson LS. Centering the pendulum: the evolution of emergency medicine opioid prescribing guidelines. *Ann Emerg Med*. 2013;62(3):241-3.
24. Kilaru AS, Gadsden SM, Perrone J, et al. How do physicians adopt and apply opioid prescription guidelines in the emergency department? A qualitative study. *Ann Emerg Med.* 2014;64(5):482-9.e1.
25. Gugelmann H, Perrone J, Nelson L. Windmills and pill mills: can PDMPs tilt the prescription drug epidemic? *J Med Toxicol*. 2012;8(4):378-86.
26. Haffajee RL, Jena AB, Weiner SG. Mandatory use of prescription drug monitoring programs. *JAMA*. 2015;313(9):891-2.
27. del Portal DA, Healy ME, Satz WA, et al. Impact of an opioid prescribing guideline in the acute care setting. *J Emerg Med*. 2016;50(1):21-7.
28. Fox TR, Li J, Stevens S, et al. A performance improvement prescribing guideline reduces opioid prescriptions for emergency department dental pain patients. *Ann Emerg Med*. 2013;62(3):237-40.
29. Neven DE, Sabel JC, Howell DN, et al. The development of the Washington State emergency department opioid prescribing guidelines. *J Med Toxicol*. 2012;8(4):353-9.
30. Jozefczyk KG, Kennedy WK, Lin MJ, et al. Computerized prescriber order entry and opportunities for medication errors: comparison to tradition paper-based order entry. *J Pharm Pract*. 2013;26(4):434-7.
31. Teich JM, Spurr CD, Schmiz JL, et al. Enhancement of clinician workflow with computer order entry. *Proc Annu Symp Comput Appl Med Care*. 1995:459-63.
32. Patel J, Ogletree R, Sutterfield A, et al. Optimized computerized order entry can reduce errors in electronic prescriptions and associated pharmacy calls to clarify (CTC). *Appl Clin Inform*. 2016;7(2):587-95.
33. Schwartzberg D, Ivanovic S, Patel S, et al. We thought we would be perfect: medication errors before and after the initiation of computerized physician order entry. *J Surg Res*. 2015;198(1):108-14.
34. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies. *Int J Surg*. 2014;12(12):1495-9.

Emergency Department Frequent Users for Acute Alcohol Intoxication

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Introduction: A subset of frequent users of emergency services are those who use the emergency department (ED) for acute alcohol intoxication. This population and their ED encounters have not been previously described.

Methods: This was a retrospective, observational, cohort study of patients presenting to the ED for acute alcohol intoxication between 2012 and 2016. We collected all data from the electronic medical record. Frequent users for alcohol intoxication were defined as those with greater than 20 visits for acute intoxication without additional medical chief complaints in the previous 12 months. We used descriptive statistics to evaluate characteristics of frequent users for alcohol intoxication, as well as their ED encounters.

Results: We identified 32,121 patient encounters. Of those, 325 patients were defined as frequent users for alcohol intoxication, comprising 11,370 of the encounters during the study period. The median maximum number of encounters per person for alcohol intoxication in a one-year period was 47 encounters (range 20 to 169). Frequent users were older (47 years vs. 39 years), and more commonly male (86% vs. 71%). Frequent users for alcohol intoxication had higher rates of medical and psychiatric comorbidities including liver disease, chronic kidney disease, ischemic vascular disease, dementia, chronic obstructive pulmonary disease, history of traumatic brain injury, schizophrenia, and bipolar disorder.

Conclusion: In this study, we identified a group of ED frequent users who use the ED for acute alcohol intoxication. This population had higher rates of medical and psychiatric comorbidities compared to non-frequent users. [West J Emerg Med.2018;19(2)398–402.]

INTRODUCTION

Frequent users of emergency departments (EDs) have been the subject of substantial research given the implications for resource utilization, healthcare costs, and ED crowding.[1-5] A unique subset of frequent ED users are those who present to the ED repeatedly for acute alcohol intoxication.[6-8] As ED visits for acute alcohol intoxication are increasing,[9] the burden of alcohol-related frequent users will be important to explore. Existing studies describing frequent ED users often cite alcohol-use disorders as a common comorbidity and a precipitant for their disproportionate utilization of emergency services.[1,2] Despite this established association, there is a paucity of data describing the encounters and individuals who frequently use the ED for alcohol intoxication, or the extent to which they use the ED for other reasons. The purpose of this study was to describe this population and their ED encounters.

METHODS

This was a retrospective, observational, cohort study of ED patients presenting for acute alcohol intoxication from 2012 to 2016. It was approved by the institutional review board. The study hospital is a county ED with an annual volume of 100,000 visits and 7,000 visits for alcohol intoxication. The ED has a 16-bed area within the department that clusters all intoxication encounters. The purpose of this area is to treat patients who are in the department *for* intoxication at patients who ared to treat complicated medical or trauma patients who also happen to be intoxicated from alcohol. Patients are selected for treatment in this area at the discretion of triage nurses, paramedics (if arriving by ambulance), and the emergency physicians. All alcohol-intoxication encounters are seen in this particular area of the ED, but there is occasional overflow to other parts of the ED if these rooms are full. All patients who are treated in one of these rooms are entered into the electronic medical record (EMR) using the chief complaint "altered mental status."

We included adults (>17 years old) if they presented to the ED for alcohol intoxication during the study period. These patients were identified using the EMR by querying for all visits where the chief complaint was "altered mental status ng for ir initial ED room was within the intoxication section of the ED. Patients were excluded if their breath alcohol concentration was zero. The variables for analyses were chosen a priori. We selected them if they were hypothesized to be relevant to the study population and if they were readily available in the EMR. A data analyst (trained in EMR data acquisition) who was blinded to the purpose of the study obtained the following variables without any manual chart abstraction: age, gender, race/ethnicity, insurance status, primary care physician, medical/psychiatric comorbidities, breath alcohol concentration, testing obtained (imaging, laboratory), chemical sedation administered, ED disposition, and length of stay. Additional data for each frequent user was manually abstracted from the chart by another investigator (MR); these included counts of ED visits that were not for alcohol intoxication, hospital admissions, and visits to a separate psychiatric services ED.

Multiple definitions for ED frequent users exist in the literature, ranging from 3-20 visits per 12-month period.[1,10] For this study, we elected to use the upper limit of this range and categorize an alcohol- related frequent user as greater than 20 visits for acute alcohol intoxication in the previous 12 months, in order to describe the highest-user cohort possible. Non-frequent users were those who did not meet this criterion.

After we identified the frequent-user cohort, we analyzed encounter characteristics for those with a frequent-user designation during that visit compared to those without. For analysis of patient characteristics and demographics, duplicate observations were excluded. The patient encounter that was retained for demographic analysis was the most recent encounter during the study period. For all comparisons, we calculated differences in means or proportions with associated 95% confidence intervals. We checked a subset of 20 charts to confirm accuracy of data abstraction.

Population Health Research Capsule

What do we already know about this issue?
Frequent users pose a unique challenge in emergency departments (ED), given their impact on resource utilization, healthcare costs, and their overall health considerations.

What was the research question?
The purpose of this study was to describe ED frequent users for alcohol intoxication and their ED encounters.

What was the major finding of the study?
Alcohol-intoxication frequent users had many medical/psychiatric comorbidities, and poor utilization of primary care.

How does this improve population health?
We intend the findings of this research to inform ED providers and community resource personnel to help them optimize care for this high-risk population.

RESULTS

We identified 32,121 encounters meeting inclusion criteria (Figure), and there were 325 unique patients defined as frequent users for alcohol intoxication. These 325 patients represented 11,370 of the encounters during the study period. The median maximum number of encounters in a one-year period was 47 encounters (range 20 to 169) for acute alcohol intoxication.

During the five-year study period, frequent users used the ED for non-alcohol intoxication purposes a total of 3,812 times (median per patient = 11, range = 0-91), were admitted to the hospital a total of 4,960 times (median per patient = 9, range = 0-89), and used psychiatric, acute care services a total of 753 times (median per patient = 2, range 0-78). Additional patient characteristics and encounter characteristics are depicted in Table 1 and Table 2. Accuracy of data abstraction was 98%.

DISCUSSION

Frequent users for alcohol intoxication are a unique subset of frequent ED users who merit attention given increasing numbers of alcohol-related visits nationally.[9] In this study, we identified 325 patients with 11,370 encounters for alcohol intoxication over a five-year period, where some individuals used the ED for

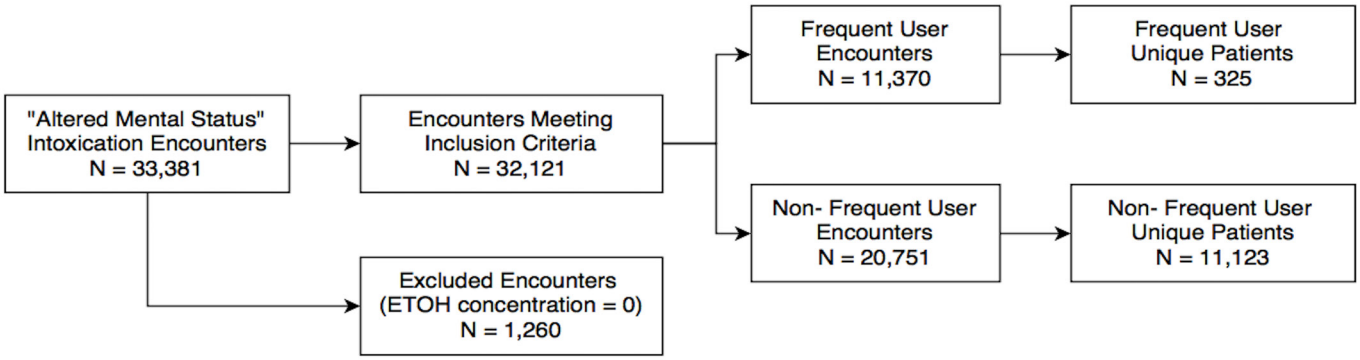

Figure. Patient inclusion and exclusion in study examining frequency of emergency department use by those with acute alcohol intoxication.

Table 1. Patient characteristics for alcohol-related frequent vs. non-frequent users.

Patient variable	Frequent user (n=325)	Non-frequent user (n=11,123)	Difference (95% CI)
Age (mean years)	47	39	8 (95% CI [6-9])
Gender (% male)	281 (86%)	7880 (71%)	16% (95% CI [11-19])
Race/Ethnicity			
Caucasian	101 (31%)	6,407 (58%)	-27% (95% CI [-32 to -22%])
African/African-American	102 (31%)	2,374 (21%)	10% (95% CI [5-15%])
Native American	108 (33%)	945 (9%)	24% (95% CI [19-29%])
Hispanic	10 (3%)	718 (6%)	-3% (95% CI [-5 to -1%)
Asian	2 (1%)	161 (1%)	0 (95% CI [-1 to 1%])
Primary care physician	161 (49%)	3105 (28%)	22% (95% CI [16-26])
Coordinated primary care services	14 (4%)	67 (0.6%)	3% (95% CI [1-6])
Insurance			
No insurance	68 (21%)	4110 (37%)	-16% (95% CI [-21 to -11])
Medicaid	87 (27%)	1248 (11%)	16% (95% CI [11-21%])
Medicare	37 (11%)	920 (8%)	3% (95% CI [0-6%])
Medical assistance	74 (23%)	1247 (11%)	12% (95% CI [7-17%])
Private insurance	26 (8%)	2148 (19%)	-11% (95% CI [-14 to -8%])
Medical comorbidities			
Liver disease	89 (27%)	611 (6%)	21% (95% CI [16-26])
Chronic kidney disease	35 (11%)	440 (4%)	7% (95% CI [4-10])
Ischemic vascular disease	22 (7%)	179 (2%)	5% (95% CI [2-8])
COPD	30 (9%)	184 (2%)	7% (95% CI [4-10])
History of TBI	62 (19%)	342 (3%)	16% (95% CI [12-20])
Dementia	30 (9%)	170 (2%)	7% (95% CI [4-10])
Psychiatric comorbidities			
Schizophrenia	40 (12%)	320 (3%)	9% (95% CI [5-13])
Bipolar disorder	67 (21%)	778 (7%)	14% (95% CI [10-18])

CI, confidence interval; *COPD*, chronic obstructive pulmonary disease, *TBI*, traumatic brain injury.
Patient characteristics calculated using a single encounter per patient (excluding duplicate encounters).

Table 2. Encounter characteristics for alcohol-related frequent users vs. non-frequent users.

Encounter variable	Frequent user encounter (n=11,370)	Non-frequent user encounter (n=20,751)	Difference (95% CI)
Initial BAC (mean mg/dl)*	256	221	35 (95% CI 33-37)
Admitted to hospital	340 (3%)	627 (3%)	0% (95% CI 0-1)
ICU admissions	109 (1%)	189 (1%)	0% (95% CI 0-1)
Laboratory testing	725 (6%)	1523 (7%)	-1% (95% CI -1 to 0)
CT performed	434 (4%)	1309 (6%)	-2% (95% CI -3 to -2)
Chemical sedation	3957 (35%)	8987 (43%)	-8% (95% CI -10 to -7)
Length of stay (mean minutes)	470	482	-12 (95% CI -17 to -7)

BAC, blood alcohol concentration; *CI*, confidence interval; *ICU*, intensive care unit; *CT*, computed tomography.
Encounter characteristic calculated using all encounters, including multiple encounters per patient.
*BAC was performed on 100% of patients.

alcohol intoxication more than 100 times in a year.

In this study, we identified several variables that differed for frequent users compared to non-frequent users. First, there were comparatively higher rates of medical and psychiatric comorbidities among alcohol- related frequent users. This finding reiterates the complexity of this population, and the fact that any of these "routine" visits have the potential for clinical decompensation and may require resources beyond the scope of simple observation for intoxication. We also identified differences in demographics (frequent users tended to be older, non-Caucasian, and male), as well as differences regarding health insurance status (frequent users were more often insured with government assistance such as Medicaid). In contrast, several variables were not different among the two groups; namely, diagnostic workups were similar between the groups, but interpretation of this finding is limited by practice patterns at our institution, where workups tend to be minimal for most alcohol-intoxication encounters.

Another important finding in this study was the low admission rate among frequent users (3%). While it is not unexpected that presentations for alcohol intoxication would result in low admission rates (as this is generally an uncomplicated chief complaint compared to other chief complaints), it does illustrate a potential barrier in caring for this population. In other studies describing frequent users for other general medical complaints, admission rates are reported to be as high as 40%.[3] In those cases, interventions can be implemented as inpatients, and resources can be initiated during admissions. In the population we describe, since admissions are so uncommon, the responsibility may be on ED personnel to identify these patients, as they will not be addressed by an inpatient team.

In our cohort of alcohol-related frequent users, we identified some concerning features regarding primary care access and utilization. Less than half (49%) of the frequent-user population had primary care physicians, and only 4% were participants in a coordinated primary care program intended for the hospital's greatest utilizers. We believe that this is an important gap in coverage for a very high-needs population. This finding also contrasts the general ED frequent-user literature, where most describe primary care access as over 90%.[1] Our institution does not appear to be identifying alcohol-related frequent users for primary care services as effectively as those who use the ED for other problems. Possible explanations for this gap in coverage could include a lack of readiness for healthcare accountability, or a struggle maintaining primary care relationships in the setting of ongoing substance abuse.

We were unable to determine the prevalence of important social stressors such as homelessness, employment, or government assistance (other than health insurance) in this cohort, but addressing these stressors in future will play an important role in assisting this population. Multiple social services interventions have been proposed for frequent ED users, such as case management and referral programs, but these have been shown to have variable rates of success.[7,11] One study conducted in our community investigated use of case management and demographic-specific housing referrals among 92 chronic inebriates. While the study found that the healthcare costs decreased pre vs. post intervention, ED visits did not decrease.[7]

LIMITATIONS

This study is subject to several limitations, including those inherent to a retrospective study design. We attempted to minimize this bias by using standardized methods for data collection research. Second, we present data from a single center, which may not be generalizable to other EDs, especially for EDs that do not see large volumes of alcohol-intoxication visits. We do believe, however, that many of our findings coincide with existing literature describing other populations of ED frequent users, thus supporting our results. It is also likely that there are other important variables describing this population (such as other comorbidities) that were not explored in this study.

Another potential limitation was our definition of frequent users. We elected to use a cutoff of 20 visits per 12 months to define our frequent users based on previous literature. The intent of using this particular cutoff was to capture the highest-user group possible, but it is possible that had we used other cutoff definitions, our results would be different. Finally, there is the potential for selection bias in this sample, as we focused our search query on alcohol-intoxication visits in a specific area of our ED, rather than the entire ED. This was, however, the most practical means to fulfill the goals of this study, which was to ensure that the encounters we describe were those *for* alcohol intoxication, rather than encounters for a primary medical or traumatic purpose where the patient was also intoxicated from alcohol.

CONCLUSION

There are patients who frequently use the ED for acute alcohol intoxication, and this group of "alcohol-related" frequent users has not been previously reported. We identified that this frequent-user population has higher rates of medical comorbidities and psychiatric comorbidities compared to non-frequent users. This population was also found to have relatively poor access to primary care (less than 50%). We intend the findings of this report to be hypothesis-generating for future work regarding how to target this population.

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REFERENCES

1. LaCalle E, Rabin E. Frequent users of emergency departments: the myths, the data, and the policy implications. *Ann Emerg Med*. 2010;56(1):42-8.
2. Doupe MB, Palatnick W, Day S, et al. Frequent users of emergency departments: developing standard definitions and defining prominent risk factors. *Ann Emerg Med*. 2012;60(1):24-32.
3. Locker TE, Baston S, Mason SM, Nicholl J. Defining frequent use of an urban emergency department. *Emerg Med J*. 2007;24(6):398-401.
4. Pines JM, Asplin BR, Kaji AH, et al. Frequent users of emergency department services: gaps in knowledge and a proposed research agenda. *Acad Emerg Med*. 2011;18(6):e64-9.
5. Leporatti L, Ameri M, Trinchero C, et al. Targeting frequent users of emergency departments: Prominent risk factors and policy implications. *Health Policy*. 2016;120(5):462-70.
6. Whiteman PJ, Hoffman RS, Goldfrank LR. Alcoholism in the emergency department: an epidemiologic study. *Acad Emerg Med*. 2000;7(1):14-20.
7. Thornquist L, Biros M, Olander R, et al. Health care utilization of chronic inebriates. *Acad Emerg Med*. 2002;9(4):300-8.
8. Biros MH. The frequency of unsuspected minor illness or injury in intoxicated patients. *Acad Emerg Med*. 1996;3(9):853-8.
9. Mullins PM, Mazer-Amirshahi M, Pines JM. Alcohol-Related Visits to US Emergency Departments, 2001–2011. *Alcohol*. 2017;52(1):119-25.
10. Curran GM, Sullivan G, Williams K, et al. Emergency department use of persons with comorbid psychiatric and substance abuse disorders. *Ann Emerg Med*. 2003;41(5):659-67.
11. Althaus F, Paroz S, Hugli O, et al. Effectiveness of interventions targeting frequent users of emergency departments: a systematic review. *Ann Emerg Med*. 2011;58(1):41-52.e42.

Nasal Cannula Apneic Oxygenation Prevents Desaturation During Endotracheal Intubation: An Integrative Literature Review

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Patients requiring emergency airway management may be at greater risk of acute hypoxemic events because of underlying lung pathology, high metabolic demands, insufficient respiratory drive, obesity, or the inability to protect their airway against aspiration. Emergency tracheal intubation is often required before complete information needed to assess the risk of procedural hypoxia is acquired (i.e., arterial blood gas level, hemoglobin value, or chest radiograph). During pre-oxygenation, administering high-flow nasal oxygen in addition to a non-rebreather face mask can significantly boost the effective inspired oxygen. Similarly, with the apnea created by rapid sequence intubation (RSI) procedures, the same high-flow nasal cannula can help maintain or increase oxygen saturation during efforts to secure the tube (oral intubation). Thus, the use of nasal oxygen during pre-oxygenation and continued during apnea can prevent hypoxia before and during intubation, extending safe apnea time, and improve first-pass success attempts. We conducted a literature review of nasal-cannula apneic oxygenation during intubation, focusing on two components: oxygen saturation during intubation, and oxygen desaturation time. We performed an electronic literature search from 1980 to November 2017, using PubMed, Elsevier, ScienceDirect, and EBSCO. We identified 14 studies that pointed toward the benefits of using nasal cannula during emergency intubation. [West J Emerg Med. [West J Emerg Med. 2018;19(2)403–411.]

INTRODUCTION

Oxygen desaturation below 70% puts patients at risk for dysrhythmia, hemoglobin decompensation, hypoxic brain injury, and death.[1-3] The challenge for emergency physicians (EP) is to secure an endotracheal tube rapidly without critical hypoxia or aspiration.[1] Preoxygenation prior to intubation extends the duration of "safe apnea" (the time it takes until a patient reaches an oxygen saturation level of 88% to 90%), to allow for placement of a definitive airway.[1] Below that level, oxygen offloading from hemoglobin enters the steeper portion of the oxyhemoglobin dissociation curve, and can decrease to critical levels of oxygen saturation (<70%) within seconds.[1]

Alveoli will continue to take up oxygen even without diaphragmatic movements or lung expansion. Within some of the larger airways, turbulent flow could generate a cascade of turbulent vortex flows extending into smaller airways. Each vortex could communicate with the vortex above and below it, like a series of interlocking gears.[4]

The main goal of preoxygenation is to extend safe apnea time, which is more likely if certain physiological criteria are met (i.e., denitrogenation of the lungs and achieving an arterial oxyhemoglobin saturation (SaO_2) of 100% as close as possible). Denitrogenation involves using oxygen to wash out the nitrogen contained in lungs after breathing room air, resulting in a larger alveolar oxygen reservoir. When breathing room air (79% nitrogen), 450 mL of oxygen is present in the lungs of an average healthy adult. When a patient breathes 100% oxygen, this washes out the nitrogen, increasing the oxygen in the lungs to 3,000 mL.

EPs and emergency medical services (EMS) use several devices to deliver oxygen or increased airflow to patients in respiratory need. Nasal cannula is used primarily for apneic

oxygenation rather than pre-oxygenation. Previous recommendations were to place high-flow nasal cannula (HFNC) with an initial oxygen flow rate of 4 L/min, then increase to 15 L/min to provide apneic oxygenation once the patient is sedated. A nasal cannula can be placed above the face mask until just prior to attempting laryngoscopy, at which point it is placed in the nares to facilitate apneic oxygenation. The standard non-rebreather mask (NRB) delivers only 60% to 70% inspired oxygen (FiO_2)at oxygen flow rates of 15 L/min. The FiO_2 can be improved by connecting the NRB to 30-60 L/min oxygen flows from rates of 15 L/min. The use of NRBs is limited in patients with high inspiratory flow rates as FiO_2 may be decreased due to NRB design (i.e., seal, valve function). Some devices with effective seals and valves will collapse onto the patients face at high inspiratory flow rates causing transient airway obstruction.

A bag-valve mask (BVM) may approximate an anesthesia circuit for preoxygenation. BVMs vary in performance according to the type of BVM device, spontaneous ventilation vs. positive pressure ventilation, and the presence of a positive end-expository pressure (PEEP) valve. During spontaneous ventilation the patient must produce sufficient negative inspiratory pressures to activate the inspiratory valve. The negative pressures generated within the mask may lead to entrapment of room air and lower FiO_2 during pre-oxygenation. A BVM's performance increases during spontaneous breathing by administering high-flow oxygen, using a PEEP valve, and assisting spontaneous ventilations with positive pressure ventilations in synchrony with the patient's spontaneous inspiratory efforts. Continuous positive airway pressure improves oxygenation by increasing functional residual capacity by reversing pulmonary shunting through the recruitment of poorly ventilated lung units.

In an apneic patient approximately 250 mL/minute of oxygen moves from the alveoli into the bloodstream. Conversely, only 8-20 mL/minute of carbon dioxide (CO_2) moves into the alveoli during apnea with the remainder buffered in the bloodstream; this causes the net pressure in the alveoli to become slightly subatmospheric, generating a mass flow of gas from pharynx to alveoli via diffusion.[3] Regarding CO_2 concentrations, Patel et al., 2015 provided evidence of those concentrations during apnea. Figure 1 shows the rate of CO_2 concentration levels rising in various forms of apnea.[5] It's interesting to note that traditional apneic oxygenation has a similar rate of CO_2 concentration rise when compared to airway obstruction.

