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

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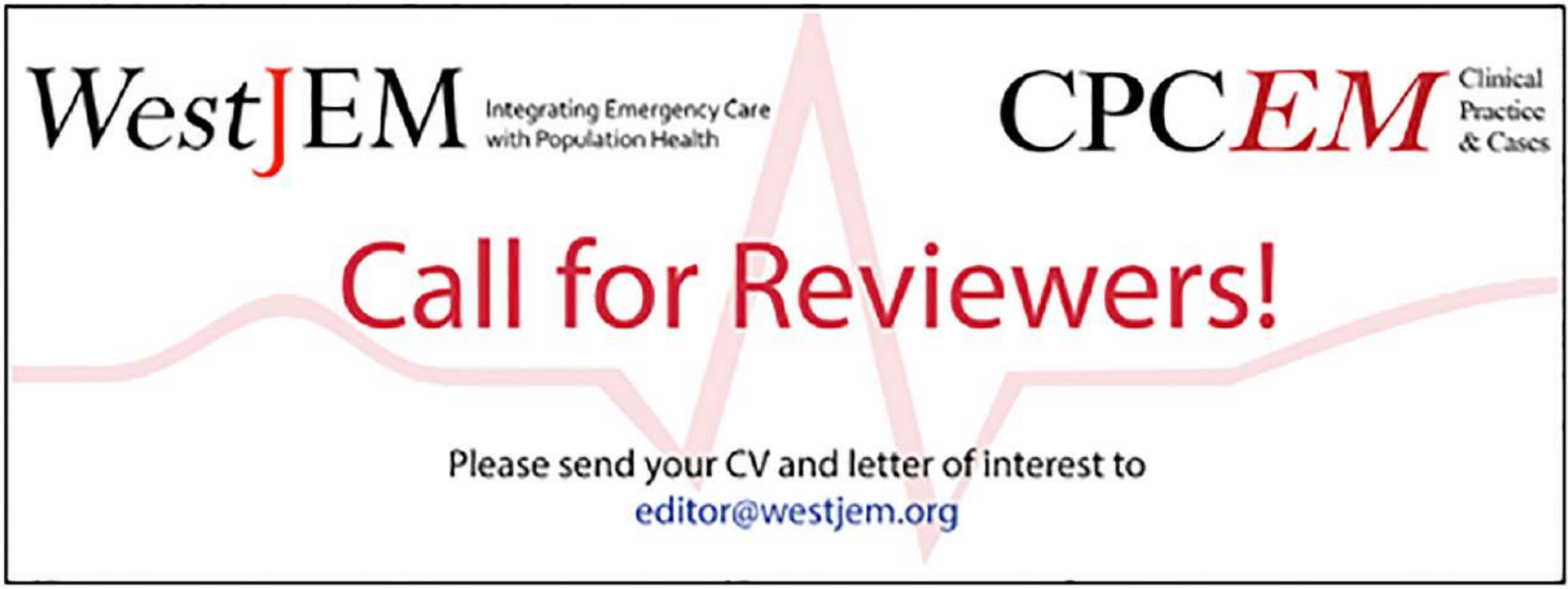

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2. Dewan MC et al. J Neurosurg. 2004;43(suppl):113-125.

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Utilization of Point-of-care Echocardiography in Cardiac Arrest: A Cross-sectional Pilot Study

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Introduction: Point-of-care (POC) echocardiography (echo) is a useful adjunct in the management of cardiac arrest. However, the practice pattern of POC echo utilization during management of cardiac arrest cases among emergency physicians (EP) is unclear. In this pilot study we aimed to characterize the utilization of POC echo and the potential barriers to its use in the management of cardiac arrest among EPs.

Methods: This was a cross-sectional survey of attending EPs who completed an electronic questionnaire composed of demographic variables (age, gender, year of residency graduation, practice setting, and ultrasound training) and POC echo utilization questions. The first question queried participants regarding frequency of POC echo use during the management of cardiac arrest. Branching logic then presented participants with a series of subsequent questions regarding utilization and barriers to use based on their responses.