High-flow oxygen therapy through a nasal cannula is a technique whereby oxygen is delivered to the nose at high flow rates. Higher flow rates generate low levels of positive pressure in the upper airways, and the fraction of FiO_2 can be adjusted by changing the fraction of oxygen in the driving gas.[21] The high flow rates may also decrease physiological dead space by flushing expired CO_2 from the upper airway.[21]

Population Health Research Capsule

What do we already know about this issue?
During apnea created by rapid sequence intubation, high-flow nasal cannula maintains or increases oxygen saturation during efforts to secure an endotracheal tube.

What was the research question?
Does the use of high-flow nasal cannula during intubation prevent oxygenation desaturation?

What was the major finding of the study?
With additional studies, this study confirms that the use of nasal cannula during intubation prevents oxygen desaturation except in those with respiratory failure.

How does this improve population health?
Employing nasal oxygen during intubation can prevent hypoxia, extending safe apnea time, and improve first-pass success attempts.

The time period between becoming apneic and oxygenated via intubation is a vulnerable moment in the patient's oxygen status, and can possibly be alleviated by using a nasal cannula. It was noted that traditional apneic oxygenation has a similar rise in CO_2 concentration as an airway obstruction; so, can the use of nasal cannula during endotracheal intubation prevent oxygen desaturation? While various devices are used to preoxygenate patients, no standardized protocol exists. Despite the use of this technique by both anesthesiologists and EPs, to date implementing a nasal cannula during intubation has not been part of the standard of care in these procedures. The objective of this review was to evaluate studies that provide evidence for HFNC efficacy in preventing oxygen desaturation during intubation.

METHODS

We identified articles from the following databases: PubMed, the National Center for Biotechnology Information, Elsevier, ScienceDirect, and EBSCO. The search was limited to articles in English published from 1980 – November 2017. We searched the following keywords: *nasal cannula, intubation, oxygen, hypoxia, hypoxemia, tracheal, pharyngeal, apnea, apneic, pre-oxygenation, insufflation*. We reviewed all abstracts to identify articles that assessed the usage of a nasal cannula during pre-oxygenation, apnea, and intubation. To ensure complete detection of all relevant studies, we cross-referenced

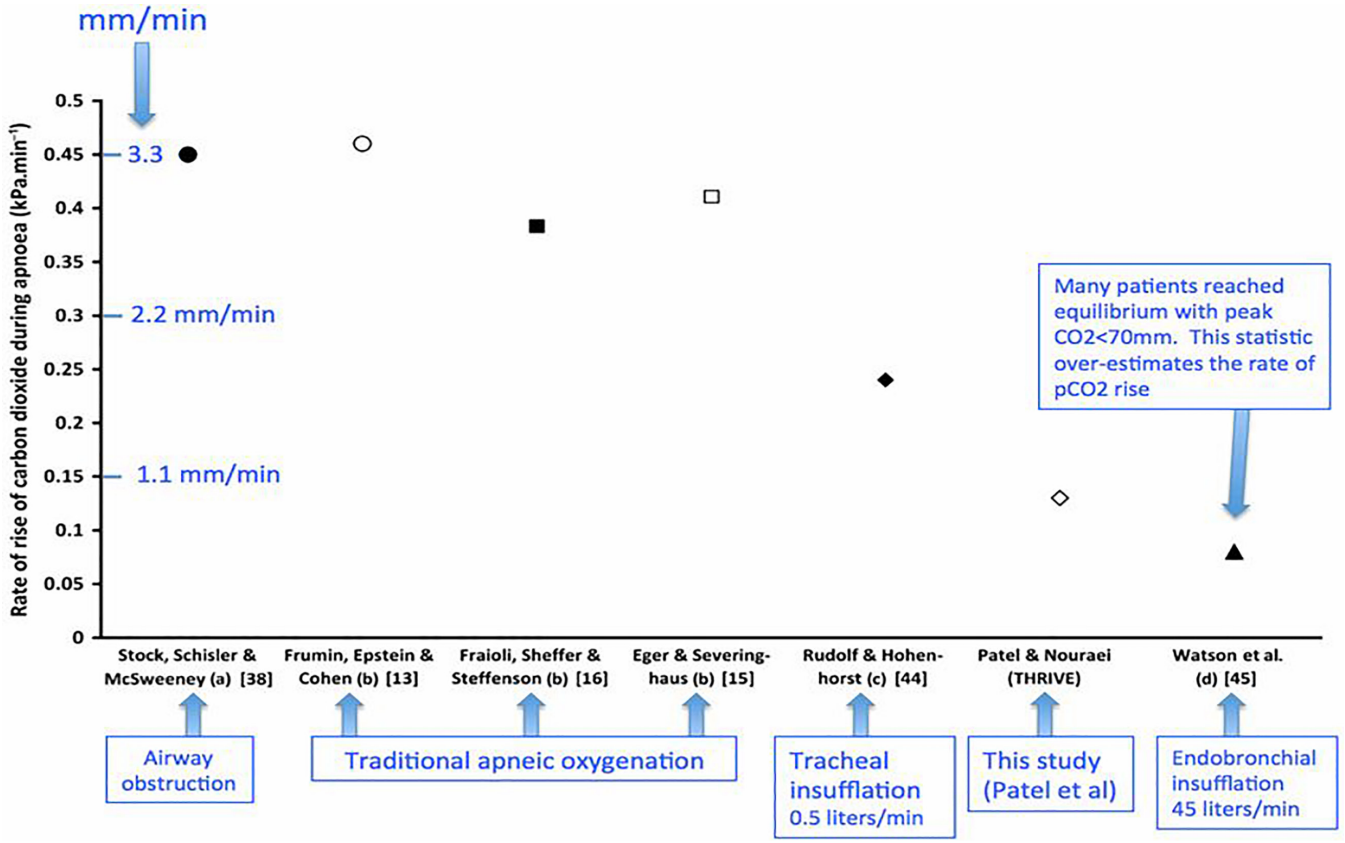

Figure 1. Rate of rise of carbon dioxide (CO_2) levels during intubation under different apnea conditions undertaken within the study referred to (a) airway obstruction; (b) classical apneic oxygenation; (c) low-flow intra-tracheal cannula; and (d) high-flow intratracheal cannula.

all articles from the bibliography of the selected articles. After reviewing each article, we selected studies that met the following inclusion criteria: the use of nasal cannula or nasopharyngeal insufflation during intubation. We excluded studies that oxygenated patients with a NRB and/or BVM during periods of apnea. Past medical history and comorbidities were not taken into consideration. We evaluated studies by comparing the use of a nasal cannula or nasopharyngeal oxygen insufflation during intubation vs. the non-use of nasal cannula or nasopharyngeal oxygen insufflation; oxygen saturation levels before and during intubation, and in some groups time to desaturation. We determined oxygen saturation using two measurements: arterial SaO_2 as determined by an arterial blood gas (ABG) test; and pulse oximetry as measured by peripheral oxygen saturation (SpO_2).

RESULTS

To assess whether the use of nasal cannula during intubation would prevent oxygen desaturation, we compiled a list of studies (Figure 2) that report the mean or median oxygen saturation percentages (SpO_2%) with this intervention. A baseline SpO_2% was taken after each patient was appropriately raised above hypoxic levels (usually > 95%) during the standard preoxygenation, four-minute procedure of a BVM. SpO_2% was then monitored during intubation. The intervention was compared against non-use to demonstrate its efficacy.

Prior to intubation, several studies first examined the duration of desaturation occurrence by using nasal cannula. Figure 3 displays the time to desaturation before intubation. The intervention was compared against non-use to display an extension of safe apnea time during intubation. We identified 14 studies that investigated the efficacy of apneic oxygenation during intubation, including the use of nasal cannula. Evidence was compiled in PICO (Populations/people/patient/problem Interventions Comparison Outcome) format and displayed in Table. Of the 18 studies, four concluded that nasal cannula use did not prevent desaturation during intubation. [8, 9, 18, 23]

DISCUSSION

Desaturation in apneic patients undergoing rapid sequence intubation (RSI) procedures is predictable and reproduceable. In fact, desaturation rates are also determined by the patient's underlying condition and body habitus (Figure 4). In periods of apnea or a completely obstructed

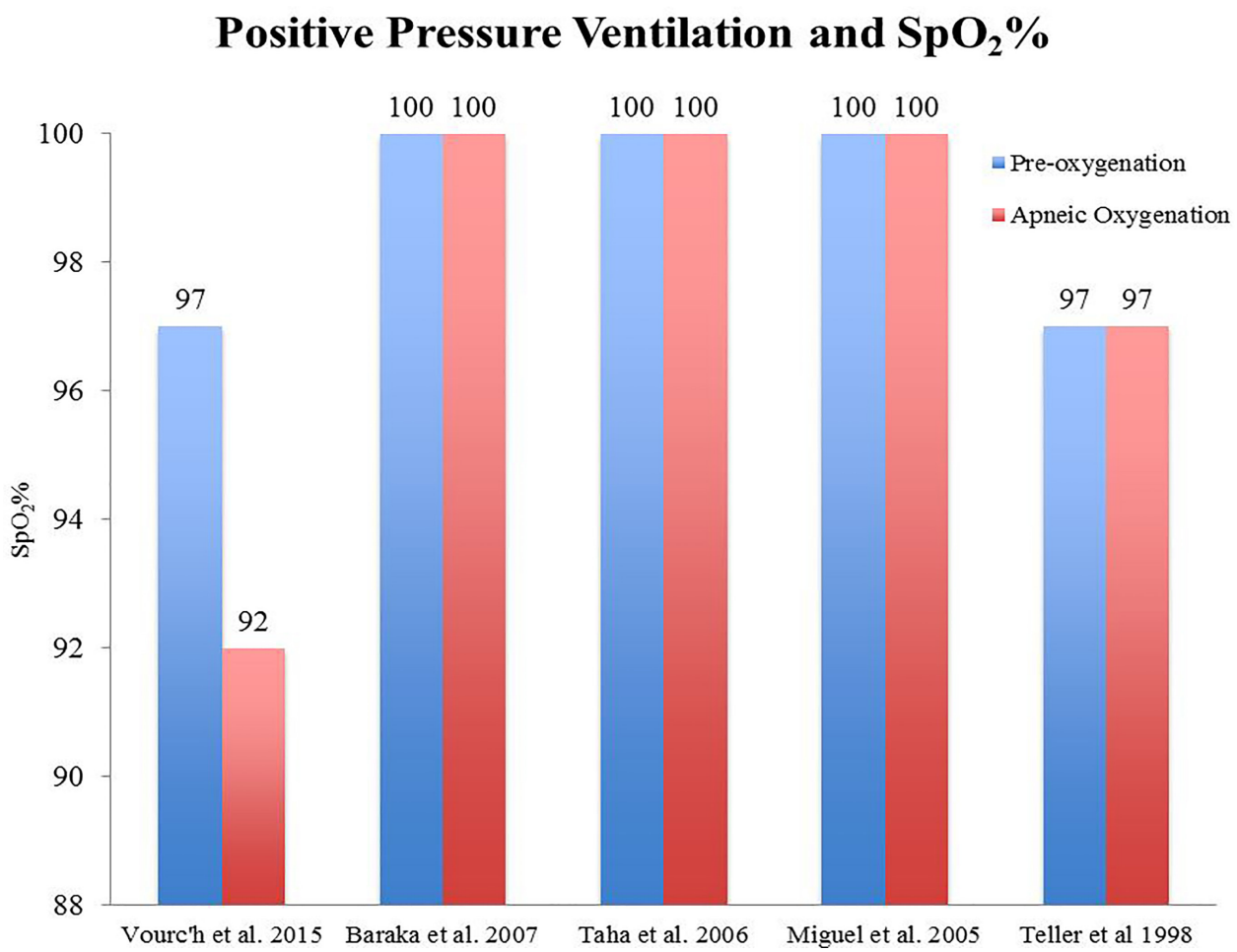

Figure 2. Positive pressure ventilation and peripheral oxygen saturation (SpO_2) %. Patients were recorded on their initial SpO_2% and lowest SpO_2% during intubation. Each patient's oxygen saturation level was raised before intubation to the respective blue lines before undergoing intubation with nasal cannula use. Red lines represent lowest SpO_2 levels reached during intubation with nasal cannula usage. Vourc'h et al., 2015 reported a mean pre-oxygenation and median apneic oxygenation SpO_2%, respectively.

airway, the time to desaturation is much shorter in obese adults and in children, demonstrated by a precipitous drop of hemoglobin oxygen levels after only 2.5-3.5 minutes. Depending on the emergency such as cardiac arrest or a trauma, which can affect cardiac output, the time to desaturation in such populations will likely be even shorter. The effects of hypoxemia can take place rather quickly: thus the need for quick intervention. The use of nasal cannula can effectively delay critical hemoglobin desaturation.[17]

In this paper, we examined 18 studies through a standardized literature search. Methodologically, all studies were performed with the same protocol of preoxygenation prior to and followed by nasal cannula use during intubation, lending more credence to its favorable results. Of those 18, 14 studies pointed towards the use of nasal cannula during intubation carrying benefits to the patient undergoing intubation, while nine studies reported an increase or maintenance of oxygen saturation levels. Despite patients having various medical conditions, nasal cannula use during intubation extended the duration of safe apnea. The gaps in current research include the following: the use of varying levels of oxygen flow such as 5L vs. 15L O_2 and whether or not it is efficacious in diverse presenting medical conditions such as trauma, anaphylaxis, or other comorbidities.

Apneic oxygenation provides significant benefit in terms of improving SpO_2 for most intubations. Miguel-Montanes et al., 2005 concluded that HFNC was found to be more effective than a NRB mask for preoxygenation in intensive care unit (ICU) patients by improving SpO_2. It remains unclear how the use of HFNC compares with preoxygenation using a combination of standard nasal cannula and a NRB mask, or to the combination of standard nasal cannula and use of a BVM with a PEEP valve for apneic oxygenation. Although HFNC cannot compensate

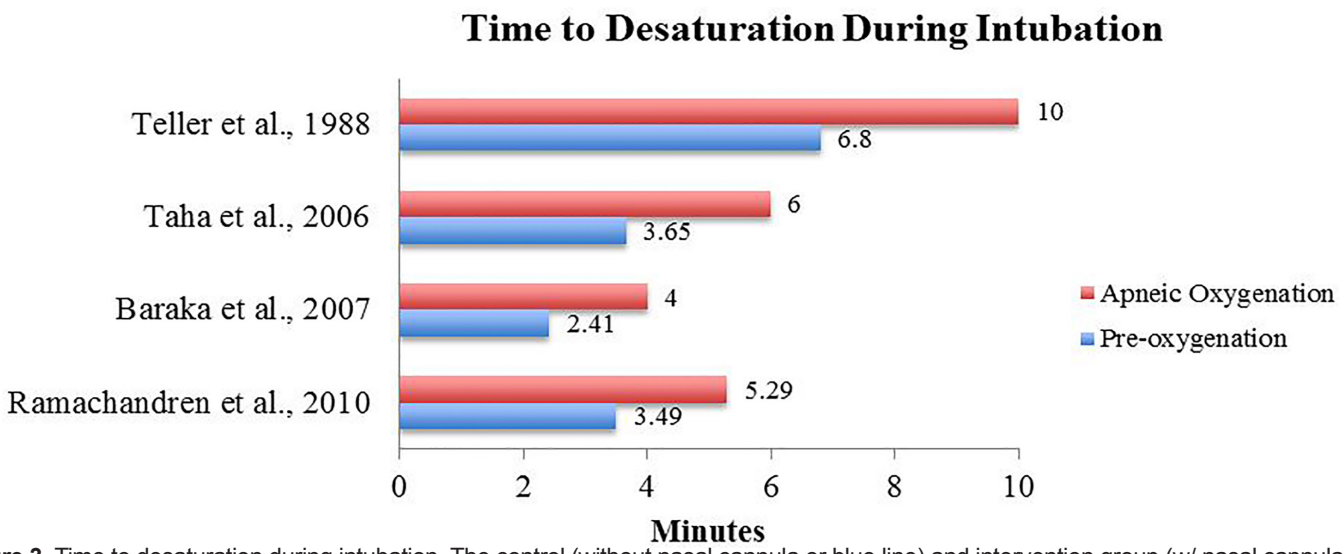

Figure 3. Time to desaturation during intubation. The control (without nasal cannula or blue line) and intervention group (w/ nasal cannula or red line) both underwent preoxygenation to peripheral oxygen saturation (SpO_2) ranges of 92-100% and was timed in minutes when SpO_2 level fell below various thresholds (range = 92-95%). Teller et al., 1988, Taha et al., 2006, and Baraka et al., 2007 had a maximum apneic cut-off limit of 10, 6, and 4 minutes.

for ineffective preoxygenation, it may serve as a useful apneic oxygenation adjunct by extending safe apnea time. Further research is required to solidify or refute this consistent evidence.

While most studies concluded there was a benefit of apneic oxygenation to prevent desaturation during intubation, four studies found no benefit.[8, 9, 18, 23] Of these, three are high-quality, randomized control trials and do not show statistical support.[8, 9, 18] One should note the characteristics of the patients. The study population in Semler et al., 2015 were ICU patients requiring intubation, while those in Vourc'h et al., 2015 were in respiratory failure; this points toward no benefit when hypoxic respiratory failure is the indication for intubation.[26] Similarly, in Caputo et al., 2017 the majority of patients in both the apneic oxygenation group (61 of 100) and standard-of-care group (59 of 100) were intubated due to a "pulmonary" indication, totaling 60% of the patient population. Considering the majority of intubations were performed due to "pulmonary" related causes, one would expect a non-significant result, which is consistent with Semler et al., 2015 and Vourc'h et al., 2015.

In contrast, the studies of patients undergoing elective surgery showed significant increases in time to oxygen desaturation, demonstrating that apneic oxygenation prior to intubation is only helpful in certain conditions, namely non-respiratory.[11-15] While Caputo et al., 2017 analyzed apneic oxygenation from a broad mix of medical conditions and did not show statistical significance, it did not distinguish between the intervention's efficacy in respiratory vs. non-respiratory causes as the results reflect all conditions (i.e., pulmonary, trauma, neurologic, cardiac, etc.). The reason that patients in respiratory failure or who are hypoxic prior to intubation do not benefit from apneic oxygenation is unclear. One hypothesis posits the development of pulmonary circulatory shunting, rendering passive ventilation ineffective.[26]

In light of Caputo et al., 2017, it continues to be confirmed that patients with respiratory failure or who are hypoxic prior to intubation are unlikely to benefit. White et al., 2017 provided strong evidence for the benefit of apneic oxygenation in terms of improved SpO_2 in surgical patients, obese patients, and those undergoing emergency intubation without respiratory failure.[26] No significant benefit was found in patients with respiratory failure.[26] Binks et al., 2017 found significant reduction in the incidence of desaturation and critical desaturation when apneic oxygenation was administered.[24] There was also significant improvement in first-pass intubation success rate.[24] Similarly, Pavlov et al., 2017 found that apneic oxygenation reduced the relative risk of hypoxemia, along with a significant trend toward lower mortality.[25]

From previous reviews of this intervention, we agree with their findings that there is strong evidence for the use of apneic oxygenation during intubation (excluding certain patient populations).[24, 25, 26] There have been relatively few studies of apneic oxygenation in the emergency department (ED); thus, more investigation is warranted, particularly between apneic oxygenation prior to intubation in respiratory and non-respiratory causes.

Table. Studies included in this review that provide evidence for (*) or against (#) the value of apneic oxygenation with nasal cannula to prevent desaturation during intubation. The characteristics of each study are detailed using a PICO (Populations/people/patient/problem Interventions Comparison Outcome) format.

Study	Patients	Intervention	Comparator	Outcome
Binks et al., 2017*	Systematic review and meta analysis of six studies with 1,822 patients requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	All but one study showed a significant risk reduction of oxygen desaturation (RR= 0.76, 95%, CI [0.60 to 0.90], p= 0.002) with significant heterogeneity (I2= 80%, p= 0.0005)
Caputo et al., 2017#	Randomized controlled trial in 200 ED patients requiring intubation. Patients were allocated to receive apneic oxygenation (n=100) or standard of care (n=100) by pre-determined randomization in a 1:1 ratio.	Nasal cannula during intubation	Standard of care- No supplemental oxygen during Laryngoscopy	There was no difference in lowest mean oxygen saturation between the two groups (92, 95% CI [91 to 93] in AO vs. 93, 95% CI 92 to 94 in standard of care, p=0.11)
Pavlov et al., 2017*	Systematic review and meta analysis of eight studies with 1,953 patients requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	Apneic oxygenation reduced the relative risk of hypoxemia by 30% (95% CI [0.59 to 0.82]). There was a trend toward lower mortality in the apneic oxygenation group (RR of death 0.77; 95% CI [0.59 to 1.02])
White et al., 2017*	Systematic review and meta analysis of eleven studies with 2,078 patients requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	Apneic oxygenation during intubation is associated with a reduced risk of desaturation (RR 0.65, p =0.005)
Jaber et al., 2016*	Randomized, controlled, single-center trial with assessor-blinded outcome assessment in 49 patients admitted to the ICU	HFNC [flow = 60 L/min, fraction of inspired oxygen (FiO2) = 100 %] combined with NIV (pressure support = 10 cmH2O, positive end-expiratory pressure = 5 cm H_2O, FiO2 = 100 %)	NIV (PS of 10 cmH2O, PEEP of 5 cm H2O, FiO2 = 100 %)	SpO2 values were significantly higher in the intervention group than in the reference group [100 (95–100) % vs. 96 (92–99) %, p = 0.029]
Riyapan and Lubin, 2016#	Retrospective, case controlled study of 29 pre-hospital patients requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	Incidence of SpO2 < 90% during intubation 17.2% vs 21.9% in the control group (p = 0.78)
Sakles et al., 2016a*	Observational study of apneic oxygenation on first-pass success without hypoxemia in 635 patients undergoing RSI in the ED	Nasal cannula during intubation	Without nasal cannula during intubation	In the AO cohort the FPS-H was 312/380 (82.1%)
Sakles et al., 2016b*	Prospective comparative study of 127 patients with intracranial hemorrhage requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	and in the no AO cohort the FPS-H was 176/255 (69.0%)AO was associated with a reduced odds of desaturation (aOR 0.13; 95 % CI [0.03 to 0.53])

AO, apneic oxygenation; *aOR*, adjusted odds ratio; *CI*, confidence interval; *ED*, emergency department; *EMS*, emergency medical service; *FiO_2*, fraction of inspired oxygen; *FPS-H*, first-pass success without hypoxemia; *HFNC*, high-flow nasal cannula; *I^2*, heterogeneity in meta analysis; *ICU*, intensive care unit; *IQR*, interquartile range; *NIV*, non-invasive ventilation; *p*, p-value; *RCT*, randomized control trial; *RR*, relative risk; *SpO_2*, oxygen saturation.

Table. Continued.

Study	Patients	Intervention	Comparator	Outcome
Semler et al. 2016#	RCT of 150 ICU patients requiring intubation	Nasal cannula during intubation	Without nasal cannula during intubation	Intervention group had an SpO_2 level of 99% [IQR=96-100%] before intubation and a low-est SpO_2 of 92% during intubation. 60.5% of patients fell <90% SpO_2 during intubation. Results were NOT statistically significant
Dyett et al., 2015*	Prospective observational study of 129 patients in the emergency department, ICU and on the wards as part of medical emergency response teams care	Nasal cannula during intubation	Without nasal cannula during intubation	Intervention group without respiratory failure had a significant reduction in incidence of hy-poxemia during intubation (0 of 31)
Miguel-Montanes et al., 2015*	Prospective quasi-experimental study of 101 patients in ICU requiring intubation	Nasal cannula during intubation	Bag valve mask intermittently during intubation	Intervention group maintained a median SpO_2 level of 100% (range 95-100%) before and during intubation
Vourc'h et al. 2015#	RCT of 124 patients with Respiratory Failure requiring intubation	Nasal cannula during intubation	High Fraction-Inspired Oxygen Facial Mask during intubation	Intervention group had a mean SpO_2 level of 97.1% before intubation and a median SpO_2 level of 91.5% during intu-bation [IQR=80-96%]. Results were NOT statisti-cally significant
Wimalasena et al., 2015*	Retrospective study of 728 patients requiring intubation by EMS	Nasal cannula during intubation	Without nasal cannula during intubation	Intervention group had a decrease in desaturation rates from 22.6% to 16.5%
Ramachandran et al., 2010*	Prospective RCT of 30 obese patients undergoing surgery	Nasal cannula during intubation	Without nasal cannula during intubation	Intervention group fell below 95% SpO_2 level at 5.29 min vs 3.49 min in the control
Baraka et al., 2007*	RCT of 34 morbidly obese patients undergoing gastric band or bypass surgery	Nasopharyngeal insufflation during intubation	Without nasopharyngeal insufflation	94% of intervention group maintained an SpO_2 level of 100% before and after intubation
Taha et al., 2006*	RCT of 30 patients undergoing surgery	Nasal cannula during intubation	Without nasal cannula during	Intervention group maintained an SpO_2 level of 100% before and during intubation vs comparator who fell below 95% after 3.65 mins
Lee 1998*	RCT of 46 patients undergoing trypanomastoidectomy	Nasal cannula during intubation	Without nasal cannula during intubation	Intervention group had a statistically significant decrease in $PaCO_2$ vs comparator at 3 mins
Teller et al., 1988*	Double-blinded, cross-over, RCT of 12 patients undergoing surgery	"Catheter" during intubation	Without "catheter" during intubation	Intervention group maintained an SpO_2 level of 97% before and during intubation

AO, apneic oxygenation; *aOR*, adjusted odds ratio; *CI*, confidence interval; *ED*, emergency department; *EMS*, emergency medical service; FiO_2, fraction of inspired oxygen; *FPS-H*, first-pass success without hypoxemia; *HFNC*, high-flow nasal cannula; I^2, heterogeneity in meta analysis; *ICU*, intensive care unit; *IQR*, interquartile range; *NIV*, non-invasive ventilation; *p*, p-value; *RCT*, randomized control trial; *RR*, relative risk; SpO_2, oxygen saturation.

LIMITATIONS

This was a review of the literature. All studies were not designed the same way nor did they control for the same outcome measures. There are additional limitations in this literature review. The major limitation relates to the different approaches used to provide apneic oxygenation in terms of preoxygenation and other pre-intubation techniques. Other limitations include the relatively small number of patients, the lack of large clinical trials, the variety of patient clinical conditions and/or comorbidities, and the varied, operationally-defined values of oxygenation desaturation.

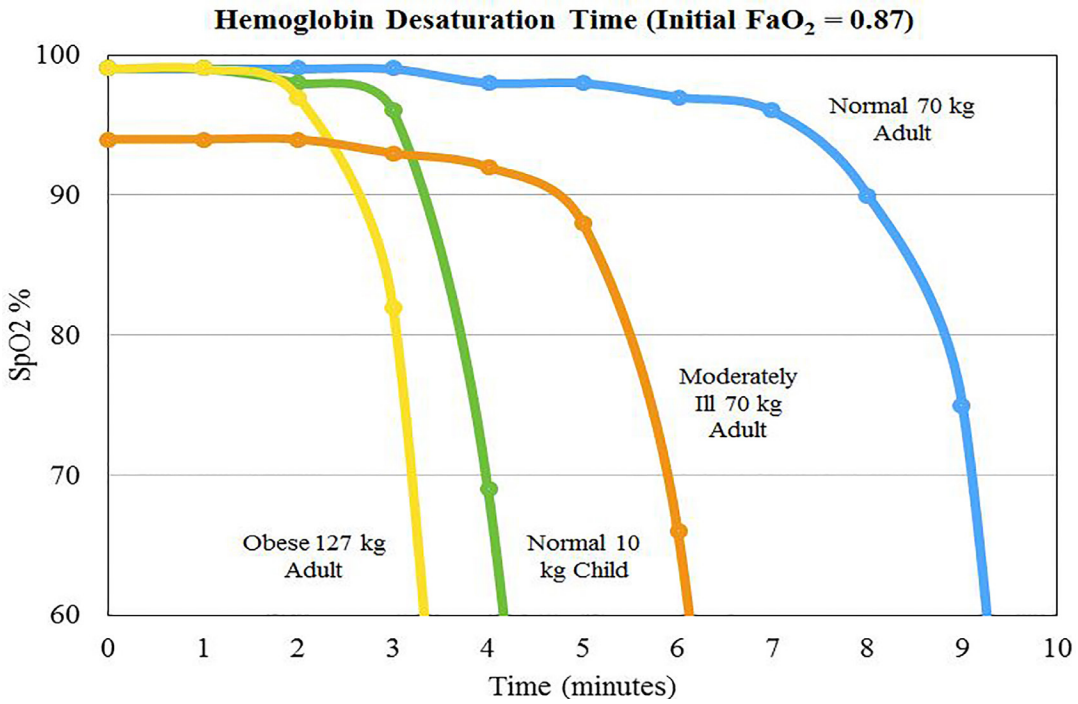

Figure 4. Hemoglobin desaturation time (initial FaO_2 = 0.87). Adapted from Patel and Nouraei (2015). %SpO_2 vs. time of apnea for various types of patients. FaO_2, alveolar oxygenation fraction; SpO_2, oxygen saturation

CONCLUSION

Nasal cannula oxygenation during intubation procedures appears to prevent or delay desaturation in all patients except those with primary respiratory failure. Incorporating the use of nasal cannula during intubation has the potential of being integrated into a new standard of care for intubation, whether in EDs or operating rooms. Further research is needed to determine the outcomes and long-term effects of this routine practice, even though the benefits of avoiding hypoxic events during endotracheal intubation are unassailable.

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REFERENCES

1. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. *Ann Emerg Med*. 2012;59(3):165-75.
2. Levitan RM. Available at: NO DESATfile://localhost/! http/::epmonthly.com:article:no-desat. Accessed on July 24, 2015
3. Weingart SD. Preoxygenation, reoxygenation, and delayed sequence intubation in the emergency department. *J Emerg Med*. 2013;44(5):992-3.
4. Farkas J. High-flow nasal cannula for apneic oxyventilation. Available at: http://emcrit.org/pulmcrit/high-flow-nasal-cannula-for-apneic-oxyventilation/. Accessed on July 24, 2015.
5. Patel A, Nouraei SA. Transnasal humidified rapid-insufflation ventilatory exchange (thrive): a physiological method of increasing apnea time in patients with difficult airways. *Anaesthesia*. 2015;70(3):323-9.
6. Dyett JF, Moser MS, Tobin AE. Prospective observational study of emergency airway management in the critical care environment of a tertiary hospital in Melbourne. *Anaesth Intensive Care*. 2015;43(5):577-86.
7. Miguel-Montanes R, Hajage D, Messika J, et al. Use of high flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild to moderate hypoxemia. *Crit Care Med*. 2015;43(3):574-83.
8. Semler MW, Janz DR, Lentz RJ, et al. Randomized trial of apneic oxygenation during endotracheal intubation of the critically ill. *Am J*

Respir Crit Care Med. 2016;193(3):273-80.

9. Vourc'h M, Asfar P, Volteau C, et al. High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial. *Intensive Care Med.* 2015;41(9):1538-48.
10. Wimalasena Y, Burns B, Reid C, et al. Apneic oxygenation was associated with decreased desaturation rates during rapid sequence intubation by Australian helicopter emergency medicine service. *Ann Emerg Med.* 2015;65(4):371-76.
11. Ramachandran SK, Cosnowski A, Shanks A, et al. Apneic oxygenation during prolonged laryngoscopy in obese patients: a randomized, controlled trial of nasal oxygen administration. *J Clin Anesth*. 2005;22(3):164-8.
12. Baraka AS, Taha SK, Siddik-Sayyid SM, et al. Supplementation of pre-oxygenation in morbidly obese patients using nasopharyngeal oxygen insufflation. *Anaesthesia*, 2007;62:769-73.
13. Taha SK, Siddik-Sayyid SM, El-Khatib MF, Dagher CM, Hakki MA, Baraka AS. Nasopharyngeal oxygen insufflation following preoxygenation using the four deep breathing technique. *Anaesthesia*, 2006;61(5):427-30.
14. Lee SC. Improvement of gas exchange by apeic oxygenation with nasal prong during fiberoptic intubation in fully relaxed patients. *J Korean Med Sci.* 1998;13(6):582-6.
15. Teller LE, Alexander CM, Frumin MJ, et al. Pharyngeal insufflation of oxygen prevents arterial desaturation during apnea. *Anesthesiology*. 1998;69(6):980-2.
16. Benumof JL, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg intravenous succinylcholine. *Anesthesiology*. 1997;87(4):979-82.
17. Baraka A, Salem MR, Joseph NJ. Critical hemoglobin desaturation can be delayed by apneic diffusion oxygenation. *Anesthesiology.* 1999;90(1):332-3.
18. Caputo N, Azan B, Domingues R, et al. Emergency department use of apneic oxygenation versus usual care during rapid sequence intubation: A randomized controlled trial (The ENDAO Trial). *Acad Emerg Med.* 2017;24(11):1387-94.
19. Jaber S, Monnin M, Girard M, et al. Apnoeic oxygenation via high-flow nasal cannula oxygen combined with non-invasive ventilation preoxygenation for intubation in hypoxaemic patients in the intensive care unit: the single-centre, blinded, randomised controlled OPTINIV trial. *Intensive Care Med.* 2016;42(12):1877-87.
20. Sakles JC, Mosier JM, Patanwala AE, et al. First pass success without hypoxemia is increased with the use of apneic oxygenation during rapid sequence intubation in the emergency department. *Acad Emerg Med*. 2016;23(6):703-10.
21. Frat JP, Thille AW, Mercat A, et al. (2015). High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. *N Engl J Med*. 2015:372(23):2185-96.
22. Sakles JC, Mosier JM, Patanwala AE, et al. Apneic oxygenation is associated with a reduction in the incidence of hypoxemia during the RSI of patients with intracranial hemorrhage in the emergency department. *Intern Emerg Med*. 2016;11(7);983-92.
23. Riyapan S, Lubin, J. Apneic oxygenation may not prevent severe hypoxemia during rapid sequence intubation: a retrospective helicopter emergency medical service study. *Air Medical J*. 2016;*35*(6):365-8.
24. Binks MJ, Holyoak RS, Melhuish TM, et al. Apneic oxygenation during intubation in the emergency department and during retrieval: a systematic review and meta-analysis. *Am J Emerg Med*. 2017;35(10):1542-6.
25. Pavlov I, Medrano S, Weingart S. Apneic oxygenation reduces the incidence of hypoxemia during emergency intubation: A systematic review and meta-analysis. *Am J Emerg Med*. 2017;35(8):1184-9.
26. White LD, Melhuish TM, White LK, et al. Apnoeic oxygenation during intubation: a systematic review and meta-analysis. *Anaesth Intensive Care*. 2017;45(1):21-7.

Comparison of Static versus Dynamic Ultrasound for the Detection of Endotracheal Intubation

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Introduction: In the emergency department setting, it is essential to rapidly and accurately confirm correct endotracheal tube (ETT) placement. Ultrasound is an increasingly studied modality for identifying ETT location. However, there has been significant variation in techniques between studies, with some using the dynamic technique, while others use a static approach. This study compared the static and dynamic techniques to determine which was more accurate for ETT identification.

Methods: We performed this study in a cadaver lab using three different cadavers to represent variations in neck circumference. Cadavers were randomized to either tracheal or esophageal intubation in equal proportions. Blinded sonographers then assessed the location of the ETT using either static or dynamic sonography. We assessed accuracy of sonographer identification of ETT location, time to identification, and operator confidence.

Results: A total of 120 intubations were performed: 62 tracheal intubations and 58 esophageal intubations. The static technique was 93.6% (95% confidence interval [CI] [84.3% to 98.2%]) sensitive and 98.3% specific (95% CI [90.8% to 99.9%]). The dynamic technique was 92.1% (95% CI [82.4% to 97.4%]) sensitive and 91.2% specific (95% CI [80.7% to 97.1%]). The mean time to identification was 6.72 seconds (95% CI [5.53 to 7.9] seconds) in the static technique and 6.4 seconds (95% CI [5.65 to 7.16] seconds) in the dynamic technique. Operator confidence was 4.9/5.0 (95% CI [4.83 to 4.97]) in the static technique and 4.86/5.0 (95% CI [4.78 to 4.94]) in the dynamic technique. There was no statistically significant difference between groups for any of the outcomes.

Conclusion: This study demonstrated that both the static and dynamic sonography approaches were rapid and accurate for confirming ETT location with no statistically significant difference between modalities. Further studies are recommended to compare these techniques in ED patients and with more novice sonographers. [West J Emerg Med.2018;19(2)412–416.]

INTRODUCTION

Endotracheal intubation is a common procedure in the emergency department (ED). Failure to detect esophageal intubation has the potential for significant morbidity and mortality. Currently, several modalities may be used to detect endotracheal tube (ETT) placement. These often include a

combination of auscultation, capnography, or ultrasound. However, there are inherent limitations with each of these methods. The potentially loud environment of the ED can make auscultation difficult, and quantitative capnography is not universally available at all centers.[1]

Ultrasound has been demonstrated to confirm ETT placement rapidly and accurately with recent meta-analyses demonstrating accuracy approaching that of capnography.[2,3] Additionally, ultrasound offers the advantage of directly visualizing the location of the ETT in cases when capnography may be less reliable (eg, cardiac arrest or hypopharyngeal placement).[4] However, studies have varied in the techniques described, with some using real-time, dynamic confirmation, while others use post-intubation, static imaging.

The goal of this study was to determine whether there was a difference in the accuracy between the static and dynamic approaches when confirming ETT location. Secondary outcomes included time to identification and operator confidence.

Population Health Research Capsule

What do we already know about this issue?
Ultrasound is increasingly being used to confirm endotracheal tube (ETT) location. However, there are variations in the techniques used.

What was the research question?
This study compared the static with the dynamic sonographic technique to determine which was more accurate for ETT identification.

What was the major finding of the study?
Both the static and dynamic ultrasound techniques were equally rapid and accurate for confirming ETT location.

How does this improve population health?
Either the dynamic or static technique may be used for ETT confirmation. Further studies are recommended in ED patients and with more-novice sonographers.

METHODS

This was a blinded, randomized, controlled trial performed in the cadaver lab of an academic hospital located in Chicago, Illinois. Three cadavers with different neck circumferences were used to simulate the variations in live patient populations. Cadaver #1 had a neck circumference of 32 cm, cadaver #2 had a neck circumference of 34 cm, and cadaver #3 had a neck circumference of 37 cm. Local institutional review board approval was obtained for this study with waiver of informed consent. This study was conducted in accordance with the Standards for the Reporting of Diagnostic Accuracy studies (STARD) criteria.[5]

Two attending emergency physicians with extensive intubation experience intubated each cadaver with a size 7.0 ETT using video laryngoscopy. Each cadaver was randomized a priori to either tracheal or esophageal intubation using a random number generator, with the goal of having equivalent numbers of tracheal and esophageal intubations in order to best define the test characteristics of each approach. The video screen was directed away from the sonographers and the intubating providers were instructed to look away after placement to avoid any potential reaction to bias the sonographers.

Two ultrasound fellowship-trained sonographers with prior experience in the use of ultrasound for ETT confirmation performed the assessments. A Zonare Z.One PRO ultrasound machine with an L14-5 linear transducer was used for all of the assessments. For each intubation, the dynamic technique was performed first by one sonographer. Then, the ETT was left in position while the other sonographer performed the static technique. Sonographers performed assessments in an alternating sequence of dynamic and static techniques to reduce the risk of shortening the learning curve with one technique. Each sonographer would leave the room after performing the sonographic assessment, so that neither sonographer was in the same room at the same time.

For the dynamic technique, sonographers placed the ultrasound transducer across the neck at the suprasternal level to locate the trachea and surrounding tissues.[6] Visualization of motion artifact within the trachea confirmed tracheal intubation (Video 1). Visualization of a "second trachea" lateral to the true trachea confirmed esophageal intubation (Video 2). For the static technique, sonographers placed the transducer in the same location post-intubation, while the intubator gently rotated the tube side-to-side to create a motion artifact (Figure 1, Video 3).[7] Presence of movement within the trachea confirmed tracheal intubation, while visualization of the "second trachea" confirmed esophageal intubation (Figure 2, Video 4).

A research assistant recorded the sonographer's prediction of the ETT location, time to ETT prediction, and operator level of confidence after each intubation. Operator confidence was assessed using a Likert scale ranging from 1-5 with 1 signifying "not confident at all" and 5 signifying "very confident." We performed a comparison between the predicted and actual location after study completion.

With an estimated 120 readings each for static and dynamic techniques, 95% level of significance, and a moderate effect size (0.3), the expected power for the study was above 90%. We used Microsoft Excel and SPSS statistical software to conduct the analysis. We used descriptive statistics, chi-square test, and

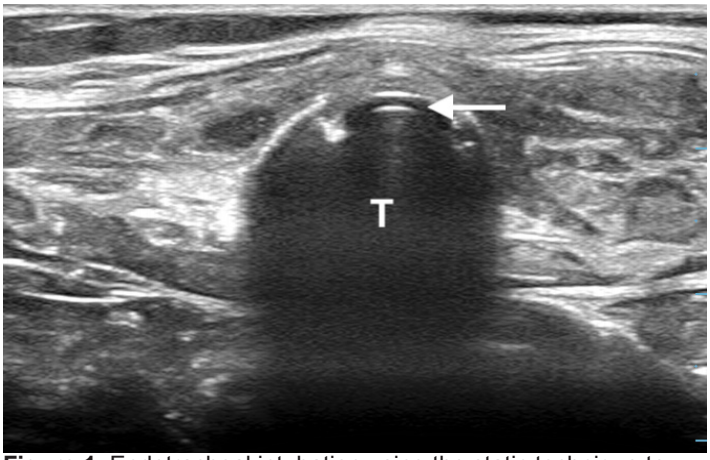

Figure 1. Endotracheal intubation using the static technique to confirm placement.
T, trachea; white arrow, endotracheal tube.

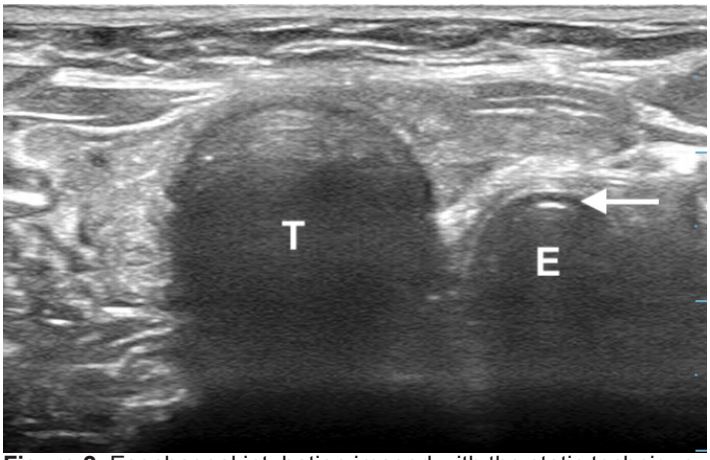

Figure 2. Esophageal intubation imaged with the static technique.
T, trachea; *E*, esophagus; white arrow, endotracheal tube.

t-test to analyze the relationships between the ultrasound static and dynamic techniques with respect to the accuracy of correctly identifying location of intubation, operator time to identification, and operator confidence. In addition, we included moderating variables such as operators, cadaver number, and actual location of the intubations in the analysis.

RESULTS

A total of 120 intubations were performed. Each intubation was assessed with both the static and dynamic techniques, resulting in 240 total assessments. There were 62 tracheal intubations and 58 esophageal intubations. The static technique was 93.6% (95% confidence interval [CI] [84.3% to 98.2%]) sensitive and 98.3% specific (95% CI [90.8% to 99.9%]) for endotracheal confirmation (Table 1). The dynamic technique was 92.1% (95% CI [82.4% to 97.4%]) sensitive and 91.2% specific (95% CI [80.7% to 97.1%]%) for endotracheal confirmation (Table 2). There was no statistically significant difference in correctly identifying the location of the ETT between the static and dynamic ultrasound techniques. For the mean operator time to identification, there was no statistical difference between the static (6.72 seconds; 95% CI [5.53 to 7.9] seconds) and the dynamic (6.4 seconds; 95% CI [5.65 to 7.16] seconds) techniques. The mean operator confidence was not statistically different between the static (4.9/5.0; 95% CI [4.83 to 4.97]) and the dynamic (4.86/5.0; 95% CI [4.78 to 4.94]) techniques.

DISCUSSION

In the ED setting, it is essential to quickly and accurately confirm correct ETT placement. While there are many options for confirmation, each has its own limitations. In fact, even colorimetric capnography may have false positives and negatives, resulting in an accuracy as low as 67.9% during cardiac arrest.[1,8,9] Ultrasound has been suggested to be particularly valuable in this application due to the ability to rapidly identify ETT location without requiring ventilations and the subsequent risk of gastric distention and aspiration if the ETT is incorrectly placed. However, current studies have used a variety of techniques, with some relying upon a static assessment, while others use dynamic assessments.[2-4,7,10-11]

This is one of the first studies to directly compare static with dynamic ultrasound for the identification of ETT location, demonstrating no statistically significant difference between techniques. This is an important finding, as there has been concern that performing dynamic sonography for ETT confirmation may be more challenging because it requires more than one trained provider to be available to perform the confirmation.[7] This may prevent the use of this technique in locations where only one ultrasound-trained provider is present. By twisting the ETT in one's fingers post-intubation, the provider is able to replicate the dynamic technique without the need for a second provider.

Additionally, with the dynamic technique, placement is best assessed as the ETT is being inserted, and localization may be more limited if the ETT is not immediately identified during the intubation attempt. Finally, having the ultrasound probe on the neck may make the intubation attempt more difficult by providing extra pressure on the trachea and distorting upper airway anatomy. Alternatively, by performing the technique post-intubation, the neck remains unencumbered, thereby allowing the intubating provider to also perform external laryngeal manipulation if needed.

Interestingly, we found no difference in the confirmation time or operator confidence. Both studies were completed in an average of six seconds, which allowed for rapid confirmation with minimal risk of desaturation. Additionally, this examination could be performed while capnography was being obtained, with both confirmatory methods used to

Table 1. Accuracy of the static technique for endotracheal intubation.

	Endotracheal intubation	Esophageal intubation	Total
Endotracheal location on ultrasound	58	1	59
Esophageal location on ultrasound	4	57	61
Total	62	58	

Table 2. Accuracy of the dynamic technique for endotracheal intubation.

	Endotracheal intubation	Esophageal intubation	Total
Endotracheal location on ultrasound	58	5	63
Esophageal location on ultrasound	5	52	57
Total	62	58	

support each other in equivocal cases. Operator confidence was high with both techniques, suggesting that both providers felt comfortable with their assessments, which is an important finding in ultrasound studies because, if the operator is not confident in their assessment, they will be unlikely to use the examination clinically.

LIMITATIONS

It is important to consider several limitations with respect to this study. First, it was performed in a cadaver model, which may not fully reflect the characteristics of a live patient. However, cadaver models have been used extensively for the evaluation of ultrasound for ETT confirmation and have demonstrated similar test characteristics to live patients for this modality.[7,11-13] Additionally, we used only three cadavers in the study and it is possible this may not have fully represented the wider population. However, we intentionally used cadavers with significant differences in anatomy to best represent the variation in a larger population.

It is possible that the repeat intubations may have improved the accuracy of the sonographers due to increased practice. To avoid this we alternated cadavers and techniques between each use to reduce the potential for improving each sonographer's learning curve during the study. While it is not possible to completely exclude the potential for sonographers to have improved their accuracy throughout the study, this was not supported by the data as equivalent numbers of misidentified ETT placements occurred in the early and later intubations. There is also no reason to suggest that this would differentially affect one technique over another. Moreover, this study was designed to evaluate the test characteristics of dynamic vs. static sonography for ETT localization. Therefore, it is important to ensure similar rates of tracheal and esophageal intubation, which would not be possible in an ED setting due to low overall rates of esophageal intubation.[14] Because this study was performed by two sonographers with prior experience using ultrasound for ETT confirmation, it is possible that the results may have differed if less experienced sonographers were used. However, the use of ultrasound for ETT confirmation has been suggested to have a rapid learning curve.[15] Nonetheless, further studies are advised to determine whether the accuracy of static vs. dynamic techniques differs in less experienced providers.

CONCLUSION

This study demonstrated that the static and dynamic sonographic approaches to confirming endotracheal intubation were both rapid and accurate with no significant difference between modalities. Further studies are recommended to compare these techniques in ED patients and with more novice sonographers.

Video 1. Endotracheal intubation with the dynamic technique.
Video 2. Esophageal intubation with the dynamic technique.
Video 3. Endotracheal intubation with the static technique.
Video 4. Esophageal intubation with the static technique.