Results: A total of 155 EPs participated in the survey, with a median age of 39 years (interquartile range 31-67). Regarding POC echo utilization, participants responded that they always (66%), sometimes (30%), or never (4.5%) use POC echo during cardiac arrest cases. Among participants who never use POC echo, 86% reported a lack of training, competency, or credentialing as a barrier to use. Among participants who either never or sometimes use POC echo, the leading barrier to use (58%) reported was a need for improved competency. Utilization was not different among participants of different age groups (P = 0.229) or different residency graduation dates (P = 0.229). POC echo utilization was higher among participants who received ultrasound training during residency (P = 0.006) or had completed ultrasound fellowship training (P <0.001) but did not differ by gender (P = 0.232), or practice setting (0.231).

Conclusion: Only a small minority of EPs never use point-of-care echocardiography during the management of cardiac arrest. Lack of training, competency, or credentialing is reported as the leading barrier to use among those who do not use POC echo during cardiac arrest cases. Participants who do not always use ultrasound are less likely to have received ultrasound training during residency. [West J Emerg Med. 2021;22(4):803–809.]

INTRODUCTION

Point-of-care echocardiography (POC echo) is established as a useful adjunct in the management of cardiac arrest patients in the emergency department (ED) setting, yet there are currently no large studies describing the optimal utilization of the technology in these cases. There are a number of reports

describing a potential prognostic role for POC echo, and it has long been promoted as a method to identify the potential etiology of cardiac arrest as well.[1-6] Recent literature has discovered that POC echo is frequently useful in verifying the presence of cardiac activity in cases of pulseless electrical activity and asystole where the management may be substantially altered from traditional Advanced Cardiac Life Support guidelines.[4,5,7,8] Additionally, POC transesophageal echo in humans has confirmed the finding, first discovered in interventional animal studies, that the traditional location of chest compressions is frequently preventing cardiac output by occluding the aortic outflow tract with each compression.[8-10] Consequently, a few small series have described how POC echo can be used to monitor and correct the quality and location of chest compressions.[5,11-14]

Despite the recognized utility of POC echo, emergency physicians (EP) do not universally use this imaging modality during cardiac arrest cases, nor do EPs always use POC echo for the same purposes during cardiac arrest management. Since cardiac arrest is one of the leading causes of death for patients over the age of 40, even small improvements in cardiac arrest management with POC echo could potentially save thousands of lives annually.[15] Although larger trials are needed to understand how POC echo can be used to optimize cardiac arrest management, we also need to begin to explore EP utilization of this technology.

In this pilot study, we aimed to better characterize the utilization and the potential barriers to the use of POC echo during cardiac arrest among EPs. This pilot will be used to validate survey questions, and the response variability will be used to calculate sample size for future larger-scale studies.

METHODS

Study Design and Setting

We developed. an anonymous, cross-sectional survey in Research Electronic Data Capture (REDCap, Vanderbilt University, Nashville, TN), and a link to the survey was emailed to a convenience sample of attending EPs at six academic and two community EDs in five different states (CA, NV, WA, PA, MA) over a two-month period in 2019 (Appendix A). Two reminder e-mails were sent in an effort to increase response rate; no incentives were provided. Study sites were intentionally chosen on the East and West Coasts of the United States to increase generalizability of the results but were limited to locations where the study investigators had contacts who they believed would contribute to a meaningful response rate to the survey. The study was approved by the institutional review board with a waiver of documentation of informed consent; reporting follows the STROBE statement for observational studies.[16]

Intervention

The survey questions were developed by four point-of-care ultrasound (POCUS) fellowship-trained EPs and were tested on an additional 20 EPs with mixed prior ultrasound experience to validate that the survey items were clear, understandable, and relevant to the construct. The survey that ultimately was sent to the study population was the third iteration, which had undergone minor changes to increase clarity or to decrease the potential for incorrect entries based on these initial survey responses. The survey consisted of five demographic questions including level of prior ultrasound training and practice location, as well as four questions regarding the utilization of POC echo during cardiac arrest (Appendix A).