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REFERENCES

1. Li J. Capnography alone is imperfect for endotracheal tube placement confirmation during emergency intubation. *J Emerg Med*. 2001;20(3):223-9.
2. Das SK, Choupoo NS, Haldar R, et al. Transtracheal ultrasound for verification of endotracheal tube placement: a systematic review and meta-analysis. *Can J Anaesth*. 2015;62(4):413-23.
3. Chou EH, Dickman E, Tsou PY, et al. Ultrasonography for confirmation of endotracheal tube placement: a systematic review and meta-analysis. *Resuscitation*. 2015;90:97-103.
4. Chou HC, Chong KM, Sim SS, et al. Real-time tracheal ultrasonography for confirmation of endotracheal tube placement during cardiopulmonary resuscitation. *Resuscitation*. 2013;84(12):1708-12.
5. Bossuyt PM, Reitsma JB, Bruns DE, et al; STARD Group. STARD 2015: an updated list of essential items for reporting diagnostic accuracy studies. *BMJ*. 2015;351:h5527.
6. Park SC, Ryu JH, Yeom SR, et al. Confirmation of endotracheal intubation by combined ultrasonographic methods in the Emergency Department. *Emerg Med Australas*. 2009;21(4):293-7.
7. Gottlieb M, Bailitz JM, Christian E, et al. Accuracy of a novel ultrasound technique for confirmation of endotracheal intubation by expert and novice emergency physicians. *West J Emerg Med*. 2014;15(7):834-9.
8. MacLeod BA, Heller MB, Gerard J, et al. Verification of endotracheal tube placement with colorimetric end-tidal CO2 detection. *Ann Emerg Med*. 1991;20(3):267-70.
9. Takeda T, Tanigawa K, Tanaka H, et al. The assessment of three methods to verify tracheal tube placement in the emergency setting. *Resuscitation*. 2003;56(2):153-7.
10. Chou HC, Tseng WP, Wang CH, et al. Tracheal rapid ultrasound exam (T.R.U.E.) for confirming endotracheal tube placement during emergency intubation. *Resuscitation*. 2011;82(10):1279-84.
11. Tejesh CA, Manjunath AC, Shivakumar S, et al. Sonographic detection of tracheal or esophageal intubation: A cadaver study. *Saudi J Anaesth*. 2016;10(3):314-6.
12. Uya A, Spear D, Patel K, et al. Can novice sonographers accurately locate an endotracheal tube with a saline-filled cuff in a cadaver model? A pilot study. *Acad Emerg Med*. 2012;19(3):361-4.
13. Lonchena T, So S, Ibinson J, et al. Optimization of ultrasound transducer positioning for endotracheal tube placement confirmation in cadaveric model. *J Ultrasound Med*. 2017;36(2):279-84.
14. Sagarin MJ, Barton ED, Chng YM, et al; National Emergency Airway Registry Investigators. Airway management by US and Canadian emergency medicine residents: a multicenter analysis of more than 6,000 endotracheal intubation attempts. *Ann Emerg Med*. 2005;46(4):328-36.
15. Chenkin J, McCartney CJ, Jelic T, et al. Defining the learning curve of point-of-care ultrasound for confirming endotracheal tube placement by emergency physicians. *Crit Ultrasound J*. 2015;7(1):14.

Intravenous Continuous Infusion vs. Oral Immediate-release Diltiazem for Acute Heart Rate Control

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Introduction: Atrial fibrillation (AF) is a common diagnosis of patients presenting to the emergency department (ED). Intravenous (IV) diltiazem bolus is often the initial drug of choice for acute management of AF with rapid ventricular response (RVR). The route of diltiazem after the initial IV loading dose may influence the disposition of the patient from the ED. However, no studies exist comparing oral (PO) immediate release and IV continuous infusion diltiazem in the emergency setting. The objective of this study was to compare the incidence of treatment failure, defined as a heart rate (HR) of >110 beats/min at four hours or conversion to another agent, between PO immediate release and IV continuous infusion diltiazem after an initial IV diltiazem loading dose in patients in AF with RVR.

Methods: This was a single-center, observational, retrospective study conducted at a tertiary academic medical center. The study population included patients ≥18 years old who presented to the ED in AF with a HR > 110 beats/min and received an initial IV diltiazem loading dose. We used multivariate logistic regression to assess the association between routes of administration and treatment failure.

Results: A total of 111 patients were included in this study. Twenty-seven percent (11/41) of the patients in the PO immediate-release group had treatment failure compared to 46% (32/70) in the IV continuous-infusion group. The unadjusted odds ratio (OR) of treatment failure with PO was less than IV at 0.4 (95% confidence interval [CI] [0.18, 0.99], p = 0.046). When we performed a multivariate analysis adjusted for race and initial HR, PO was still less likely to be associated with treatment failure than IV with an OR of 0.4 (95% CI [0.15, 0.94], p = 0.041). The median dose of PO diltiazem and IV continuous infusion diltiazem at four hours was 30 mg and 10 mg/h, respectively.

Conclusion: After a loading dose of IV diltiazem, PO immediate-release diltiazem was associated with a lower rate of treatment failure at four hours than IV continuous infusion in patients with AF with RVR. [West J Emerg Med. 2018;19(2)417-422.]

INTRODUCTION

Atrial fibrillation (AF), a supraventricular tachyarrhythmia, is the primary diagnosis for over 467,000 hospitalizations each year.[1] Historically, there have been two approaches to managing AF in the emergency department (ED): rate control and rhythm control.

The AFFIRM trial compared rate and rhythm control in 4,060 chronic AF patients. It found no difference in overall

mortality, but there were fewer hospitalizations with rate control compared to rhythm.[2] The subsequent RACE II trial established that lenient heart rate (HR) control (HR <110 beats/min) was as effective as strict control (HR <80 beats/min) in preventing cardiovascular events and required fewer outpatient visits to achieve the goal HR.[3] A number of medications are used for rate control including beta blockers and non-dihydropyridine calcium channel blockers.[1]

Diltiazem, a non-dihydropyridine calcium channel blocker, is a common initial choice in the management of AF with rapid ventricular response (RVR) due to its ability to be given as an intravenous (IV) push, continuous infusion, and oral (PO) immediate-release or extended-release tablet. In the ED a loading dose (LD) of IV diltiazem is usually administered followed by PO immediate-release tablet or IV continuous infusion. Both options allow for dose titration in the short term before converting to a longer-acting PO formulation for discharge. The PO immediate-release diltiazem tablet has an onset of action of 30-60 minutes and is dosed every six hours.[4] IV continuous infusion diltiazem has a rapid onset of action and is titrated every 15-30 minutes.

The route of diltiazem after the initial IV LD can influence the disposition of the patient from the ED, the level of care needed, and hospital length of stay (LOS). Patients who receive only the PO immediate-release diltiazem absorb a therapeutic dose quickly and can generally be discharged or admitted to a general medicine floor, but cannot be titrated more frequently than every six hours. Patients who received the IV continuous infusion must have their dose frequently titrated by nursing and often require stepdown care. No studies exist comparing the efficacy of PO immediate-release and IV continuous-infusion diltiazem in the emergent management of AF with RVR. The objective of this study was to compare the incidence of treatment failure at four hours between PO immediate-release and IV continuous-infusion diltiazem after an IV LD.

Population Health Research Capsule

What do we already know about this issue?
Diltiazem is often used in the acute, emergent management of atrial fibrillation. No studies exist comparing oral (PO) immediate release and intravenous (IV) continuous infusion diltiazem.

What was the research question?
Compare the incidence of treatment failure at four hours between PO immediate release and IV continuous infusion diltiazem.

What was the major finding of the study?
PO immediate-release diltiazem was associated with a lower rate of treatment failure at four hours than IV continuous infusion.

How does this improve population health?
If PO immediate-release diltiazem is associated with less treatment failure, it may permit the disposition of emergency department patients to a less resource-intensive setting.

METHODS

Study Design

This was a retrospective, observational, medical record review conducted with data from Virginia Commonwealth University Health, a tertiary medical center ED that treats over 95,000 patients annually. We retrospectively identified cases of ED diltiazem use from July 1, 2014, to July 1, 2015, from electronic medical records. Inclusion criteria included the following: patients ≥ 18 years old who presented to the ED in AF, with a HR > than 110 beats/min, who received an initial diltiazem IV LD and then subsequently PO immediate- release or IV continuous-infusion diltiazem. Of note, no ED AF protocol existed at the time of the study. Diltiazem dose and route selection were at the discretion of the ED provider. We excluded patients if they were pregnant or a prisoner. We also excluded patients if they had received electrical cardioversion or other rate control or antiarrhythmic medication in the prehospital or ED setting before being administered an IV LD of diltiazem. This study was approved by the institutional review board.

Study Protocol

We collected and managed study data using REDCap® electronic data capture tools.[5] Baseline demographic information recorded included the patient's age, sex, race, and weight. Diltiazem dosing characteristics at baseline and four hours and the use of adjunctive medication for HR or rhythm control at four hours were collected. Clinical outcomes recorded included HR and blood pressure (BP) at baseline and four hours, ED disposition, and hospital LOS.

Two of the study's investigators abstracted all available data independently. Both were involved in the study design and used a standardized data collection form in REDCap® that included study definitions to ensure consistency between the investigators. Investigators were not blinded to the study outcome. Any discrepancies between abstractors resulted in a collaborative review of the chart by both investigators until discrepancies were resolved. As a result, interrater reliability was not determined.

Measures

The primary endpoint of the study was the percentage of patients with treatment failure at 4 ± 1 hour after initiation of PO immediate-release diltiazem or continuous IV diltiazem infusion. Treatment failure was defined as HR of > 110 beats/min at 4 ± 1 hour, a switch in therapy from PO immediate-release diltiazem to IV continuous infusion diltiazem, the requirement of an additional IV diltiazem bolus within four hours from the start of PO or IV continuous infusion, or addition/switch of therapy to another rate control or antiarrhythmic agent within four hours. A clinical endpoint of 4 ± 1 hour was selected to give time for both the PO and the IV diltiazem to have therapeutic effect. It was also concluded that this was a reasonable amount of time for the ED provider to determine disposition. We made the decision not to include time points extending beyond four hours due to the increased number of confounding factors, including the conversion to PO β-blockers or extended-release PO diltiazem.

Patient characteristics collected included age, weight, race, sex, initial HR and BP, and initial diltiazem LD. We assessed the safety endpoint of clinically significant hypotension by recording the indication for diltiazem discontinuation and the need for vasopressors administration for hemodynamic support.

Sample Sizes and Data Analysis

No power calculation was done due to the study's exploratory nature. We based dates for study inclusion on when diltiazem PO immediate-release tablets became readily available in the ED medication-dispensing unit. If included patients presented to the ED multiple times during the study period, only the most recent encounter was considered.

We analyzed data using Excel, R 3.2.2, and JMP 11.0.0 (copyright 2013 SAS Institute, Cary, NC). Nominal variables were evaluated with X^2 or Fisher's exact test, and we compared continuous variables using Student's t-test. We used univariate logistic regression to identify those characteristics associated with treatment failure and therefore eligible for inclusion in a final, multivariable model. Per the modeling strategy presented by Hosmer et al., a liberal p-value of 0.15 was used to identify these potential confounders.[6] We used multivariable logistic regression to control for these confounding characteristics while modeling the association between dosing route and treatment failure at four hours. An a priori α level of ≤0.05 was used to determine statistical significance.

RESULTS

We reviewed 324 patients for study inclusion and excluded 213 (Figure 1). The most common reasons for exclusion were the lack of an IV diltiazem LD, the administration of an IV diltiazem LD only, and duplicate encounters. Complete data were available for 111 patients, 41 in the PO immediate-release diltiazem and 70 in the IV continuous-infusion diltiazem groups. Study population demographics are reported in Table 1. The overall mean age was 62 years, with 52% male gender and a mean weight of 93 kg. When PO immediate- release diltiazem and the IV continuous-infusion diltiazem groups were compared, the only baseline characteristic that was significantly different between the two was the mean initial HR. The PO group had an initial HR of 131 +/- 19 beats/min compared to the IV group which had an initial HR of 145 +/- 18 beats/min (P=0.002).

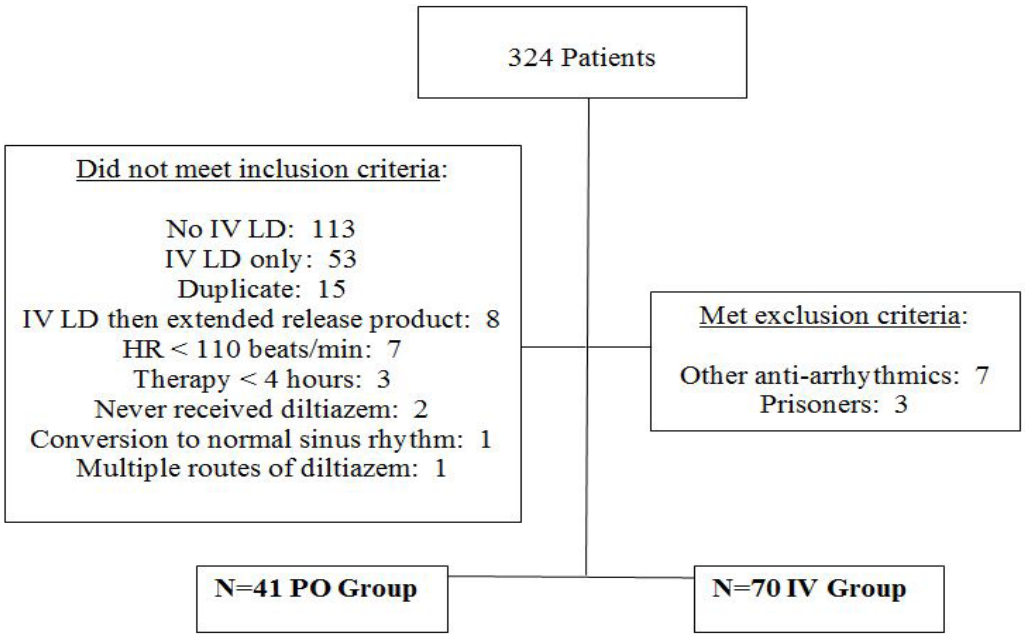

Figure 1. Inclusion/exclusion criteria and treatment assignment. *PO*, oral; *IV*, intravenous; *LD*, loading dose; *HR*, heart rate.

For the primary endpoint of treatment failure at four hours, 27% of patients (11/41) in the PO immediate-release diltiazem group met criteria compared to 46% of patients (32/70) in the IV group, a difference of 19% (p=0.049). The unadjusted odds ratio (OR) of treatment failure with PO when compared to IV was 0.4 (95% confidence interval [CI] [0.18, 0.99], p=0.046) (Table 2). We performed a multivariate analysis adjusting for initial HR and race. Mean initial HR was included due to the statistically significant difference in baseline characteristics. We included race from the univariate logistic regression models because the p-value was below the 0.15 threshold (Table 2). Although ED disposition was significantly different between the groups, we did not include it in the multivariable logistic regression since it was a secondary outcome of interest and not a potential confounder. In the multivariate model, the adjusted odds of treatment failure at four hours with PO compared to IV remained statistically significant at 0.4 (95% CI [0.15, 0.94], p=0.041). A HR of >110 at four hours accounted for 25 of 32 treatment failures in the IV group compared to nine of 11 in the PO immediate- release group.

Fifty-three percent of patients in the PO immediate-release diltiazem group received an initial dose of 30 mg and 41% received 60 mg. The median dose of IV continuous-infusion diltiazem at four hours was 10 mg/h (range 2.5 mg/h to 20 mg/h). Patient disposition from the ED can be seen in Table 1, with a statistically significant difference in the disposition between PO and IV (P<0.0001). The odds of disposition to a general floor were 6.1 times higher (95% CI [2.47 – 15.92], P < 0.0001) with PO compared to IV. Patients in the PO group were less likely than IV to be admitted to the stepdown or intensive care unit (ICU) with an OR of 0.3 (95% CI [0.10 – 0.80], P = 0.0112), and 0.2 (95% CI [0.02 – 0.69], p-value 0.0051), respectively. We found no statistically significant difference in discharge to home with an OR 1.4 (95% CI [0.26 - 6.96], P = 0.7234) due to the small sample size. The mean and median LOS was 4.7 days and three days, respectively, in the PO group and nine days and five days, respectively, in the IV group.

From a safety standpoint, no patients required vasopressors for BP support or had their diltiazem therapy discontinued for hypotension. Diltiazem was stopped for only two indications in both the PO and IV group- change in agent and lack of indication (i.e., the patient's AF had resolved). In one case, the discontinuation reason was unknown.

DISCUSSION

In the emergent setting, diltiazem has been shown to be superior to digoxin, metoprolol, and amiodarone in the initial management of AF and flutter.[1,7-10] IV diltiazem has often been considered superior to PO in the management of AF due its 100% bioavailability and titratability. However, PO immediate-release diltiazem confers many benefits over IV continuous infusion including a fast onset of action, minimal titration requirement, decreased nursing resources, and the ability to disposition to a general floor or possibly discharge home. A comparison of PO immediate-release and IV continuous-infusion diltiazem in the emergent clinical setting had never been performed.

In our study, we found that PO immediate-release diltiazem resulted in a 0.4 (95% CI 0.15-0.94) OR of treatment failure when compared to IV continuous infusion. In other words, PO immediate-release diltiazem resulted in an

Table 1. Charachteristic of the sample.

Variable	Overall summary N=111 (SD)	PO group N=41 (SD)	IV group N=70 (SD)	P-value (for t-test or $\chi 2$)
Age	62 (13.8)	62 (13.6)	61 (14.1)	0.698
Sex (Male)	58 (52%)	20 (49%)	38 (54%)	0.575
Race (Caucasian)	49 (44%)	17 (41%)	32 (46%)	0.663
Weight (kg)	93 (28.5)	89 (24.6)	95 (30.6)	0.316
Mean initial HR (beats/min)	140 (19.7)	131 (18.6)	145 (18.4)	0.002
Mean initial SBP (mmHg)	133 (26.2)	136 (23.5)	131 (27.7)	0.359
Mean initial DBP (mmHg)	87 (20.9)	91 (17.6)	85 (22.4)	0.109
Mean initial diltiazem dose (mg/kg)	0.23 (0.124)	0.22 (0.108)	0.24 (0.133)	0.579
ED Disposition				<0.0001
Discharge	9 (8%)	4 (10%)	5 (7%)	
General floor	46 (41%)	28 (68%)	18 (26%)	
Stepdown	36 (32%)	7 (17%)	29 (41%)	
Intensive care unit	20 (18%)	2 (5%)	18 (26%)	

PO, oral; *IV*; intravenous; *Kg*; kilogram; *HR*, heart rate; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *mmHg*, millimeter of mercury; *mg*, milligram; *SD*, standard deviation.

Table 2. Characteristics associated with treatment failure at four hours when comparing use of oral immediate-release diltiazem vs. intravenous continuous infusion.

Variable	Unadjusted odds ratio (95% CI)	P-value	Adjusted odds ratio (95% CI)	P-value
PO diltiazem	0.4 (0.18 - 0.99)	0.046	0.4 (0.15 - 0.94)	0.041
Age (per 5 year decrease)	1.1 (0.92 - 1.22)	0.436		
Male gender	1.3 (0.58 - 2.70)	0.567		
Non-Caucasian race (Reference level: Caucasian)	1.9 (0.86 - 4.17)	0.116	2.0 (0.89 - 4.49)	0.1
Weight (per each 5 kg decrease)	1.0 (0.94 - 1.08)	0.781		
Initial IV loading dose (per 0.1 mg/kg increase)	1.2 (0.89 - 1.66)	0.229		
Initial HR (per 5 beat/min increase)	1.0 (0.92 - 1.12)	0.805	1.0 (0.92 - 1.15)	0.688

PO, oral; *IV*, intravenous; *HR*, heart rate; *kg*, kilogram; *mg*, milligram; *CI*, confidence interval.

odds of heart rate control 2.6 times greater than IV continuous infusion at four hours. This is a surprising result given the higher bioavailability of the IV route compared to the oral formulation. A possible reason for this difference in treatment failure may be that IV continuous infusion was sub-optimally titrated. In our sample, the median hourly dose of the IV continuous infusion at four hours was only 10 mg/h, well below the maximum dose of 15 mg/h. Slow titration to sub-maximal doses may have resulted in suboptimal diltiazem plasma concentrations in comparison with patients who were given immediate-release PO diltiazem. In theory, PO dosing may have achieved a higher plasma concentration as a result of the entire diltiazem dose being given at once. Therefore, our results may not reflect the comparison of two treatment regimens at optimal dosing capacity, but rather the real-world practice in which medication titration is not always optimized.

PO diltiazem was associated with statistically significant higher odds of being admitted to the general floor and lower odds of being admitted to stepdown or the ICU. Patients who received PO also had a two-day shorter median LOS compared to IV. While the differences in these two parameters cannot be ascertained in a definitive manner due to the retrospective nature of the study, it is possible that the extended time needed to transition patients from IV to PO diltiazem before discharge may have played a contributing factor. Patient disposition and decreased LOS represent a possible area of healthcare cost savings that should be investigated in future prospective studies.

Providers may choose IV continuous-infusion diltiazem if they want to titrate to lower doses in patients with borderline hemodynamic stability. In our study, however, clinically significant hypotension (defined as hypotension requiring discontinuation of the therapy and/or vasopressors) did not occur in the PO or IV group. Overall, our findings call in to question the primacy of IV continuous-infusion diltiazem for AF. PO diltiazem was associated with a lower rate of treatment failure and higher rate of heart control than IV continuous infusion and with similar safety. Importantly, these findings are the result of a retrospective study with limited sample size and therefore must be confirmed in a larger, prospective, randomized controlled trial.

LIMITATIONS

This study has several limitations. Its retrospective nature limited sample size and abstraction. Incomplete documentation prevented characterization of the severity of the patient's symptoms, past medical history of AF, and home medications. In addition, identifying the total amount of diltiazem received via the continuous infusion route to allow for summative dose comparisons against oral was not possible due to inconsistent documentation of IV titrations. The statistically significant difference between groups in baseline HR suggests a potential selection bias against IV continuous-infusion diltiazem as providers may have selected this route of administration for more acutely ill patients and reserved PO diltiazem for milder cases. While we accounted for a select number of patient-specific factors in our logistic regression model, the potential for additional, unmeasured confounders still exist, which could mean the study showed only association, not causation. Our primary endpoint measured treatment failure at 4 ± 1 hour to give time for both the PO and the IV diltiazem to have therapeutic effect. A majority of patients failed due to HR > 110; our study may have excluded other time points where HR control was achieved. Lastly, the small sample size and low power resulted in large CI for the odds ratios.

CONCLUSION

After a loading dose of IV diltiazem, PO immediate-release diltiazem was associated with a lower rate of treatment failure at four hours when compared to IV continuous infusion in patients with atrial fibrillation with rapid ventricular response.

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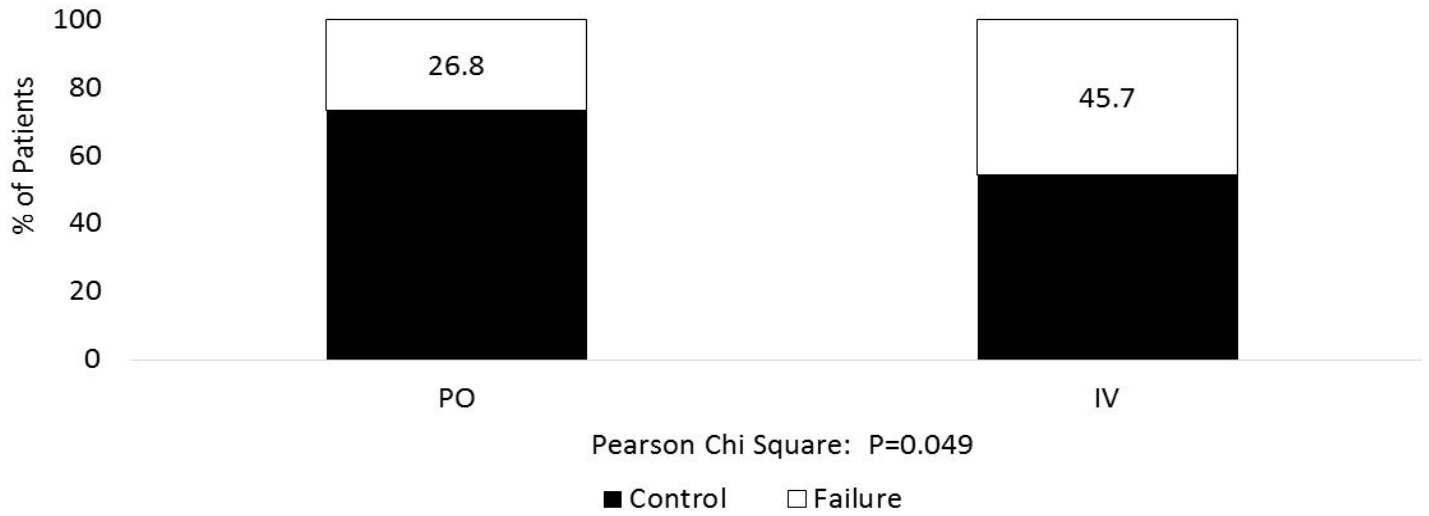

Figure 2. Percentage of patients with treatment failure at four hours.
PO, oral; IV, intravenous

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REFERENCES

1. January CT, Wann LS, Alpert JS, et al. AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on practice guidelines and the Heart Rhythm Society. *Circulation.* 2014;130(23):e199-267.
2. Wyse DG, Waldo AL, DiMarco JP, et al. A comparison of rate control and rhythm control in patients with atrial fibrillation. *N Engl J Med.* 2002;347(23):1825-33.
3. Van Gelder IC, Groenveld HF, Crijns HJ et al. Lenient versus strict rate control in patients with atrial fibrillation. *N Engl J Med.* 2010;362(15):1363-73.
4. Lexicomp Online®, Lexi-Drugs® Hudson, Ohio: Lexi-Comp, Inc.; 2016.
5. Harris PA, Taylor R, Thielke R, et al. Research electronic data capture (REDCap) - A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform.* 2009;42(2):377-81.
6. Hosmer DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*. Hoboken, NJ: John Wiley & Sons, Inc; 2013.
7. Schreck DM, Rivera AR, Tricarico VJ. Emergency management of atrial fibrillation and flutter: Intravenous diltiazem versus intravenous digoxin. *Ann Emerg Med.* 1997;29(1):135-40.
8. Demircan C, Cikriklar HI, Engindeniz Z, et al. Comparison of the effectiveness of intravenous diltiazem and metoprolol in the management of rapid ventricular ate in atrial fibrillation. *Emerg Med J.* 2005;22:411-4.
9. Siu C, Lau C, Lee W, Lam K, Tse H, Intravenous diltiazem is superior to intravenous amiodarone or digoxin for achieving ventricular ate control in patients with acute uncomplicated atrial fibrillation. *Crit Care Med.* 2009;37(7):2174-9.
10. Fromm C, Suau SJ, Cohen V et al. Diltiazem vs. metoprolol in the management of atrial fibrillation or flutter with rapid ventricular rate in the emergency department. *J Emerg Med.* 205;49(2):175-82.

Pay It Forward: High School Video-based Instruction Can Disseminate CPR Knowledge in Priority Neighborhoods

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Introduction: The implementation of creative new strategies to increase layperson cardiopulmonary resuscitation (CPR) and defibrillation may improve resuscitation in priority populations. As more communities implement laws requiring CPR training in high schools, there is potential for a multiplier effect and reach into priority communities with low bystander-CPR rates.

Methods: We investigated the feasibility, knowledge acquisition, and dissemination of a high school-centered, CPR video self-instruction program with a "pay-it-forward" component in a low-income, urban, predominantly Black neighborhood in Chicago, Illinois with historically low bystander-CPR rates. Ninth and tenth graders followed a video self-instruction kit in a classroom setting to learn CPR. As homework, students were required to use the training kit to "pay it forward" and teach CPR to their friends and family. We administered pre- and post-intervention knowledge surveys to measure knowledge acquisition among classroom and "pay-it-forward" participants.

Results: Seventy-one classroom participants trained 347 of their friends and family, for an average of 4.9 additional persons trained per kit. Classroom CPR knowledge survey scores increased from 58% to 93% ($p < 0.0001$). The pay-it-forward cohort saw an increase from 58% to 82% ($p < 0.0001$).

Conclusion: A high school-centered, CPR educational intervention with a "pay-it-forward" component can disseminate CPR knowledge beyond the classroom. Because schools are centrally-organized settings to which all children and their families have access, school-based interventions allow for a broad reach that encompasses all segments of the population and have potential to decrease disparities in bystander CPR provision. [West J Emerg Med. 2018;19(2)423-429.]

INTRODUCTION

Each year 395,000 people suffer an out-of-hospital cardiac arrest (OHCA) in the United States.[1] Shortening the time between OHCA onset and the first three links in the chain of survival—early access to emergency medical services (EMS), early cardiopulmonary resuscitation (CPR), and early defibrillation— is critical to improve survival outcomes.[2] Multiple studies have demonstrated that layperson CPR increases chance of survival by 2-3 fold.[3,4,5,6] The importance of immediate response by the public has been highlighted by the Institute of Medicine (IOM) report "Strategies to Improve Cardiac Arrest Survival: A Time to Act" (2015).[7] One of the key recommendations of the IOM report was a call to "foster a culture of action through public

awareness and training" to reduce the risk of irreversible neurologic injury and functional disability.[7]

Wide disparities in bystander CPR rates and OHCA outcomes persist, with some communities reporting a five-fold difference in survival.[1,8,9,10] Residents who live in neighborhoods that are primarily Black, Hispanic, or low-income are more likely to have an OHCA, less likely to receive bystander CPR, and are less likely to survive.[8 11] The implementation of creative new strategies to increase layperson CPR and defibrillation may improve resuscitation in priority populations.[12,13] No single training approach is comprehensive enough to eliminate these disparities. Most communities will only improve survival through a multifaceted, community-wide approach that may include teaching hands-only CPR for bystanders,[14,15] emphasis on brief educational videos[16] and video self-instruction,[17,18] mandatory school-based training,[19] and dispatcher-assisted CPR.[20,21]

One particularly high-yield approach for high-risk communities is the implementation of mandatory CPR training in high schools.[22] The American Heart Association (AHA), the World Health Organization, and the IOM along with multiple other national and international advocacy groups have endorsed CPR training in high school as a key foundation to improve OHCA survival outcomes.[7,19,22] The 2015 IOM report calls for state and local education departments to partner with training organizations and public advocacy groups to promote and facilitate CPR and automated external defibrillator (AED) training as a high school graduation requirement.[7] Today communities across the U.S. have recognized the value of CPR training in high schools, and 36 states have enacted laws calling for mandatory training prior to graduation.[23]

The benefit of CPR training in high schools is understood as a long-term investment to ensure that multiple generations are trained and ready to act.[19] However, a more immediate consequence of school-centered training may be the amplification of community CPR training and literacy as students become trainers for their household and circle of friends.[24,25] Students can be asked to "pay it forward" by sending them home with CPR training materials and assigning them the task of training friends and family members.

This pilot program sought to investigate the feasibility, knowledge acquisition, and dissemination of a high school-centered, CPR video self-instruction program with a "pay-it-forward" component in a low-income, urban, predominantly Black neighborhood with historically low bystander-CPR rates. Schools provide large-scale, centrally organized community settings accessible to both children and adult family members of all socioeconomic backgrounds. A student-mediated, CPR educational intervention may be an effective conduit to relay OHCA knowledge and preparedness in high-risk neighborhoods.

Population Health Research Capsule

What do we already know about this issue?
Victims of cardiac arrest from primarily Black, Hispanic, and low-income neighborhoods are less likely to receive bystander CPR, and are less likely to survive.

What was the research question?
Can a high school-centered, video-based CPR educational program disseminate CPR knowledge in priority neighborhoods?

What was the major finding of the study?
The program increased CPR literacy in students and amplified community literacy as students became community CPR trainers.

How does this improve population health?
Widespread adoption of high school, CPR-training programs can amplify CPR literacy and may improve bystander CPR rates and cardiac arrest outcomes in priority neighborhoods.

METHODS

Program Setting and Population

The neighborhood of West Garfield Park in Chicago, Illinois, had been previously identified by our group using spatial epidemiologic clustering techniques as a community with high rates of cardiac arrest and low rates of bystander CPR.[26] The school selected for our CPR training intervention was Providence St. Mel, a Catholic high school located in the heart of West Garfield Park. Students enrolled in this school are 99.8% Black, and 61.8% come from low-income households. Participant enrollment was by purposeful convenience sample of ninth and tenth grade high school students in their physical education class period.

Human Participant Protection

This study was determined exempt from review by the Office for the Protection of Research Subjects of the University of Illinois at Chicago.

Program Design

The "pay it forward" CPR training program for high schools consisted of two parts: (1) a classroom-based, video-directed, learning intervention with an instructor-facilitated, practical skills module, and (2) a student-facilitated, in-home educational intervention using CPR Anytime Kits™.

Classroom intervention: Instructor-facilitated, video self-training

Two in-class training sessions of 45 minutes each during physical education period were delivered by two volunteer trainers with AHA Basic Life Support Certification and at least 30 hours of experience teaching Hands-Only CPR. During the first 10 minutes, students completed a written multiple-choice CPR and AED knowledge survey (Appendix A). Survey questions were adapted from a previously validated survey instrument used by the Denver High Arrest Neighborhoods to Decrease Disparities in Survival (HANDS) Program.[27] Upon completion the pre-intervention survey was collected from the class, and each student received an AHA CPR Anytime™ video self-instruction kit. This previously validated kit includes an instructional DVD (in English and Spanish) and inflatable mannequins with a built-in feedback mechanism that clicks with adequate compression depth.[28] The next 20-30 minutes consisted of instructor-facilitated, video-based instruction. The CPR Anytime™ kit DVD was shown in front of the class while the instructors were on hand to answer questions and supervise hand positioning. Students were also taught how to operate an AED and practiced using a trainer AED. During the last 5-10 minutes of the class period, students completed a knowledge assessment survey, which was a replica of the pre-training survey. To protect participants' privacy, pre- and post-training surveys did not include personal identifiable information.

"Pay it forward"

As homework, students were required to teach at least three friends or family members by using the video self-instruction kits in a train-the-trainer model. Students were asked to replicate their classroom experience by first administering pre surveys, followed by showing the self-instruction video and coaching participants through the practical portion at home, and finally administering the post survey to participants. Students were to return their data collection form and family and friends pre-/post-test surveys at two weeks to receive full credit. The surveys completed by family and friends did not include personal, identifiable information.

Measurements and Outcomes

The primary outcome was knowledge gained by high school students trained in school as measured by improvement in the knowledge survey. The secondary outcome measure was dissemination into the neighborhood as measured by (1) the number of people trained per student, and (2) knowledge acquisition by friends and family members trained at home.

Data Analysis

Descriptive statistics are presented as frequencies and percentages. We used Pearson's chi-square analysis to determine whether differences in pre- vs. post-knowledge surveys were statistically significant. Analyses were performed with Stata version 14.2 (StataCorp LP, College Station, TX).

RESULTS

Seventy-one students participated in the classroom-based educational intervention and took training kits home to teach friends and family. Sixty-nine completed the pre-training survey. All 71 students completed the post-training survey and took home the video self-instruction kits to "pay it forward." Because the surveys did not request personal identifiable information, we analyzed survey results in aggregate. Table 1 compares the percent of correct answers in the pre-training survey and post-training survey. The aggregate percent of correct answers increased from 58% pre training to 93% post training ($p < 0.0001$). An increase in correct responses was observed for several key concepts including adequate compression rate (from 20% to 96%, $p < 0.0001$), compression depth (from 25% to 92%, $p < 0.0001$), appropriate circumstances to perform COCPR (from 36% to 94%, $p < 0.0001$), and ease of defibrillator use (from 28% to 94%, $p < 0.0001$).

These 71 students in turn trained 347 friends and family members for a total of 418 people trained. On average, each student trained an additional 4.9 people (347/71) and each kit was used to train 5.9 in total (418/71). Pre-training surveys were completed by all 347 "pay-it-forward" participants; 344 also completed the post-training survey.

Table 2 summarizes knowledge acquisition for the "pay-it-forward" arm of the study. There was a statistically significant increase in the aggregate number of correctly answered questions between pre- and post-training surveys (58% to 82%, $p < 0.0001$). An increase in correct responses was observed for key concepts including compression rate (32% to 66%, $p < 0.0001$), compression depth (37% to 78%, $p < 0.0001$), when is it appropriate to use COCPR (46% to 74%, $p < 0.0001$) and ease of using a defibrillator (28% to 98%, $p < 0.0001$).

DISCUSSION

To our knowledge, this is the first study conducted in the U.S. to demonstrate that a high school-centered, CPR educational intervention with a "pay-it-forward" component can disseminate CPR knowledge beyond the classroom and reach into low-income, minority neighborhoods. High school participants and subsequently trained friends and family demonstrated a statistically significant improvement in aggregate scores. Moreover, students trained an average of 4.9 additional people, demonstrating the potential for a multiplier effect.

In a study from Denmark, mass distribution of similar video self-instruction kits resulted in dissemination to an average of 2.5 additional people per student (only 19.8% of participants responded to questionnaires on whom they trained).[24] In another study from Norway with a better survey response rate of 78%, an additional 2.8 people were trained

Table 1. Pre- and post-training survey data demonstrating statistically significant increase in knowledge acquisition of cardiopulmonary resuscitation (CPR) for students trained in high school.

	Before CPR training N =69		After CPR training N = 71		
Question	Correct	Percent	Correct	Percent	P value
It is better to do any CPR than to do no CPR?	58	84%	71	100%	0.0005
How do you check a person for a response?	49	71%	61	86%	0.0317
It is appropriate to use Hands-Only CPR in which situation?	25	36%	67	94%	< 0.0001
When providing Hands-Only CPR one should push on the victim's:	68	99%	69	97%	0.5764
What are the correct steps for providing Hands-Only CPR?	50	72%	55	77%	0.4945
When using an automated external defibrillator (AED) one should:	55	80%	71	100%	0.0001
How fast should you compress when doing Hands-Only CPR?	14	20%	68	96%	<0.0001
What does an automated external defibrillator (AED) do?	45	65%	68	96%	<0.0001
How deep should you do chest compressions when performing Hands-Only CPR?	17	25%	65	92%	<0.0001
How easy is it to use an automated external defibrillator (AED)?	19	28%	67	94%	<0.0001
Aggregate correct answers	400/690	58%	662/710	93%	<0.0001

per student participant.[25] Students in our training intervention outperformed their Denmark and Norway counterparts. Our survey response rate was 97% (69/71), and students taught on average an additional 4.9 people. Moreover, all participants, students and family and friends, demonstrated significant CPR and AED knowledge increase compared to baseline.

Opponents to compulsory training cite cost and time as barriers to implementation.[29,30] However, an investment of one 45- to 60-minute period every school year is sufficient to ensure widespread CPR knowledge.[31,32] In our study, training was completed in a 45-minute physical education class period, with minimum loss of standard curriculum time, and at low cost. With a retail price of $38.50,[33] the estimated cost per person trained in our pilot program was $6.54. By using video-based learning with an inflatable mannequin, schools can teach Hands-Only CPR skills in a single class period at low cost and with good knowledge acquisition.

Financially restricted schools and communities may not be able to invest in individual training kits for each high school student to take home or even for use in school. A more cost-effective model may include video-based training with use of shared CPR mannequins in the classroom setting. Instead of taking kits home for skills training, students can pay it forward and instruct others by using video and web-based learning platforms without skills practice. Previous research in Arizona has demonstrated that bystanders who learned CPR by watching a 60-second video without skills practice had significantly improved responsiveness, chest compression rate, and decreased hands-off intervals compared to no training.[16]

The "pay-it-forward" model also provides an opportunity for high school students to reinforce their knowledge of the chain of survival. Medical students in Germany demonstrated that their own CPR skills improved by teaching schoolchildren.[34] Another study from Belgium demonstrated that instructing schoolchildren to teach Basic Life Support (BLS) to their relatives and friends led to a more positive attitude of the adults towards bystander CPR.[35] A CPR educational intervention in which high school students become teachers to friends and family can reinforce student knowledge while empowering youth to become community health advocates. As of the drafting of this study, 36 states including Illinois have made CPR a mandatory component of the public high school curriculum.[23] The widespread adoption of CPR training in schools represents a long-term investment to ensure that multiple generations are trained and ready to act.[19] An immediate benefit is the potential impact of adolescents as lay rescuers.[19] Another short-term benefit not well investigated is the potential for an immediate multiplier effect by reaching out of the classroom and into the communities served by the schools.

One successful example of health information flowing from child to parent is the Hip Hop for Stroke (HHS) program, a school-based, multimedia, stroke-literacy intervention targeting children aged 8-12 in Central Harlem.[36] HHS improved knowledge of stroke symptoms and intent to activate 9-1-1 in children participants while increasing parental stroke literacy.[37] While the concept of child-mediated health education is not new, its application to OHCA remains novel and untested as a major strategy to address significant disparities in outcome by community. Because schools provide large-scale, centrally organized settings accessed by people from all ranges of the social spectrum, a high school-centered, communitywide CPR training program has remarkable potential for reach into communities that would otherwise be hard to reach by traditional CPR education efforts.

Table 2. Pre- and post-training survey data demonstrating statistically significant increase in knowledge acquisition for friends and family members trained in cardiopulmonary resuscitation at home.

	Before CPR training N =347		After CPR training N = 344		
Question	Correct	Percent	Correct	Percent	P value
It is better to do any CPR than to do no CPR?	285	82%	321	93%	<0.0001
How do you check a person for a response?	192	55%	261	76%	<0.0001
It is appropriate to use Hands-Only CPR in which situation?	161	46%	256	74%	<0.0001
When providing Hands-Only CPR one should push on the victim's:	293	84%	316	92%	0.0026
What are the correct steps for providing Hands-Only CPR?	202	58%	267	78%	<0.0001
When using an automated external defibrillator (AED) one should:	271	78%	321	93%	<0.0001
How fast should you compress when doing Hands-Only CPR?	111	32%	228	66%	<0.0001
What does an automated external defibrillator (AED) do?	227	65%	289	84%	<0.0001
How deep should you do chest compressions when performing Hands-Only CPR?	129	37%	267	78%	<0.0001
How easy is it to use an automated external defibrillator (AED)?	152	44%	295	86%	<0.0001
Aggregate correct	2023/3470	58%	2821/3440	82%	<0.0001

There is significant evidence regarding the high efficacy of child-mediated CPR education. Previous survey studies of witnesses to OCHA have demonstrated that any previous CPR training is a predictor of CPR performance.[38 39] Moreover, parallel efforts in faith-based, community-based, and employment organizations to teach Hands-Only CPR and share that knowledge with their constituents may have a ripple effect in communities with low bystander-CPR rates.[40 41 42]

Multifaceted, community-based approaches aimed at strengthening the link in the chain of survival have been successful at increasing bystander-CPR rates and, subsequently, cardiac arrest survival.[43,44,45] To eliminate disparities in bystander CPR provision, public education campaigns must prioritize neighborhoods with the highest need as identified using public health surveillance tools such as registries.[27, 46] The effect in communities found to have a high incidence of cardiac arrest and little-to-no incidence of bystander CPR could be exponential.

LIMITATIONS

A significant limitation of this study was the inability to determine individual knowledge acquisition given that surveys did not include personal, identifiable information. However, the marked and statistically significant improvement in aggregate scores suggest that a video self-instruction, CPR-training program with a "pay-it-forward" component can increase understanding of the indications for and the steps to perform CPR.

Another limitation was the inability to ensure quality control of the pay-it-forward component. It is uncertain whether students provided the answers to the people that they trained or if the increase in the post-intervention scores truly reflected knowledge increase. It is also unclear whether knowledge will translate into adequate technique or increased bystander CPR and AED use. Despite these limitations, our "pay-it-forward" model is an inexpensive, novel strategy to disseminate CPR and AED knowledge in priority neighborhoods with limited access to traditional CPR training courses.

CONCLUSION

Our student-led, pay-it-forward model using video self-instruction kits is an efficient training intervention to deliver bystander CPR and AED educational intervention in low-income, minority neighborhoods. Because schools are centrally organized settings to which all children and their families have access, school-based interventions allow for a broad reach that encompasses all segments of the population and have potential to decrease disparities in provision of bystander CPR and use of AEDs. Future research will seek to determine long-term knowledge retention of this educational intervention, as well as measure associated trends in bystander CPR within communities reached.

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REFERENCES

1. Daya M, Schmicker R, May S, et al. Current burden of cardiac arrest in the United States: report from the Resuscitation Outcomes Consortium. (Paper commissioned by the Committee on the Treatment of Cardiac Arrest: Current Status and Future Directions. 2015.) Available at: http://www.nationalacademies.org/hmd/%20~/media/Files/Report%20Files/2015/ROC.pdf. Accessed October 12, 2017.
2. Weisfeldt ML, Becker LB. Resuscitation After Cardiac arrest: a 3-phase time-sensitive model. *JAMA*. 2002;288(23):3035-8.
3. Gallagher EJ, Lombardi G, Gennis P. Effectiveness of bystander cardiopulmonary resuscitation and survival following out-of-hospital cardiac arrest. *JAMA*. 1995; 274(24):1922-5.
4. Sasson C, Rogers MA, Dahl J, et al. Predictors of survival from out-of-hospital cardiac arrest. *Circ Cardiovasc Qual Outcomes.* 2010;3(1):63-81.
5. Nolan, JP. Optimizing outcome after cardiac arrest. *Curr Opin Crit Care*. 2011;17(5):520-6.
6. Abella BS, Aufderheide TP, Eigel B, et al. Reducing barriers for implementation of bystander-initiated cardiopulmonary resuscitation: a scientific statement from the American Heart Association for healthcare providers, policymakers, and community leaders regarding the effectiveness of cardiopulmonary resuscitation. *Circulation*. 2008;117(5):704-9.
7. Graham R, McCoy MA, Schultz AM. Strategies to improve cardiac arrest survival: a time to act. Institute of Medicine Report. 2015
8. Sasson C, Magid DJ, Chan P, et al. Association of neighborhood characteristics with bystander-initiated CPR. *N Eng J Med*. 2012;367(17):1607-15.
9. Girotra S, van Diepen S, Nallamothu BK, et al. Regional variation in out-of-hospital cardiac arrest survival in the United States. *Circulation*. 2016;133(22):2159-68.
10. Moon S, Bobrow BJ, Vadeboncoeur TF, et al. Disparities in bystander CPR provision and survival from out-of-hospital cardiac arrest according to neighborhood ethnicity. *Am J Emerg Med*. 2014;32(9):1041-5.
11. Shah KS, Shah AS, Bhopal R. Systematic review and meta-analysis of out-of-hospital cardiac arrest and race or ethnicity: black US populations fare worse. *Eur J Prev Cardiol*. 2014;21(5):619-38.
12. Sasson C, Meischke H, Abella BS, et al. Increasing Cardiopulmonary resuscitation provision in communities with low bystander cardiopulmonary resuscitation rates. *Circulation.* 2013;127(12):1342-50.
13. Emil LF, Matthew ED, Benjamin S, et al. Association of neighborhood characteristics with incidence of out-of-hospital cardiac arrest and rates of bystander-initiated CPR: implications for community-based education intervention. *Resuscitation*. 2014;85(11):1512-7.
14. Bobrow BJ, Spaite DW, Berg RA, et al. Chest compression–only CPR by lay rescuers and survival from out-of-hospital cardiac arrest. *JAMA*. 2010;304(13):1447-54.
15. Sayre MR, Berg RA, Cave DM, et al. Hands-only (compression-only) cardiopulmonary resuscitation: a call to action for bystander response to adults who experience out-of-hospital sudden cardiac arrest: a science advisory for the public from the American Heart Association Emergency Cardiovascular Care Committee. *Circulation*. 2008;117(16):2162–2167
16. Panchal AR, Meziab O, Stolz U, et al. The impact of ultra-brief chest compression-only CPR video training on responsiveness, compression rate, and hands-off time interval among bystanders in a shopping mall. *Resuscitation*. 2014;85(9):1287-90.
17. McCarrison R, Ren D, Woomer GR, et al. Evaluation of a self-instructional CPR program for parents with children enrolled in community swim lessons. *J Pediatr Health Care*. 2017;31(3):314-9.
18. Potts J, Lynch B. The American Heart Association CPR Anytime Program: the potential impact of highly accessible training in cardiopulmonary resuscitation. *J Cardiopulm Rehabil.* 2006;26(6):346-54.
19. Cave DM, Aufderheide TP, Beeson J, et al. Importance and implementation of training in cardiopulmonary resuscitation and automated external defibrillation in schools: a science advisory from the American Heart Association. *Circulation*. 2011;123(6):691–706.
20. Song KJ, Shin SD, Park CB, et al. Dispatcher-assisted bystander cardiopulmonary resuscitation in a metropolitan city: a before-after population-based study. *Resuscitation*. 2014;85(1):34-41.
21. Lerner EB, Rea TD, Bobrow BJ, et al. Emergency medical service dispatch cardiopulmonary resuscitation prearrival instructions to improve survival from out-of-hospital cardiac arrest: a scientific statement from the American Heart Association. *Circulation.* 2012;125(4): 648–55.
22. Böttiger BW, Van Aken H. Kids save lives–. *Resuscitation*. 2015;94:A5-7
23. States where CPR Training is Mandatory for High School Graduation [Internet]. School CPR Blog. Available at: http://schoolcpr.com/about/states-where-cpr-training-is-mandatory-for-high-school-graduation/.

Accessed March 17, 2017.