If participants answered "always" or "sometimes" to question 1, "How often do you use point-of-care echocardiography during cardiac arrest cases?" then branching logic in the REDCap^{T} survey presented questions 2-4 regarding the use of POC echo during cardiac arrest. If participants answered "never" to question 1, then questions 5 and 6 were presented rather than questions 2-4. Question 6 was also presented to participants who answered "sometimes" to question 1.

Outcomes

The purpose of this pilot study was to assess for trends in both the utilization and the perceived barriers to the use of POC echo during cardiac arrest in the emergency department (ED) setting. POC utilization (always vs sometimes and never) was compared with the demographic variables listed in Table 1. Additionally, we compared the proportion of the first half of respondents who answered "always" to the proportion from the second half of respondents to determine whether there was a temporal relationship to the responses. Participants also had the option to write in answers to echo utilization and barrier questions by choosing "other" options to allow additional insight into these variables at this pilot stage of the survey (Appendix B).

Analysis

We calculated and reported descriptive statistics with 95% confidence intervals (CI) . The relationship between respondent demographics and POC echo utilization was assessed using prevalence ratios with 95% CIs, and *P*-values calculated using Fisher's exact test. We used chi-squared analysis to compare early survey participants and late participants regarding frequency of POC echo utilization. We performed analyses using Stata15.1/SE for Windows (StataCorp, LP, College Station, TX).

RESULTS

A total of 155 EPs participated in the survey, with a median age of 39 years (interquartile range 31-67). The total survey response rate was 56% (95% CI, 50, 62); the response rate for academic centers was 52% [95% CI, 45, 58] and for community centers was 90% (95% CI, 80, 100). Demographic information is provided in Table 1. The majority

Table 1. Demographic data and answers to the echocardiography utilization questionnaire.

Variable	N	% (95% CI)
Gender		
Male	88	57 (49-65)
Female	67	43 (35-51)
Age, years		
30-39	80	52 (44-59)
40-49	56	36 (29-43)
50-59	9	5.8 (2.1-9.4)
60-69	8	5.2 (1.7-8.6)
70-79	2	1.2 (0.3-4.5)
Residency graduation year		
2010-2018	94	61 (53-68)
2000-2009	43	28 (21-35)
1990-1999	10	6.4 (2.6-10)
1980-1989	5	3.2 (0.4-6.0)
1970-1979	2	1.3 (0.5-3.0)
Ultrasound training in residency	134	86 (81-92)
Ultrasound fellowship training	25	16 (10-22)
Practice setting		
Academic	133	86 (80-91)
Community	22	14 (8.7-20)
Pediatric only*	8	5.2 (1.6-8.6)
1. How often do you use point-of-care echocardiography during cardiac arrest cases? Choose one:		
Always	102	66 (58-73)
Sometimes	46	30 (22-37)
Never	7	4.5 (1.2-7.8)
2. What type of point-of-care echocardiography do you use during cardiac arrest cases? Choose one:		
TTE	147	99 (98-100)
TEE	0	0.0 (0.0-0.0)
Both	1	1.0 (0.6-2.0)
3. When do you use point-of-care echocardiography during cardiac arrest cases? Choose all that apply:		
Beginning of resuscitation	69	47 (39-55)
End of resuscitation	116	78 (72-85)
During pulse/rhythm checks	124	84 (78-90)
Other**	9	6.1 (2.2-9.9)
4. What do you use point-of-care echocardiography for during cardiac arrest cases? Choose all that apply		
To identify potentially treatable causes	132	89 (84-94)
To prognosticate	141	95 (92-99)
To evaluate chest compression quality	4	2.7 (0.1-5.3)
Other**	1	0.7 (0.1-3.7)

* All were academic.
**See Appendix 2 for free-text answers to "Other."
CI, confidence interval; *TTE,* transthoracic echocardiography; *TEE,* transesophageal echocardiography.

Table 1. Continued.