24. Isbye DL, Rasmussen LS, Ringsted C, Lippert FK. Disseminating cardiopulmonary resuscitation training by distributing 35 000 personal manikins among school children. *Circulation*. 2007 Sep 18;116(12):1380-1385
25. Lorem T, Steen PA, Wik L. High school students as ambassadors of CPR--a model for reaching the most appropriate target population? *Resuscitation*. 2010;81(1):78-81.
26. Del Ríos M, Kotini-Shah P, Heinert S, et al. Association Of neighborhood characteristics with incidence and survival from out of hospital cardiac arrest In Chicago (abstract). *Acad Emerg Med*. 2015; 22(S1): A316.
27. Sasson C, Haukoos JS, Eigel B, et al. The HANDDS program: a systematic approach for addressing disparities in the provision of bystander cardiopulmonary resuscitation. *Acad Emerg Med*. 2014;21(9):1042-9.
28. Einspruch EL, Lynch B, Aufderheide TP, et al. Retention of CPR skills learned in a traditional AHA Heartsaver course versus 30-min video self-training: a controlled randomized study. *Resuscitation.* 2007;74(3):476-86.
29. Reder S, Quan L. Cardiopulmonary resuscitation training in Washington State public high schools. *Resuscitation*. 2003;56(3):283-8.
30. Hoyme DB, Atkins DL. Implementing cardiopulmonary resuscitation training programs in high schools: Iowa's experience. *J Pediatr*. 2017;181:172-176.e3
31. Watanabe K, Lopez-Colon D, Shuster JJ, et al. Efficacy and retention of Basic Life Support education including automated external defibrillator usage during a physical education period. *Prev Med Rep*. 12;5:263-7.
32. Kelley J, Richman PB, Ewy GA, et al. Eighth grade students become proficient at CPR and use of an AED following a condensed training programme. *Resuscitation*. 2006;71(2):229-36.
33. Family & Friends® CPR Anytime® [Internet]. Laerdal.com. Available at: http://www.laerdal.com/us/doc/1080/Family-Friends-CPR-Anytime#/Webshop/MAINPRODUCTS. Accessed March 6, 2017.
34. Beck S, Meier-Klages V, Michaelis M, et al. Teaching school children basic life support improves teaching and basic life support skills of medical students: a randomised, controlled trial. *Resuscitation*. 2016 30;108:1-7.
35. Stroobants J, Monsieurs KG, Devriendt B, et al. Schoolchildren as BLS instructors for relatives and friends: Impact on attitude towards bystander CPR. *Resuscitation.* 2014;85(12):1769-74.
36. Williams O, Noble JM. 'Hip-Hop' Stroke. *Stroke.* 2008;39(10):2809-16.
37. Williams O, DeSorbo A, Noble J, et al. Child-mediated stroke communication. *Stroke.* 2012;43(1):163-9.
38. Swor R, Khan I, Domeier R, et al. CPR training and CPR performance: do CPR-trained bystanders perform CPR? *Acad Emerg Med*. 2006;13(6):596-601.
39. Tanigawa K, Iwami T, Nishiyama C, et al. Are trained individuals more likely to perform bystander CPR? An observational study. *Resuscitation*. 2011;82(5):523-8.
40. Todd KH, Heron SL, Thompson M, et al. Simple CPR: a randomized, controlled trial of video self-instructional cardiopulmonary resuscitation training in an African American church congregation. *Ann Emerg Med*. 1999;34(6):730-7.
41. Batcheller AM, Brennan RT, Braslow A, et al. Cardiopulmonary resuscitation performance of subjects over forty is better following half-hour video self-instruction compared to traditional four-hour classroom training. *Resuscitation*. 2000;43(2):101-10.
42. Roppolo LP, Pepe PE, Campbell L, et al. Prospective, randomized trial of the effectiveness and retention of 30-min layperson training for cardiopulmonary resuscitation and automated external defibrillators: The American Airlines Study. *Resuscitation*. 2007;74(2):276-85.
43. Nielsen AM, Isbye DL, Lippert FK, et al. Persisting effect of community approaches to resuscitation. *Resuscitation*. 2014;85(11):1450-4.
44. Lick CJ, Aufderheide TP, Niskanen RA, et al. Take Heart America: a comprehensive, community-wide, systems-based approach to the treatment of cardiac arrest. *Crit Care Med*. 2011;39(1):26-33.
45. van Diepen S, Abella BS, Bobrow BJ, et al. Multistate implementation of guideline-based cardiac resuscitation systems of care: description of the HeartRescue project. *Am Heart J*. 2013;166(4):647-653.e2
46. Sasson C, Meischke H, Abella BS, et al. Increasing cardiopulmonary resuscitation provision in communities with low bystander cardiopulmonary resuscitation rates. *Circulation*. 2013;127(12):1342-50.

Higher Mallampati Scores Are Not Associated with More Adverse Events During Pediatric Procedural Sedation and Analgesia

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Introduction: Procedural sedation and analgesia (PSA) is used by non-anesthesiologists (NAs) outside of the operating room for several types of procedures. Adverse events during pediatric PSA that pose the most risk to patient safety involve airway compromise. Higher Mallampati scores may indirectly indicate children at risk for airway compromise. Medical governing bodies have proposed guidelines for PSA performed by NAs, but these recommendations rarely suggest using Mallampati scores in pre-PSA evaluations. Our objective was to compare rates of adverse events during pediatric PSA in children with Mallampati scores of III/IV vs. scores of Mallampati I/II.

Methods: This was a prospective, observational study. Children 18 years of age and under who presented to the pediatric emergency department (PED) and required PSA were enrolled. We obtained Mallampati scores as part of pre-PSA assessments. We defined adverse events as oxygen desaturation < 90%, apnea, laryngospasm, bag-valve-mask ventilation performed, repositioning of patient, emesis, and "other." We used chi-square analysis to compare rates of adverse events between groups.

Results: We enrolled 575 patients. The median age of the patients was 6.0 years (interquartile range = 3.1,9.9). The primary reasons for PSA was fracture reduction (n=265, 46.1%). Most sedations involved the use of ketamine (n= 568, 98.8%). Patients with Mallampati scores of III/IV were more likely to need repositioning compared to those with Mallampati scores of I/II (p=0.049). Overall, patients with Mallampati III/IV scores did not experience a higher proportion of adverse events compared to those with Mallampati scores of I/II. The relative risk of any adverse event in patients with Mallampati scores of III/IV (40 [23.8%]) compared to patients with Mallampati scores of I/II (53 [18.3%]) was 1.3 (95% confidence interval [0.91-1.87]).

Conclusion: Patients with Mallampati scores of III/IV vs. Mallampati scores of I/II are not at an increased risk of adverse events during pediatric PSA. However, patients with Mallampati III/IV scores showed an increased need for repositioning, suggesting that the sedating physician should be vigilant when performing PSA in children with higher Mallampati scores. [West J Emerg Med. 2018;19(2)430-436.]

INTRODUCTION

Procedural sedation and analgesia (PSA) is the use of sedative, analgesic, or dissociative drugs to relieve pain and anxiety associated with diagnostic and therapeutic procedures, while maintaining continuous and independent ventilation without loss of protective reflexes.[1,2] Many procedures that were formerly performed under general anesthesia in the operating room (OR) are now successfully completed using PSA in locations outside the OR, including the emergency department (ED).[3] As a result, PSAs are now being performed more

frequently by non-anesthesiologists (NAs), such as emergency physicians, and it is estimated that roughly a quarter of a million pediatric patients will receive PSA in the ED alone each year.[4, 5] Therefore, it is paramount that emergency physicians be prepared not only to administer proper PSA to children, but also to manage any complications or adverse events that may arise when PSA takes place in the pediatric ED.

Adverse event rates during pediatric PSA in non-OR settings are reported between 2.3%-17.6%.[6, 7] The definition of adverse events during PSA varies in the literature and has included the following: oxygen desaturation less than 90-93%; apnea; stridor; laryngospasm; bronchospasm; cardiovascular instability; paradoxical reactions; emergence reactions; emesis; and aspiration.[5, 6] Of these, the adverse events that pose the most significant risk to the safety of the patient are those that compromise the airway.[8] Smaller studies have found rates of airway compromise during PSA ranging from 5-6%.[9-11] Medications used for PSA varied in these studies and included chloral hydrate, propofol, ketamine, midazolam and fentanyl.

Larger studies have also found significant but lower rates of airway compromise among pediatric patients undergoing PSA. The Pediatric Sedation Research Consortium found that among nearly 30,000 PSAs performed outside the OR, oxygen desaturation occurred 157 times per 10,000 sedations; stridor and laryngospasm both occurred in 4.3 per 10,000 sedations; and unexpected apnea occurred in 24 per 10,000 sedations.[12] Finally, similar adverse event rates with oxygen desaturations were reported in a systematic meta-analysis of studies involving PSA in the ED.[13] Thus, evidence shows that despite various medications used in pediatric PSAs in different settings, the risk of airway compromise remains.

Because of the universal risk for airway compromise among PSA medications, further research has sought to identify patient factors that predict higher risk for adverse events during PSA. For example, studies have shown that patients of younger age (<1-2 years old) or with higher American Society of Anesthesiologists (ASA) classification (ASA>2) may experience more adverse respiratory events during PSA.[9, 14, 15] In light of the inherent airway risks of PSA and the potential ability to identify predisposing factors for adverse events prior to PSA, professional medical governing bodies have proposed guidelines and recommendations specifically for PSA performed by NAs. The guidelines encompass risk assessment prior to PSA by performing a complete history and physical exam and determining ASA classification and nil per os (NPO) status. They also stress the importance of appropriate monitoring during PSA and access to airway rescue equipment and pharmacological reversal agents. When implemented, these guidelines have proven to decrease the rate of respiratory adverse events.[16-19]

It is notable, however, that the guidelines cursorily, if at all, suggest using Mallampati scores in pre-PSA evaluations. Mallampati scores are obtained by visualizing a patient's posterior oropharynx while the patient is seated and opening his mouth with his tongue protruded. The modified Mallampati classification scheme scores adequacy of visualization from I to IV, with I being full visualization and IV being visualization of only the hard palate. The Mallampati score is used to predict difficulty with intubation, with those who score III or IV being more difficult to intubate, and has been validated in children.[20-23] Given that a higher Mallampati score may indirectly indicate children who have potentially difficult or anatomically different airways, this classification scheme may add important risk information to pediatric pre-PSA assessments. Thus, the objective of this study was to assess whether pre-PSA Mallampati score can predict adverse events during pediatric PSA.

Population Health Research Capsule

What do we already know about this issue?
While pediatric procedural sedation and analgesia (PSA) is considered safe, the most common adverse events are related to respiratory compromise.

What was the research question?
Would children with higher Mallampati scores experience higher rates of adverse events during PSA?

What was the major finding of the study?
Patients with higher and lower Mallampati scores had similar adverse event rates with the exception of need for repositioning.

How does this improve population health?
Because many non-pediatric physicians perform PSA, this study reinforces that vigilant monitoring during PSA is necessary to provide optimal care for our pediatric patients.

METHODS

Study Design

This was a prospective observational study that took place between March – August 2013 at a tertiary care institution that performs approximately 900 PSAs in the PED annually. This study received institutional review board approval from the participating institution.

Study Setting and Population

We included all children between the ages of 0 and 18 years who presented to the PED for medical or surgical conditions requiring procedural sedation during the study period. Children

with genetic syndromes, anatomic abnormalities such as retrognathia, cleft lip and/or palate, macroglossia or any other medical condition that would preclude PSA were automatically excluded since they did not meet criteria for PSA in the PED.

Study Protocol

Mallampati Scoring and Documentation

Sedations were performed by pediatric emergency medicine (PEM) attending physicians, PEM fellows, or senior pediatric or EM residents on their sedation rotation in the PED. The sedating physician was responsible for performing a pre-PSA evaluation, including obtaining a Mallampati score, which was documented in the patient's electronic medical record (EMR). Given that the Mallampati scoring system has previously been shown to have moderate inter-rater reliability and that having multiple physicians perform a pre-PSA assessment would hinder the workflow in the PED, only one physician obtained the Mallampati score for each patient.[24] The modified Mallampati scoring system is illustrated in the figure.[20, 25]

Prior to the study period, senior pediatric and EM resident physicians performing PSAs participated in a four-hour procedural sedation course at the beginning of their academic year and received a follow-up, 30-minute, one-on-one sedation simulation session prior to their sedation rotation in the PED. During both of these sessions, residents received verbal and written instructions on how to use the Mallampati scoring system and how to document these scores in the EMR. PEM attending physicians and fellows received both verbal and written instructions on Mallampati scoring and documentation during two separate sessions. Finally, all physicians completing pre-PSA assessments received a pocket card outlining the Mallampati scoring so that it could be referred to at the patient's bedside.

Definition of Adverse Events

Given that the adverse events posing the most significant risk to the safety of the patient are those that compromise the airway, the following were categorized as adverse events for the purposes of this study: oxygen desaturation < 90%; apnea as defined of cessation of spontaneous ventilation for 20 seconds; laryngospasm; need for bag-mask ventilation (BMV) as determined by the physician performing PSA; emesis; and events categorized as "other" by the physician administering PSA.[7] Additionally, the need for repositioning was also considered to be an adverse event (though of less significance than the aforementioned) for the purposes of this study, since children with larger occiputs could be more prone to obstructive airway compromise.

Data Collection

In addition to adverse events, we collected the following data points for this study: past medical history; past surgical history; allergies; Mallampati score; ASA classification; previous anesthesia; reason for sedation; medication(s) given during sedation; vital signs; use of suctioning; use of supplemental oxygen; length of sedation; length of procedure; and total length of stay in the ED. The data was stored in the Research Electronic Data Capture (REDCap™, Vanderbilt University, 2013), an online software that allows for database creation and statistical analysis.

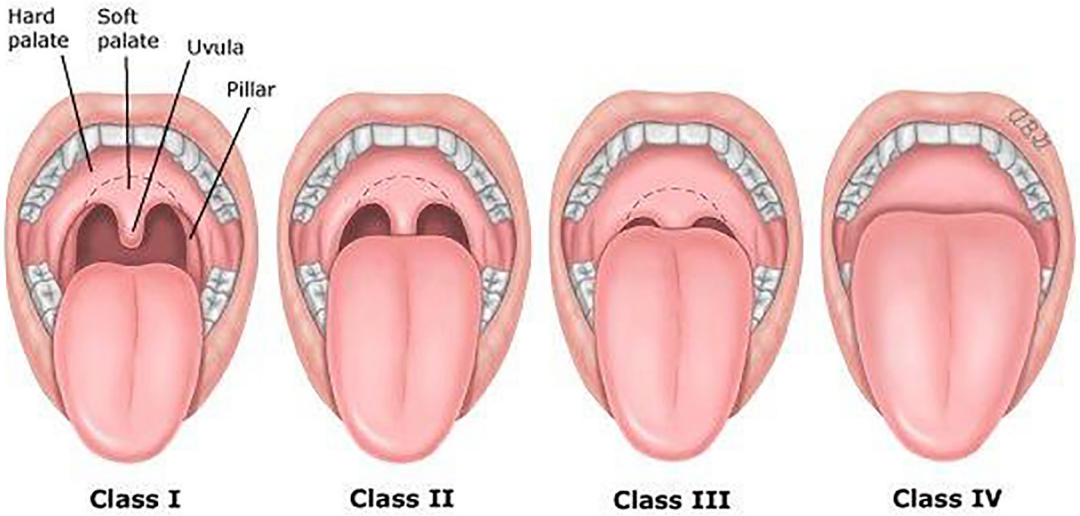

Figure. The modified Mallampati classification system.
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Data Analysis

Based on previous studies, we estimated that 38% of the general population would have a Mallampati score of III or IV.[26] The known adverse event rate for PSA at the site of this study is approximately 10%. Based on these assumptions, and in order to detect a 15% difference in the rate of adverse events between individuals with Mallampati scores of III/IV vs. those with Mallampati scores of I/ II, a minimum of 204 study subjects (n= 125 for Mallampati III/IV and n=79 for Mallampati I/II) were required for enrollment (α= 0.05 and β= 0.20).

We used descriptive statistics to analyze patient characteristics and demographic data. For categorical data, groups were compared using chi square or Fisher's exact test, where appropriate. The Kruskal-Wallis test was used to compare patient characteristics between the Mallampati groups. We performed all statistical analyses using SPSS Statistics for Windows Version 24 (IBM Inc., Armonk, NY).

RESULTS

During the study period 575 PSAs were completed. Mallampati scores were documented in 458 patients, and were either not recorded or unable to be obtained secondary to patient compliance in 117 patients. The median age of the patients undergoing PSA was 6.0 years (interquartile range [IQR] 3.1, 9.9). The majority of patients in the study population who underwent PSA were Caucasian (n= 461, 80.2%) and male (n=327, 56.9%). The median length of sedation was 24.0 minutes (IQR=17.0, 32.0). The primary reasons for sedation were fracture reduction (n=265, 46.1%) and laceration repair (n= 153, 26.6%). In addition, 92.5% (n=532) of the patients were categorized as ASA I or II. The majority of sedations used ketamine either alone or in combination with another medication (n= 568, 98.8%). Table 1 illustrates these characteristics based on Mallampati scores.

Table 2 shows the number of adverse events during PSA by Mallampati scores. Patients with Mallampati scores of III/IV did not experience a significantly higher proportion of adverse events compared to those with Mallampati scores of I/II. However, a higher proportion of those with Mallampati scores of III/IV compared to those with Mallampati scores of I/II required repositioning during PSA ($p < 0.05$). The relative risk of any adverse event in patients with Mallampati scores of III/IV [40 (23.8%)] compared to patients with Mallampati scores of I/II [53 (18.3%)] was 1.3 (95% confidence interval [CI] [0.91-1.87]).

DISCUSSION

Our study found that there was not a significant difference in the proportion of adverse events between those individuals with Mallampati scores of III/IV vs. those with Mallampati scores of I/II. In fact, post-hoc power analysis showed that this study had a 95% power to detect a 15% difference in the proportion of adverse events between these two groups.

Table 1. Characteristics of the patients undergoing procedural sedation and analgesia, with Mallampati score.

Characteristic	Mallampati I/II n= 290	Mallampati III/IV n= 168	Mallampati not assessed/ documented n= 117
Age, y, median (IQR)	7.0 (4.2, 10.9)	6.7 (3.9,10.8)	2.6 (1.6,5.0)
Male, n (%)	154 (53.1)	109 (64.9)	64 (54.7)
Caucasian race, n (%)	236 (81.4)	135 (80.4)	90 (76.9)
Length of sedation, min, median (IQR)	24 (17.0, 31.0)	25 (17.0, 34.0)	25 (16.0, 31.0)
ASA I or II, n (%)	277 (95.5)	165 (98.2)	90 (76.9)
Procedure, No. (%)			
Fracture reduction	153 (52.8)	83 (49.4)	29 (24.8)
Laceration repair	67 (23.1)	44 (26.1)	42 (35.9)
Abscess, incision and drainage	37 (12.8)	24 (14.3)	32 (27.4)
Lumbar puncture	1 (0.3)	1 (0.6)	1 (0.9)
Nailbed repair	15 (5.2)	5 (3.0)	8 (6.8)
Genital injury	5 (1.7)	1 (0.6)	0 (0)
Other	12 (4.1)	10 (6.0)	5 (4.3)
Sedation drugs, No. (%)			
Ketamine	159 (54.8)	97 (57.7)	82 (70.1)
Combination (ketamine + another medication)	129 (44.5)	68 (40.5)	33 (28.2)
Other	1 (0.3)	1 (0.6)	1 (0.9)

ASA, American Society of Anesthesiologist Classification System; *IQR*, interquartile range

Table 2. Adverse events by Mallampati score

Adverse Event Occurred n (% within Mallampati group)	Mallampati I/II n= 290	Mallampati III/IV n= 168	P-value
Any adverse event	53 (18.3)	40 (23.8)	0.16
Oxygen desaturation	20 (6.9)	16 (9.5)	0.31
Bag mask ventilation	3 (1.0)	2 (1.2)	1.00
Repositioning	19 (6.6)	20 (11.9)	0.049
Laryngospasm	3 (1.0)	3 (1.8)	0.67
Apnea	2 (0.7)	1 (0.6)	1.00
Emesis	2 (0.68)	0 (0)	0.53
Other	18 (6.2)	11(6.5)	0.89

Notably, a greater proportion of patients with Mallampati scores of III/IV compared with those of Mallampati scores of I/II required repositioning during PSA. This is not surprising since those with higher Mallampati scores likely have the body habitus, particularly increased neck girth and larger facies, that could predispose a patient to obstructive respiratory events during PSA. Hirsch et al. found that children who were obese and undergoing PSA experienced a greater desaturation rate compared with children who were not obese (9.9% vs 5.4%; p=0.04).[27] Furthermore, Mallampati scores have also been shown to be an independent predictor of obstructive sleep apnea, thus highlighting the fact that these scores may be an indirect measurement of anatomical factors that should be considered in pre-PSA assessments.[28]

In this study, nearly 20% of the patients did not have a documented Mallampati score or the physician administering PSA was unable to obtain a score. Although the physicians who did not document a Mallampati score were not required to provide information on why these scores were not reported, we surmise that the primary reason for scores not obtained was secondary to patient compliance. The median age of those whose scores were either not obtained or unable to be obtained was 2.6 years, thus suggesting that age may limit the physician's ability to obtain a Mallampati score. Mallampati scoring requires the patient to sit upright, voluntarily open his mouth and refrain from saying "ahh" (a maneuver that falsely elevates the palate). Koop et al. showed that children under the age of four are less likely to be able to cooperate with such maneuvers and may not have the cognitive ability to follow through with multi-step tasks that require greater attention.[29, 30]

Similarly, other studies comparing Mallampati scores to other indirect methods predicting difficult endotracheal intubations, such as the Cormack and Lehane grading system, have also encountered difficulty in obtaining Mallampati scores for children ages 1-3 years.[31, 32] Furthermore, pediatric patients presenting to the PED for PSA are often suffering from painful injuries, and under these circumstances physical examinations, particularly oropharyngeal exams, can be viewed as distressing from the patient and parent perspectives.[33] Thus, age, physical pain, and distress or anxiety may hinder the physician's ability to obtain a Mallampati score.

While this study was powered to detect differences in adverse events between those with Mallampati scores of III/IV vs. those with Mallampati scores of I/II, it is still rare for adverse, sedation-related events to occur, particularly with the use of ketamine. The adverse event rate during the study period was 11.6%, which is similar to previously reported PSA adverse event rates at this institution.[8, 15] This event rate is, however, higher than the reported adverse event rate with using ketamine as a single agent (0.4%- 2.3%).[34, 35] This discrepancy may be due to the fact that children in this study may have had more than one adverse event documented during a single sedation, such as apnea, oxygen desaturation, and BMV.

Previous studies have shown that ketamine has a low side-effect profile with the most common adverse events being those related to respiratory compromise and emesis.[11, 36] In fact, the odds of respiratory adverse events associated with ketamine use increases when it is administered intramuscularly instead of intravenously.[36] In addition, ketamine-associated emesis can be reduced by administering ondansetron prior to the start of PSA.[33] However, neither of the two patients who had emesis during PSA in this study received ondansetron as a premedication. Moreover, while the authors did not evaluate NPO status and how this relates to emesis, previous studies have shown that the NPO time does not affect the rate of major adverse events during PSA.[37, 38]

LIMITATIONS

There are a few limitations in this study. We did not analyze the route of administration of the PSA agent during initial data collection. Also, ketamine was the primary PSA agent in this study and if different institutions use other medications, such as an opioid or benzodiazepine, the results may vary. This, along with being a single-site study, limits the generalizability of the results. Furthermore, although adjustments for confounders were not made in this study, Table 1 illustrates that the

Mallampati III/IV and Mallampati I/II groups were very similar with the covariates that were measured.

Additionally, the definitions for adverse events in this study focused on those involving airway compromise and the thresholds used were slightly different from those previously described in the literature. For instance, we used the definition of oxygen desaturation <90% to account for true hypoxia requiring supplemental oxygen instead of the definition of oxygen desaturation occurring between 90-93%. [5, 6] Consequently, the rate of oxygen desaturation may be lower in this study. Finally, since it is not routine procedure at this institution to use end-tidal CO2 during PSA, this may have limited our ability to obtain true objective data in regard to apneic episodes.

CONCLUSION

We found that there was not a significant difference in the rate of adverse events between patients with Mallampati scores III/VI compared to those with Mallampati scores of I/II. However, patients with Mallampati scores of III/VI had a higher proportion needing repositioning, suggesting that the sedating physician should be more vigilant with these patients.

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REFERENCES

1. Krauss B, Green SM. Procedural sedation and analgesia in children. *Lancet*. 2006;367(9512):766-80.
2. Meredith JR, O'Keefe KP, Glwankar S. Pediatric procedural sedation and analgesia. *J Emerg Trauma Shock*. 2008;1(2):88-96.
3. Havidich J. The current status of procedural sedation for pediatric patients in out-of-operating room locations. *Curr Opin Anesthesiol*. 2012;25(4):453-60.
4. Monroe KK, Beach M, Reindel R, et al. Analysis of procedural sedation provided by pediatricians. *Pediatr Int*. 2013;55(1):17-23.
5. Sacchetti A, Stander E, Ferguson N, et al. Pediatric procedural sedation in the community emergency department: results from the ProSCED registry. *Pediatr Emerg Care*. 2007;23(4):218–22.
6. Pena BM, Krauss B. Adverse events of procedural sedation and analgesia in a pediatric emergency department. *Ann Emerg Med*. 1999;34(4):483-91.
7. Malviya S, Voepel-Lewis T, Tait AR. Adverse events and risk factors associated with the sedation of children by nonanesthesiologists. *Anesth Analg*. 1997;85(6):1207-13.
8. Tobias JD, Leder M. Procedural sedation: A review of sedative agents monitoring, and management of complications. *Saudi J Anaesth*. 2011;5(4):395-410.
9. Hertzog JH, Campbell JK, Dalton HJ, et al. Propofol anesthesia for invasive procedures in ambulatory and hospitalized children: Experience in the pediatric intensive care unit. *Pediatrics*. 1999;103:e30.
10. Roback MG, Wathen JE, Bajaj L, et al. Adverse events associated with procedural sedation and analgesia in a pediatric emergency department: a comparison of common parenteral drugs. *Acad Emerg Med*. 2005;12(6):508–13.
11. Cravero JP, Blike GT, Beach M, et al. Pediatric Sedation Research Consortium. Incidence and nature of adverse events during pediatric sedation/anesthesia for procedures outside the operating room: report from the Pediatric Sedation Research Consortium. *Pediatrics*. 2006;118(3):1087-96.
12. Bellolio MF, Puls HA, Anderson JL, et al. Incidence of adverse events in paediatric procedural sedation in the emergency department: a systematic review and meta-analysis. *BMJ Open*. 2016;6(6):e011384.
13. Green SM, Roback MG, Krauss B, et al. Predictors of airway and respiratory adverse events with ketamine sedation in the emergency department: an individual-patient data meta-analysis of 8,282 children. *Ann Emerg Med*. 2009;54(2):158–68.
14. Caperell K, Pitetti R. Is higher ASA class associated with an increased incidence of adverse events during procedural sedation in a pediatric emergency department? *Pediatr Emerg Care*. 2009;25(10):661-4.
15. Hoffman GM, Nowakowski R, Troshynski TJ, et al. Risk reduction in pediatric procedural sedation by application of an American Academy of Pediatrics/American Society of Anesthesiologists process model. *Pediatrics*. 2002;109(2):236-43.
16. Pitetti R, Davis PJ, Redlinger R, et al. Effect on hospital-wide sedation practices after implementation of the 2001 JCAHO procedural sedation and analgesia guidelines. *Arch Pediat Adolesc Med*. 2006;160(2):211–6.
17. SIGN Guideline 58: safe sedation of children undergoing diagnostic and therapeutic procedures. *Paediatr Anaesth*. 2008;18(1):11–2.
18. Cote CJ, Wilson S. American Academy of Pediatrics; American

Academy of Pediatric Dentistry. Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016. *Pediatrics.* 2016;138(1): e2016-1212.

19. Mallampati SR, Gatt SP, Gugino LD, et al. A clinical sign to predict difficult tracheal intubation: a prospective study. *Can Anaesth Soc J*. 1985;32(4):429-34.
20. Inal MT, Memis D, Sahin SH, et al. Comparison of different tests to determine difficult intubation in pediatric patients. *Rev Bras Anesthesiol*. 2014;64(6):391-4.
21. Heinrich S, Birkholz T, Ihmsen H, et al. Incidence and predictors of difficult laryngoscopy in 11,219 pediatric anesthesia procedures. *Paediatr Anaesth*. 2012;22(8):729-36.
22. Santos AP, Mathias LA, Gozzani JL, et al. Difficult intubation in children: applicability of the Mallampati index. *Rev Bras Anestesiol*. 2011;61(2):156-8.
23. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. *Anaesthesia*. 1987;42(5):487-490.
24. Kandray DP, Juruaz D, Yacavone M, et al. Inter-rater reliability of the Mallampati classification for patients in a dental hygiene clinic. *J Dent Hyg.* 2013;87(3)134-9.
25. Kara CO, Tumkaya R, Ardic N, et al. Does tonsillectomy reduce the risk of being a habitual or severe snorer? *Eur Arch Otorhinolaryngol*. 2008;265(10):1263-8.
26. Hirsch DG, Tyo J, Wrotniak BH. Desaturation in procedural sedation for children with long bone fractures: Does weight status matter? *Am J Emerg Med.* 2017;35(8):1060-3.
27. Vardhan H, Kumar M, Schroeder JW, et al. Mallampati score and pediatric obstructive sleep apnea. *J Clin Sleep Med*. 2014;10(9):985-90.
28. Koop VJ, Baily A, Vally RD, et al. Utility of Mallampati classification for predicting difficult intubation in pediatric patients. *Anesthesiology.* 1995;83:A1147.
29. Davidson MC, Amso D, Anderson LC. Development of cognitive control and executive functions from 4 to 13 years: evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*. 2006;44:2037-78.
30. Aggarwal A, Sharma KR, Verma UC. Evaluation of "Difficult Airway Predictors in Pediatric Population" as a clinical investigation. *J Anes Clin Res*. 2012;3(11):1-5.
31. Rafique NB, Khan FA. Comparison of Mallampatti test, thyromental distance and distance from tragus to nares for predicting difficult intubation in pediatric patients. *Open J Anesthesiol*. 2014;4:104-109.
32. Nelson TM, Huebner CE, Kim A, et al. A pilot study of parent, dentist and independent rater assessment of child distress during preventative dental visits. *J Dent Child (Chic).* 2016;83(2):71-7.
33. Cudny ME, Wang NE, Bardas SL, et al. Adverse events associated with procedural sedation in pediatric patients in the emergency department. *Hosp Pharm*. 2013;48(2):134–42.
34. Grunwell JR, Travers C, McCracken CE, et al. Procedural sedation outside of the operating room using ketamine in 22, 645 children: a report from the Pediatric Sedation Research Consortium. *Pediatr Crit Care Med*. 2016;17(12):1109-16.
35. Bhatt M, Johnson DW, Chan J, et al. Risk Factors for adverse events in emergency department procedural sedation for children. *JAMA Pediatr.* 2017;171(10):957-64.
36. Melendez E, Bachur R. Serious adverse events during procedural sedation with ketamine. *Pediatr Emerg Care*. 2009;25(5):325-8.
37. Langston WT, Wathen JE, Roback MG, et al. Effect of ondansetron on the incidence of vomiting associated with ketamine sedation in children: a double-blind randomized, placebo-controlled trial. *Ann Emerg Med*. 2008;52(1):30-4.
38. Beach ML, Cohen DC, Gallagher SM, et al. major adverse events and relationship to *nil per os* status in pediatric sedation/anesthesia outside the operating room: a report of the Pediatric Sedation Research Consortium. *Anesthesiology*. 2016;124(1):80-8.

Addition of Audiovisual Feedback During Standard Compressions Is Associated with Improved Ability

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Introduction: A benefit of in-hospital cardiac arrest is the opportunity for rapid initiation of "high-quality" chest compressions as defined by current American Heart Association (AHA) adult guidelines as a depth 2-2.4 inches, full chest recoil, rate 100 -120 per minute, and minimal interruptions with a chest compression fraction (CCF) ≥ 60%. The goal of this study was to assess the effect of audiovisual feedback on the ability to maintain high-quality chest compressions as per 2015 updated guidelines.

Methods: Ninety-eight participants were randomized into four groups. Participants were randomly assigned to perform chest compressions with or without use of audiovisual feedback (+/- AVF). Participants were further assigned to perform either standard compressions with a ventilation ratio of 30:2 to simulate cardiopulmonary resuscitation (CPR) without an advanced airway or continuous chest compressions to simulate CPR with an advanced airway. The primary outcome measured was ability to maintain high-quality chest compressions as defined by current 2015 AHA guidelines.

Results: Overall comparisons between continuous and standard chest compressions (n=98) were without significant differences in chest compression dynamics (p's >0.05). Overall comparisons between +/- AVF (n = 98) were significant for differences in average rate of compressions per minute (p= 0.0241) and proportion of chest compressions within guideline rate recommendations (p = 0.0084). There was a significant difference in the proportion of high quality-chest compressions favoring AVF (p = 0.0399). Comparisons between chest compression strategy groups +/- AVF were significant for differences in compression dynamics favoring AVF (p's < 0.05).

Conclusion: Overall, AVF is associated with greater ability to maintain high-quality chest compressions per most-recent AHA guidelines. Specifically, AVF was associated with a greater proportion of compressions within ideal rate with standard chest compressions while demonstrating a greater proportion of compressions with simultaneous ideal rate and depth with a continuous compression strategy. [West J Emerg Med. 2018;19(2)437-444.]

INTRODUCTION

Despite advances in the field of resuscitation science and modest improvement in outcomes, mortality from in-hospital cardiopulmonary arrest (CPA) remains relatively high.[1,2] However, a common denominator in recent reports of modest outcome improvements in CPA resuscitation has been the link to quality of cardiopulmonary resuscitation (CPR).[3,4] In particular, high-quality chest compressions have been described as the

foundation that all additional, "downstream" resuscitative efforts are built upon and highly associated with improved survival and favorable neurological outcomes.[3-5] Most recently, high-quality chest compressions have been defined by the updated 2015 American Heart Association (AHA) adult guidelines as a depth of 2-2.4 in, full chest recoil, a rate between 100-120 beats per minute, and a chest compression fraction (CCF) of at least 60%.[3]

Even when delivered according to guidelines, external manual chest compressions are inherently inefficient, providing only 30% to 40% of normal blood flow to the brain and less than one third of normal blood flow to the heart.[6-10] This inefficiency highlights the need for rescuers to deliver the highest-quality chest compressions in a timely and consistent manner. [11,12]

Although the relationship between high-quality chest compressions and improved survival has been well described, concern remains with the reports of trained rescuers performing suboptimal compression depth, rate, and hands-off fraction time (i.e., CFF).[13-17] Rescuer overestimation of depth and underestimation of rate, as well as increased performance fatigue in prolonged situations, may be primary forces in the relatively poor adherence to current guidelines.[18-21] Real-time, CPR performer feedback via defibrillator has been a relatively recent approach in maintaining chest compression performance and associated with continuous high-quality chest compression.[13,22-26] Currently, there are no studies investigating the ability to maintain high-quality chest compressions within the current 2015 AHA guidelines with and without the influence of real-time audiovisual feedback (AVF), which may assist in maintaining high-quality chest compression. The goal of this study was to assess the ability to maintain high-quality chest compressions by 2015 updated guidelines both with and without (+/-) AVF in a simulated arrest scenario.

Population Health Research Capsule

What do we already know about this issue?
Recent AHA guideline updates call for an upper limit on chest compression rate and depth. Audiovisual feedback (AVF) has been previously associated with improved compliance to previous guidelines.

What was the research question?
Does addition of AVF improve compliance to 2015 updated AHA guidelines?

What was the major finding of the study?
AVF is associated with the ability to maintain high-quality chest compressions as per most-recent AHA guidelines.

How does this improve population health?
Ability to maintain high-quality chest compressions over a greater proportion of time is an important link in the "chain of survival" for cardiac arrest victims.

METHODS

This was a randomized, prospective, observational study conducted within a community hospital with over 22,000 annual inpatient admissions. All participants were voluntary emergency department (ED) and medical-surgery nursing staff with both Basic and Advanced Cardiac Life Support (BLS/ACLS) certification. We obtained institutional review board approval, and written consent was required prior to participation. We defined CPR providers as a two-person team consisting of one participant performing chest compressions while the second administered ventilations via bag-valve mask (BVM). Chest compressions and ventilations were performed on a *Little Anne CPR Training Manikin* (Laerdal Medical, Stavanger, Norway). AVF on chest compression rate and depth was provided to participants through ZOLL See-Thru CPR® on R Series® defibrillators (Zoll Medical Corporation, Chelmsford, USA).

In a "mock code" scenario, 98 teams were randomly assigned to perform CPR +/- AVF chest compression feedback. Participants were further randomly assigned to perform either standard chest compressions (SC) with a compression-to-ventilation ratio of 30:2 to simulate CPR without an advanced airway or continuous chest compressions (CCC) to simulate CPR with an advanced airway for a total of four distinct groups.[3] Chest compressions were performed for two minutes, representing a standard cycle interposed between rhythm/pulse checks and/or compressor switch. Defibrillator data for analysis included chest compression rate, depth, and compression fraction over the entire two minutes. The primary outcome measured was ability to maintain high-quality chest compressions as defined by current 2015 AHA guidelines.[3] Secondary outcomes included group differences in chest compression depth, rate, and fraction time. Based on recent findings per Wutzler et al. on the ability to maintain effective chest compressions we estimated a sample size of at least 68 teams to maintain a two-sided alpha of 0.05, and a power of 80%.[27] Data are presented as means and standard deviations. We compared CPR variables (depth, rate, compression fraction and ventilations) between respective groups by Mann-Whitney U test or continuous variables and by chi-squared test for categorical variables. Only participants with technically adequate data available were used in this comparison. We considered p values < 0.05 statistically significant. No participants were excluded.

RESULTS

Overall comparisons between continuous and SC compressions (n=98) were without significant differences in chest compression dynamics (p's >0.05) (Table 1). Overall comparisons between no AVF and AVF (n = 98) were significant for differences in average rate of compressions per minute (p= 0.0241) as well as proportion of chest compressions within guideline rate recommendations, 37.9% vs. 65%, respectively (p = 0.0084) (Table 2). Finally, there was a significant difference in the proportion of chest compressions simultaneously within current rate and depth guideline recommendations (p = 0.0401). This significant difference in average time of ideal chest compressions favored the AVF cohort (p = 0.0399) (Table 2). All groups were able to maintain CCF ≥80%.

We made comparisons between chest compression strategy groups with the use of AVF (n = 40). With the assistance of AVF, there was a significant difference between the standard and continuous compression groups in average depth, 2.8 (0.38) inches vs. 2.3 (0.62) inches, respectively (p =0.0045). There was a significant difference in the proportion of chest compressions within current guideline- recommended depth (p= 0.0384) (Table 1). Comparisons between chest compression strategy groups without AVF (n =58) were significant for a difference in CCF, though both were at or above current recommendations. Otherwise, comparisons did not yield any significant chest compression dynamic differences between groups (p's > 0.05) (Table 1).

Within the CCC-only cohort (n=50) there were no significant isolated average compression rate or depth differences between +/- AVF (p's > 0.05). However, a statistically significant difference was noted between +/- AVF groups and the proportion of compressions within ideal depth, 45% vs. 16.7%, respectively(p = 0.0288) (Table 2). Additionally, within this cohort there was a significant difference between feedback groups and the proportion of individuals with an average rate and depth within current guidelines (p = 0.0209). Subsequent analysis revealed that AVF participants demonstrated a greater proportion of time in high-quality chest compressions as previously defined (p = 0.0259) (Table 2). Finally, we compared the SC compression cohort +/- AVF (n =48). Comparisons were significant for differences in average compression rate between the AVF and no AVF groups, 110 (11.24) per minute vs. 117.8 (12.21) per minute respectively (p = 0.0208) Notably, both are within current guidelines. Additionally, there was a significant difference between groups and the proportion of chest compressions with an average rate within current guidelines (p= 0.0034). (Table 2)

DISCUSSION

Previous iterations of the AHA's CPR and Emergency Cardiovascular Care guidelines have recommended chest compression rate ≥ 100 compression/min; however, the 2015 updates have called for a chest compression-rate upper limit of 120/min.[28] The recommendation appears to be based on both animal studies as well as recent clinical observations from large out-of-hospital cardiac arrest registries describing an association between chest compression rates, return of spontaneous circulation (ROSC), and survival to hospital discharge.[29-31] This makes sense as observations in animal studies have described anterograde coronary blood flow as positively correlated with diastolic aortic pressures and subsequently compression rate.

However, at rates greater than 120 compressions/min, this relationship weakens as diastolic coronary perfusion time decreases.[29] Regarding human data, recent observations from the Resuscitation Outcomes Consortium registry suggest an optimum target of between 100 and 120 compressions per minute.[29-31] In this randomized, controlled study we report that overall, AVF is associated with a greater ability to provide simultaneously guideline-recommended rate and depth. This is important as previous studies have focused on the proportion of correct chest compression rate and depth; however, it has been shown that despite adequate individual mean values, the actual proportion of chest compressions that fell within guideline criteria simultaneously for rate and depth was low.[3,32] Overall comparisons between SC and CCC cohorts were without significant differences in compression dynamics.

AVF appeared to have an effect regardless of chest compression strategy, with isolated analysis of both compression strategy groups notable for differences. Within the SC group, significant differences were noted in both average rate and proportion of compressions within current guideline recommendations. Analysis of the CCC cohort was notable for the association with AVF, a greater proportion of compression depth within current guidelines and proportion of time with ideal compressions. One potential explanation for the association between AVF and ability to perform "high-quality" chest compressions on a more consistent basis is the ability to possibly avoid early fatigue by "pacing" an individual through the early periods of a highly stressful cardiac arrest situation where one could understandably want to push as fast and hard as possible, which in turn may lead to early fatigue and subsequently "poor quality."[20,33,34] Finally, similar to overall analysis, comparisons between compression strategies without AVF did not result in any significant compression differences.

The isolated effect of AVF on compression dynamic overall appears to be related to compression strategy. Within the CCC cohort, the effect appears to be on ability to maintain ideal depth, while in the SC cohort, the effect appears to be related to rate control. We do note that within this cohort, although a statistically significant difference is noted in average rate of compressions, both are within current guidelines. However, it should be noted that the non-AVF cohort demonstrated an average rate at the most upper level of current recommendations, and more importantly was associated with a lower rate of proportion of compressions

Table 1. Cardiopulmonary resuscitation variables of ventilation, chest compression rate, depth, chest compression fraction,and ability to maintain rate and depth as per most current American Heart Association recommendations. Shown as overall, audiovisual feedback, and no audiovisual feedback. Groups compared by chest compression strategy.

	Overall				Audiovisual feedback				No audiovisual feedback			
	Continuous chest compression	Standard chest compression	Total	P value	Continuous chest compression	Standard chest compression	Total	P value	Continuous chest compression	Standard chest compression	Total	P value
	(n =50)	(n =48)	(n =98)		(n =20)	(n =20)	(n =40)		(n =30)	(n =28)	(n =58)	
Age (years) (SD)	38.8 (10.64)	36.4 (9.77)	37.7 (10.25)	0.2881	37.4 (11.26)	34.4 (9.84)	35.9 (10.55)	0.481			39 (9.92)	0.486
Gender (male) (%)	52	25	38.8	0.0061*	65	15%	40	0.0012*	43.3	32.1	37.9	0.380
ED RN Staff (%)	90	91.3	90.6	0.3316	90	83.3	86.8	0.3941	90	96.4	93.1	0.334
Average depth (in) (SD)	2.5 (0.69)	2.7 (0.50)	2.6 (0.61)	0.051	2.3 (0.62)	2.8 (0.38)	2.5 (0.55)	0.0045*	2.6 (0.72)	2.7 (0.58)	2.7 (0.65)	0.773
Average rate (per minute) (SD)	119.7 (15.77)	114.5 (12.32)	117.2 (14.35)	0.1130	119 (18.8)	110 (11.24)	114.5 (15.96)	0.1105	120.2 (13.71)	117.8 (12.21)	119 (12.9)	0.596
Compression depth within 2015 guidelines (%)	28	16.7	22.4	0.1789	45	15	30	0.0384*	16.7	17.9	17.2	0.904
Compression rate within 2015 guidelines (%)	48	50	49	0.8431	55	75	65	0.1848	43.3	32.1	37.9	0.380
Chest compression rate and depth simultaneously within 2015 guidelines (%)	12	4.2	8.2	0.1568	25	5	15	0.0765	3.3	3.6	3.4	0.968
Chest compression fraction (%) (SD)	90 (19)	80 (15)	90 (19)	<0.0001*	90 (25)	80 (5)	90 (19)	<0.0001*	100 (12)	80 (20)	90 (19)	<0.0001*
Ventilations (per minute)	9.3 (2.78)	6.2 (1.77)	7.8 (2.8)	<0.0001*	9.5 (2.77)	6.2 (1.77)	7.9 (2.83)	0.0003*	9.2 (2.85)	6.3 (1.81)	7.8 (2.8)	0.007*

ED, emergency medicine; *SD*, standard deviation; *RN*, registered nurse.
*Denotes statistical significance.

Table 2. Cardiopulmonary resuscitation variables of ventilation, chest compression rate, depth, chest compression fraction, and ability to maintain rate and depth as per most current American Heart Association recommendations. Shown as overall, continuous chest compressions, and standard chest compressions. Groups compared by use of audiovisual feedback.

	Overall				Continuous chest compression				Standard chest compression			
	Audiovisual				Audiovisual				Audiovisual			
	Yes (n = 40)	No (n = 58)	Total (n = 98)	P value	Yes (n =20)	No (n =30)	Total (n =50)	P value	Yes (n =20)	No (n =28)	Total (n =48)	P value
Age (years) (SD)	35.9 (10.55)	39 (9.92)	37.7 (10.25)	0.0929	37.4 (11.26)	39.8 (10.28)	38.8 (10.64)	0.361	34.4 (9.84)	38 (9.61)	36.4 (9.77)	0.2154
Gender (Male) (%)	40	37.9	38.8	0.8363	65	43.3	52	0.133	15	32	25	0.1763
ED RN staff (%)	86.8	93.1	90.6	0.2202	90	90	90	0.391	83.3	96.4	91.3	0.2384
Average depth (in) (SD)	2.5 (0.55)	2.7 (0.65)	2.6 (0.61)	0.2687	2.3 (0.62)	2.6 (0.72)	2.5 (0.69)	0.867	2.8 (0.38)	2.7 (0.58)	2.7 (0.50)	0.7143
Average rate (per minute) (SD)	114.5 (15.96)	119 (12.95)	117.2 (14.35)	0.0241*	119 (18.8)	120.2 (13.71)	119.7 (15.77)	0.389	110 (11.24)	117.8 (12.21)	114.5 (12.32)	0.0208*
Compression depth within 2015 guidelines (%)	30	17.2	22.4	0.1368	45	16.7	28	0.028*	15	17.9	16.7	0.7934
Compression rate within 2015 guidelines (%)	65	37.9	49	0.0084*	55	43	48	0.418	75	32.1	50	0.0034*
Chest compression rate and depth Simultaneously within 2015 guidelines (%)	15	3.4	8.2	0.0401*	25	3.3	12	0.020*	5%	3.6	4.2	0.8071
Chest compression fraction (%) (SD)	90 (19)	90 (19)	90 (19)	0.9211	90 (25)	100 (12)	90 (19)	0.973	80 (5)	80 (20)	80 (15)	0.5865
Ventilations (per minute) (SD)	7.8 (2.83)	7.8 (2.8)	7.8(2.8)	0.9928	9.5 (2.77)	9.2 (2.85)	9.3 (2.78)	0.951	6.2 (1.77)	6.3 (1.81)	6.2 (1.77)	0.9787

ED, emergency medicine; *SD*, standard deviation; *RN*, registered nurse.
*Denotes statistical significance.

with rate within guideline recommendations over the testing period. This is important as recent studies have reported an inverse association between compression rates and depth, with rates above 120/min having the greatest impact on reducing compression depth.[35-38]

Recent reports have called this upper rate limit into question and suggest that faster rate limits (120-130/min) may be actually associated with a higher likelihood of ROSC in in-hospital cardiac arrest.[39] Unfortunately, in that study compression depth was not reported, leaving optimal rates in in-hospital arrest up to continued debate.[39] Interestingly, within the AVF cohort, chest compression depth appeared to be both deeper on the average and out of guideline-recommended depth for the SC cohort. Yet again, these differences did not translate to overall differences in the proportion of time within recommended depth between compression groups. Chest compression strategy and relationship with AVF may be related to the nature of the strategy. That is, with continuous compressions fatigue may become an issue and feedback on depth may be of greater importance over time while bursts of activity after brief pauses with standard compressions may require greater mindfulness in rate of compressions. Further study into the individual effects of AVF on compression strategy is warranted.

Finally, we note that although the presence of AVF appears to have improved the quality of chest compressions, proportions of high-quality compressions were surprisingly low between all groups with a high of 25% and nadir of 3.3% (Table(s) 1, 2). However, our findings are consistent with reported "effective compressions," i.e., trial period with mean compression rate and depth within guidelines and CCF ≥80% per Wutzler et al. In their simulation-based study, there was an "effective compression" rate of 25.4% with feedback vs. 12.7% without.[40] These findings warrant further investigation into possible influencing factors and sources of variation including fatigue, critical care experience, and time since last training update.

LIMITATIONS

Although we report a significant effect from the addition of AVF, it is difficult to assess how this translates into clinical application, as real-time feedback devices have shown the ability to aid in the delivery of longer effective, steadier chest compressions over time, the outcomes on neurologically intact survival to hospital discharge remain to be seen.[41] Similarly, we did not account for the potential variability that time from last CPR skills update or years since training may have contributed to our findings. Similarly, there is an inherent limitation with the use of manikins in CPR studies. Manikins have markedly greater stiffness at the onset of compression, and maintain a linear stiffness throughout the usual range of displacement, rather than becoming stiffer with greater chest displacement that is a more human characteristic.[42,43]

CONCLUSION

Overall, audiovisual feedback is associated with greater ability to maintain high-quality chest compressions as defined by most recent AHA guidelines. Specifically, audiovisual feedback was associated with a greater proportion of compressions within ideal rate with standard chest compressions while demonstrating a greater proportion of compressions with simultaneous ideal rate and depth with a continuous compression strategy.

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Conflicts of Interest: By the *West*JEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

REFERENCES

1. Girotra S, Nallamothu BK, Spertus JA, et al. Trends in survival after in-hospital cardiac arrest. *N Engl J Med*. 2012;367(20):1912-20.
2. Morrison LJ, Neumar RW, Zimmerman JL, et al. Strategies for improving survival after in-hospital cardiac arrest in the United States: 2013 consensus recommendations: a consensus statement from the American Heart Association. *Circulation*. 2013;127(14):1538-63.
3. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: Adult Basic Life Support and Cardiopulmonary Resuscitation Quality: 2015 American Heart Association Guidelines Update for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2015;132(18 suppl 2):S414-35.
4. Talikowska M, Tohira H, Finn J. Cardiopulmonary resuscitation quality and patient survival outcome in cardiac arrest: A systematic review and meta-analysis. *Resuscitation*. 2015;96 66-77.
5. Meaney PA, Bobrow BJ, Mancini ME, et al. Cardiopulmonary resuscitation quality: [corrected] improving cardiac resuscitation outcomes both inside and outside the hospital: a consensus statement from the American Heart Association. *Circulation*. 2013;128(4):417-35.
6. Ralston SH, Voorhees WD, Babbs CF. Intrapulmonary epinephrine during prolonged cardiopulmonary resuscitation: improved regional blood flow and resuscitation in dogs. *Ann Emerg Med*.

1984;13(2):79-86.
7. Michael JR, Guerci AD, Koehler RC, et al. Mechanisms by which epinephrine augments cerebral and myocardial perfusion during cardiopulmonary resuscitation in dogs. *Circulation*. 1984;69(4):822-35.
8. Halperin HR, Tsitlik JE, Guerci AD, et al. Determinants of blood flow to vital organs during cardiopulmonary resuscitation in dogs. *Circulation*. 1986;73(3):539-550.
9. Rubertsson S, Karlsten R. Increased cortical cerebral blood flow with LUCAS; a new device for mechanical chest compressions compared to standard external compressions during experimental cardiopulmonary resuscitation. *Resuscitation*. 2005;65(3):357-63.
10. Georgiou M, Papathanassoglou E, Xanthos T. Systematic review of the mechanisms driving effective blood flow during adult CPR. *Resuscitation*. 2014;85(11):1586-93.
11. Chalkias A, Xanthos T. Pathophysiology and pathogenesis of post-resuscitation myocardial stunning. *Heart Fail Rev*. 2012;17(1):117-28.
12. Chalkias A, Xanthos T. Post-cardiac arrest brain injury: pathophysiology and treatment. *J Neurol Sci*. 2012;315(1-2):1-8.
13. Yeung J, Meeks R, Edelson D, et al. The use of CPR feedback/ prompt devices during training and CPR performance: A systematic review. *Resuscitation*. 2009;80(7):743-51.
14. Wik L, Kramer-Johansen J, Myklebust H, et al. Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest. *JAMA*. 2005;293(3):299-304.
15. Aufderheide TP, Sigurdsson G, Pirrallo RG, et al. Hyperventilation-induced hypotension during cardiopulmonary resuscitation. *Circulation*. 2004;109(16):1960-5.
16. Milander MM, Hiscok PS, Sanders AB, et al. Chest compression and ventilation rates during cardiopulmonary resuscitation: the effects of audible tone guidance. *Acad Emerg Med*. 1995;2(8):708-13.
17. Valenzuela TD, Kern KB, Clark LL, et al. Interruptions of chest compressions during emergency medical systems resuscitation. *Circulation*. 2005;112(9):1259-65.
18. Pozner CN, Almozlino A, Elmer J, et al. Cardiopulmonary resuscitation feedback improves the quality of chest compression provided by hospital health care professionals. *Am J Emerg Med*. 2011;29(6):618-25.
19. Heidenreich JW, Berg RA, Higdon TA, et al. Rescuer fatigue: standard versus continuous chest-compression cardiopulmonary resuscitation. *Acad Emerg Med*. 2006;13(10):1020-6.
20. Sugerman NT, Edelson DP, Leary M, et al. Rescuer fatigue during actual in-hospital cardiopulmonary resuscitation with audiovisual feedback: A prospective multicenter study. *Resuscitation*. 2009;80(9):981-4.
21. Yang Z, Li H, Yu T, et al. Quality of chest compressions during compression-only cardiopulmonary resuscitation: a comparative analysis following the 2005 and 2010 American Heart Association guidelines. *Am J Emerg Med*. 2014;32(1):50-4.
22. Abella BS, Edelson DP, Kim S, et al. CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system. *Resuscitation*. 2007;73(1):54-61.
23. Noordergraaf GJ, Drinkwaard BW, van Berkom PF, et al. The quality of chest compressions by trained personnel: The effect of feedback, via the CPREzy, in a randomized controlled trial using a manikin model. *Resuscitation.* 2006;69(2):241-52.
24. Skorning M, Beckers SK, Brokmann JC, et al. New visual feedback device improves performance of chest compressions by professionals in simulated cardiac arrest. *Resuscitation.* 2010;81(1):53-8.
25. Abella BS, Edelson DP, Kim S, et al. CPR quality improvement during in-hospital cardiac arrest using a real-time audiovisual feedback system. *Resuscitation*. 2014;73 (1):54-61.
26. Niebauer JM, White ML, Zinkan JL, et al. Hyperventilation in pediatric resuscitation: performance in simulated pediatric medical emergencies. *Pediatrics*. 2011;128(5):e1195-200.
27. Wutzler A, Bannehr M, von Ulmenstein S, et al. Performance of chest compressions with the use of a new audio-visual feedback device: a randomized manikin study in health care professionals. *Resuscitation*. 2015;87:81-85.
28. Berg RA, Hemphill R, Abella BS, et al. Part 5: adult basic life support: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2010;122(18 Suppl 3):S685-705.
29. Wolfe JA, Maier GW, Newton JR Jr, et al. Physiologic determinants of coronary blood flow during external cardiac massage. *J Thorac Cardiovasc Surg*. 1988;95(3):523-32.
30. Idris AH, Guffey D, Aufderheide TP, et al. Relationship between chest compression rates and outcomes from cardiac arrest. *Circulation*. 2012;125 (24):3004-12.
31. Idris AH, Guffey D, Pepe PE, et al. Chest compression rates and survival following out-of-hospital cardiac arrest. *Crit Care Med*. 2015;43(4):840-8.
33. Nolan JP, Hazinski MF, Aickin R, et al. Part 1: Executive summary: 2015 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiovascular Care Science with Treatment Recommendations. *Resuscitation*. 2015;95.e1-31.
34. Ashton A, McCluskey A, Gwinnutt CL, et al. Effect of rescuer fatigue on performance of continuous external chest compressions over 3 min. *Resuscitation*. 2014;55(2):151-5.
35. Ochoa FJ, Ramalle-Gomara E, Lisa V, et al. The effect of rescuer fatigue on the quality of chest compressions. *Resuscitation*. 2014;37(3):149-52.
36. Monsieurs KG, De Regge M, Vansteelandt K, et al. Excessive chest compression rate is associated with insufficient compression depth in prehospital cardiac arrest. *Resuscitation*. 2012;83(11):1319-23.
37. Field RA, Soar J, Davies RP, et al. The impact of chest compression rates on quality of chest compressions–a manikin study. *Resuscitation.* 2012;83(3): 360-4.
38. Stiell IG, Brown SP, Christenson J, et al. What is the role of chest compression depth during out-of-hospital cardiac arrest

resuscitation? *Crit Care Med*. 2012;40(4):1192-8.

39. Sutton RM, Wolfe H, Nishisaki A, et al. Pushing harder, pushing faster, minimizing interruptions…But falling short of 2010 cardiopulmonary resuscitation targets during in-hospital pedi atric and adolescent resuscitation. *Resuscitation.* 2013;84(12):1680-4.
40. Kilgannon JH, Kirchhoff M, Pierce L, et al. Association between chest compression rates and clinical outcomes following in-hospital cardiac arrest at an academic tertiary hospital. *Resuscitation*. 2017;110:154-61.
41. Wutzler A, Bannehr M, von Ulmenstein S, et al. Performance of chest compressions with the use of a new audio-visual feedback device: a randomized manikin study in health care professionals. *Resuscitation*. 2015;87:81-5.
42. Buleon C, Delaunay J, Parienti JJ, et al. Impact of a feedback device on chest compression quality during extended manikin cardiopulmonary resuscitation: a randomized crossover study. *Am J Emerg Med*. 2016;34(9):1754-60.
43. Baubin MA, Gilly H, Posch A, et al. Compression characteristics of CPR manikins. *Resuscitation*. 1995;3 (2):117-26.
44. Tsitlik JE, Weisfeldt ML, Chandra N, et al. Elastic properties of the human chest during cardiopulmonary resuscitation. *Crit Care Med*. 1983;11(9):685-92.

This Article Corrects: "GLASS Clinical Decision Rule Applied to Thoracolumbar Spinal Fractures in Patients Involved in Motor Vehicle Crashes"

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GLASS Clinical Decision Rule Applied to Thoracolumbar Spinal Fractures in Patients Involved in Motor Vehicle Crashes.
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Erratum in
West J Emerg Med. 2018 March;19(2):445. Last two author affiliations symbols incorrect [Dipan Bose, PhD‡; Joshua Werner, DO*]

Abastract

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

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

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

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

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9th Mediterranean Emergency Medicine Congress-Global Research on Acute Conditions Team (*MEMC-GREAT*) Top Meeting Abstracts

1 Paediatric Traumatic Cardiac Arrest in England and Wales: A 10-Year Epidemiological Study

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Objective: Traumatic cardiac arrest in children has traditionally been described as having a poor outcome. Survival rates vary widely between studies with higher rates observed from mechanisms leading to a respiratory cause of traumatic cardiac arrest (e.g., drowning and hanging). However, there is little evidence regarding outcomes following traumatic cardiac arrest in children. The primary aim of our study was to describe 30-day survival following traumatic cardiac arrest. Secondary aims were to provide an analysis of injury patterns, describe the functional outcome at discharge and to report the association between survival and interventions performed.

Design and Method: We conducted a population-based analysis for all children (<18 years) on the Trauma Audit Research Network database from 2006-2015. Patients with traumatic cardiac arrest in the pre-hospital setting and/or in the emergency department (ED) were included. Data are described as number (%) and median (interquartile range) as appropriate. We used survival odds ratios (95% confidence intervals [CI]) and chi-square tests during statistical analysis.

Results: During the study period, 21,710 paediatric patients were included in the database with 129 (0.6%) sustaining traumatic cardiac arrest and meeting study inclusion criteria. The majority had a prehospital traumatic cardiac arrest (103 [79.8%]). Overall, 62.8% were male, aged 11.7 years (3.4-16.6), and with Injury Severity Score 34 (25-45); 110 (85.3%) had blunt injuries, with road-traffic collision the most common mechanism (56.6%). Of these 129 patients, 123 (95.3%) had severe haemorrhage and/or traumatic brain injury.

Overall 30-day survival was 5.4% (95% [CI 2.6-10.8]). "Prehospital only" traumatic cardiac arrest (13.0%) had a significantly higher survival than "prehospital and ED" traumatic cardiac arrest (1.8%), (p=0.0430). There were no survivors from "ED only" traumatic cardiac arrest. Treatment at a major trauma centre was associated with a statistically significant increase in survival (p=0.0186).

Conclusion: This study has demonstrated that resuscitation of children in the rare event of traumatic cardiac arrest is not futile, with overall outcomes comparable to survival rates seen in adults. Survival from prehospital traumatic cardiac arrest is possible, and the early identification and aggressive management of these patients is advocated.

2 Triage Accuracy and Variability Using the Emergency Severity Index: A Multinational Study

Mistry B[1], Stewart de Ramirez S[1], Balhara K[1], Levin S[1], Kelen G[1], Schmitz P[3], Anton X[4], Martinez D[1], Psoter K[2], Radu D[3], Yassin Othman I[4], Abdel Latif E'nouz M[4], Hinson JS[1]/ Johns Hopkins University School of Medicine, [1] Department of Emergency Medicine, [2] Department of Pediatrics, Baltimore, Maryland; [3] Hospital Moinhos de Vento, Department of Emergency Medicine, Porto Alegre, Brazil; [4]Al Rahba Hospital, Department of Emergency Medicine, Abu Dhabi, United Arab Emirates

Objective: The Emergency Severity Index (ESI) is a five-level emergency department (ED) triage scale that relies heavily on operator experience and intuition. Reports from countries where emergency medicine is a relatively young specialty suggest sub-optimal performance of the scale and high variability of triage score designation by end users. In this internationally collaborative study we used standardized triage scenarios to assess the degree of accuracy and variability in ESI score assignment in three different countries.

Design and Method: We used 25 patient scenarios from the ESI handbook to evaluate accuracy and inter-rater reliability of triage score assignment in a cohort of triage nurses from EDs in the United States, United Arab Emirates and Brazil. All participants had undergone formalized training and demonstrated proficiency in use of the scale. We defined accuracy as concordance with the handbook key, and we made comparisons across sites using ANOVA. Inter-rater reliability was calculated by Krippendorff's alpha and was assessed within and across sites. Sub-analyses included impact of scenario type and years of nursing experience.

Results: A total of 87 nurses participated (35 in the UAE, 30 in Brazil, 25 in the U.S.). Overall, only 59.2% of scenarios (1,288/2,175 scenarios) were scored correctly. There was no difference in pooled score-assignment accuracy between sites (U.S. 61.3%, UAE 58.7%, Brazil 58.3%, p = 0.70). Performance was lowest for pediatric cases, and nursing experience had no impact on accuracy. Inter-rater reliability was moderate and consistent across sites (Krippendorff's alpha = 0.73).

Conclusion: In this multinational study, we observed uniformly low accuracy of triage score assignment across all settings and a high degree of variability in score assignment both within and across sites that was not influenced by nursing experience or practice setting. While the ESI is made efficient and popular by its simplistic algorithm and reliance on clinical judgment, these same attributes may allow for a large degree of practice variation.

3 Comparison of the NEXUS II and Canadian Head CT Decision Instruments

Mower WR, Gupta M, Rodriguez R, Hendey GW/ UCLA Geffen School of Medicine, Department of Emergency Medicine, Los Angeles, California

Objective: We sought to compare the applicability of the NEXUS and Canadian Head Computed Tomography (CT) decision instruments, and assess their ability to identify blunt trauma patients with traumatic brain injuries, as well as their potential to reduce CT head imaging.

Design and Methods: We conducted a prospective observational study of consecutive blunt head injury patients selected for CT head imaging. Prior to imaging, clinicians recorded enrollment criteria and risk classification for the NEXUS Head CT rule, as well as for both the high-risk (needing neurosurgical intervention) and medium-risk (CT evidence of significant intracranial injury) versions of the Canadian Head CT rule.

Results: All 11,770 enrolled patients met the NEXUS enrollment criteria, while 7,759 patients (65.9%) met the inclusion and exclusion criteria of the Canadian Head CT Rule, including 111 patients (1.43%) who required neurosurgical intervention, and 306 (3.94%) who had significant intracranial injuries. The Canadian high-risk criteria for neurosurgical intervention identified 108 of 111 patients requiring neurosurgical intervention to yield a sensitivity of 97.3% (95% confidence interval [CI] [92.3% - 99.4%]), while the NEXUS rule, when applied to this same cohort, identified all 111 patients requiring neurosurgical intervention, yielding a sensitivity of 100% (95% CI [96.7% - 100.0%]). We also found that the Canadian medium-risk factors identified 301 of 306 patients with significant injuries (sensitivity = 98.4%; 95% CI [96.2% - 99.5%]), while the NEXUS rule identified 299 of these patients (sensitivity = 97.7%; 95% CI [95.3% - 99.1%]). In our study the Canadian medium-risk rule exhibited a specificity of 12.3% (95% CI [11.6% - 13.1%]), while the NEXUS rule exhibited a specificity of 33.3% (95% CI [32.3% - 34.4%]).

Conclusion: The NEXUS and Canadian Head CT decision instruments both exhibited high sensitivity in identifying patients with traumatic brain injuries, but less then two-thirds of patients could be evaluated by the Canadian rule. The NEXUS rule exhibited higher specificity in identifying patients with significant injuries and provided a nearly three-fold reduction in imaging in comparison to the Canadian rule.

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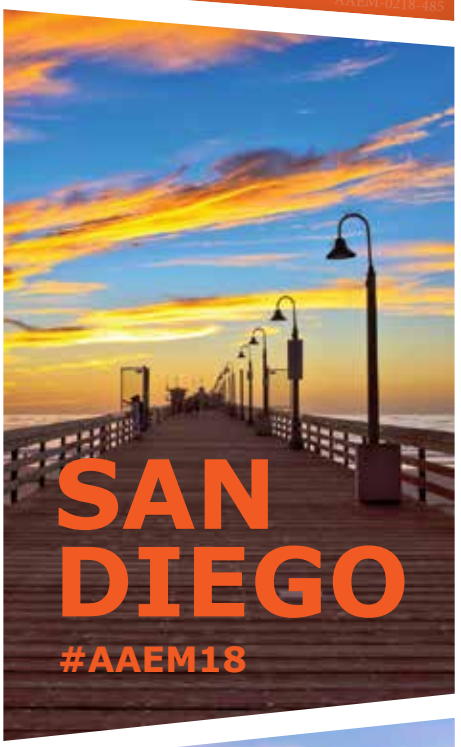


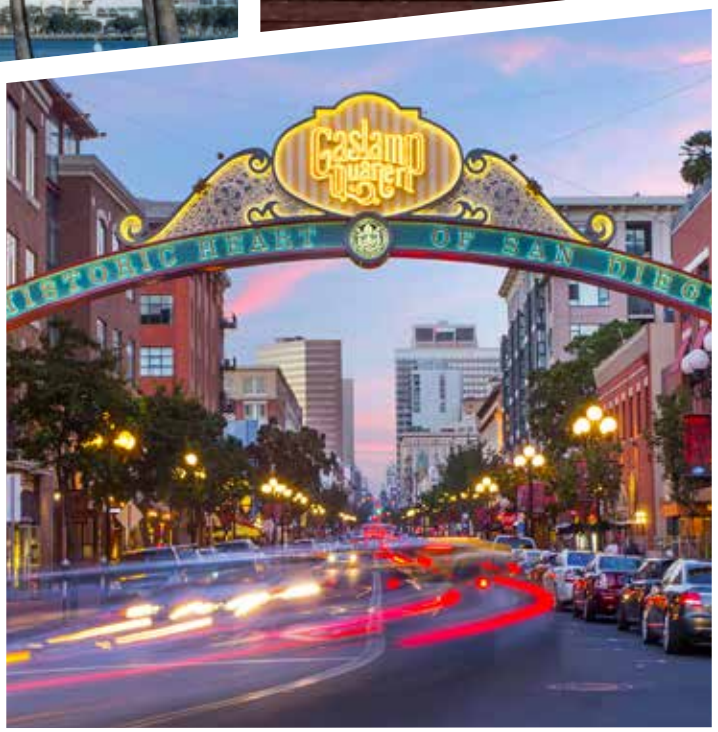
Monday, April 9, 2018

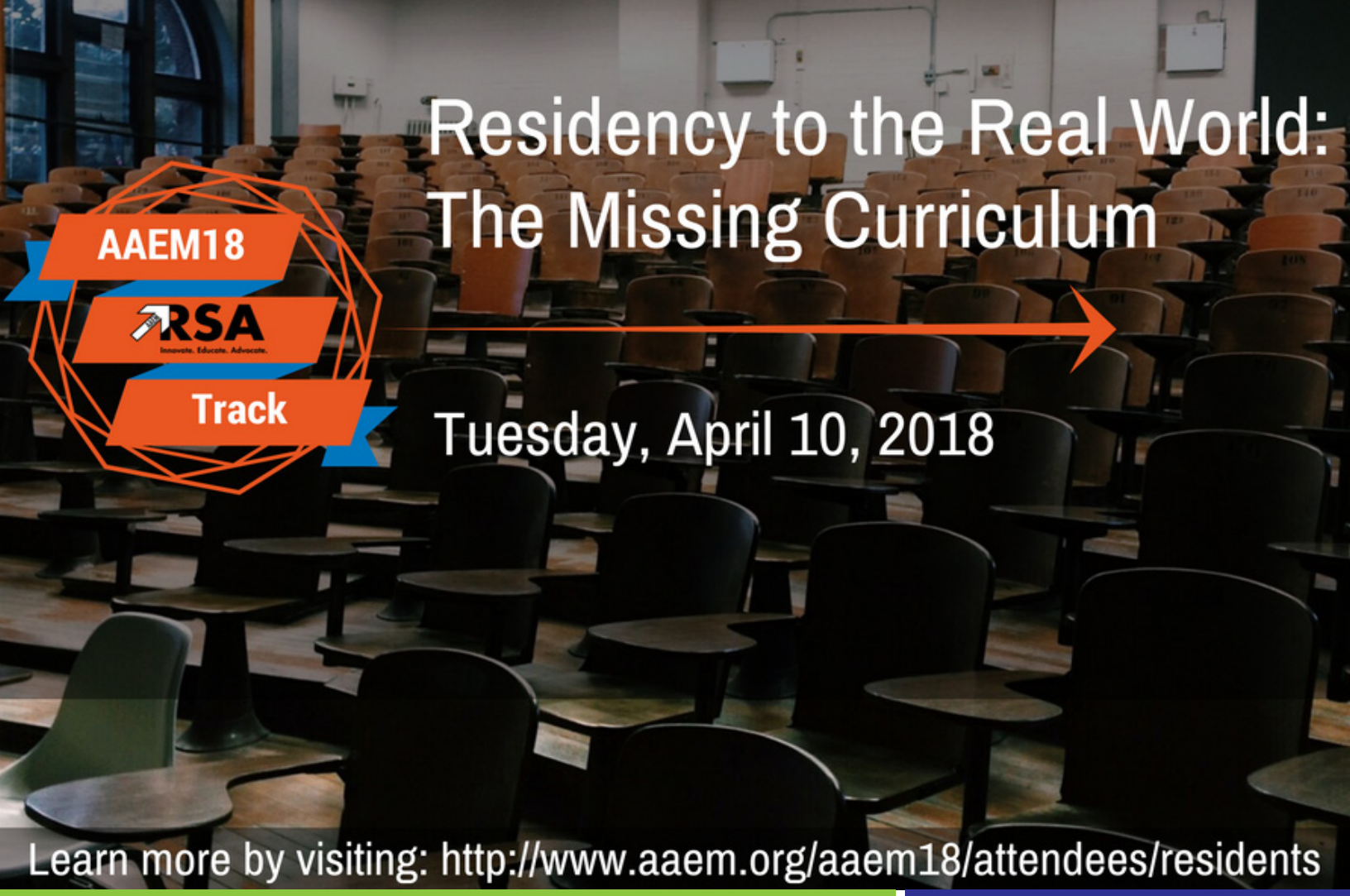
MARRIOTT MARQUIS SAN DIEGO MARINA

Rancho Santa Fe 3

3:45 pm - 5:35 pm PST

WWW.AAEM.ORG/AAEM18





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