Variable	N	% (95% CI)
5. Why don't you use point-of-care echocardiography during cardiac arrest cases? Choose all that apply:		
Lack of ultrasound training, competency, or credentialing	6	86 (42-100)
Lack of support from literature or national recommendations	1	14 (2.5-51)
Limited ultrasound machine availability	1	14 (2.5-51)
Technical challenges	1	14 (2.5-51)
Liability for incorrect use	1	14 (2.5-51)
"Other**	1	14 (2.5-51)
6. Which of the following would make it more likely for you to use point-of-care echocardiography during cardiac arrest cases? Choose all that apply:		
Improved competency	31	58 (45-72)
Credentialing status	8	15 (5.4-25)
Known survival benefits	21	40 (26-53)
More accessible ultrasound machines	13	25 (13-36)
More physical space	14	26 (15-38)
An assistant	25	47 (34-61)
Other**	1	1.9 (0.3-9.9)

* All were academic.
**See Appendix 2 for free-text answers to "Other."
CI, confidence interval.

of participants graduated from residency in the last decade, had received ultrasound training during their residency, and practiced in an academic setting.

A small minority of participants reported that they never use POC echo during cardiac arrest cases; all seven of the non-users were from the academic group, and most of those reported lack of training, competency, or credentialing as a barrier (Table 1). Among participants reporting that they either sometimes or never used POC echo during cardiac arrest, they cited a need for improved competency as the leading barrier to use (Table 1). There was no temporal difference in the proportion of participants who reported always using POC echo; 51 (77%) of the first half of participants and 51 (78%) of the second half of participants reported always using POC echo during cardiac arrest ($p = 0.91$).

Utilization of POC echo was not different among participants of different age groups or participants with different residency graduation dates (Table 2). Regarding the remaining demographic variables, POC echo use was higher among participants who received ultrasound training during residency or had received ultrasound fellowship training. Only two (29%, 95% CI, 8.2, 64) of the seven non-users graduated from residency prior to 2000, and four (57%, 95% CI, 25, 84) had not received any ultrasound training in residency.

DISCUSSION

In this pilot study, we found that participants who do not use POC echo during cardiac arrest reported a lack of training, competency, or credentialing as the leading barriers to utilization. Participants who do not always use ultrasound are less likely to have received ultrasound training during residency. Our findings are consistent with prior studies which have reported that common barriers to POC ultrasound utilization, in general, are lack of training, departmental flow requirements, and lack of access to an ultrasound machine.[17-20] In this study, one noteworthy finding is that neither age nor residency graduation date resulted in less POC echo use.

Point-of-care ultrasound training in the ED began during the 1990s with the introduction of the Focused Assessment with Sonography in Trauma (FAST) exam to the United States and steadily increased until the Accreditation Council for Graduate Medical Education (ACGME) designated ultrasound as one of the 23 milestone competencies for emergency medicine (EM) residency graduates in 2012.[21] While it is unlikely that any of the study participants who graduated before 1990 received ultrasound training during residency, POCUS training has been mandatory for all EM residents since 2012. Consequently, it would seem that age, graduation date, and ultrasound training would have similar, inter-related results in regard to POC echo utilization, but that is not the case in this pilot study. This result is due, in part, to older participants who have learned to use ultrasound after residency graduation; in fact, the three oldest participants reported that they always use POC echo.

There is also variability in the quality of POCUS training among residency training programs. Some participants who

Table 2. Point-of-care echocardiography utilization compared to demographic variables.

Demographic variable	Always N (%)	Sometimes or Never N (%)	Prevalence ratio	95% CI	*P*-value
Age					
30-39 years (n=80)	58 (73)	22 (28)	REF		
40-49 years (n=56)	31 (55)	25 (45)	0.76	0.58-1.0	0.045
50+ years (n=19)	13 (68)	6 (11)	0.94	0.68-1.3	0.779
Residency Graduation Year					
2010-2018 (n=94)	65 (69)	29 (31)	REF		
2000-2009 (n=43)	25 (58)	18 (42)	0.84	0.63-1.12	0.246
1970-1999 (n=17)	11 (65)	6 (35)	0.94	0.64-1.36	0.779
Gender					
Male (n=88)	54 (61)	34 (39)	REF		
Female (n=67)	48 (72)	19 (28)	1.2	0.93-1.5	0.232
Ultrasound Training					
No (n=21)	8 (38)	13 (62)	REF		
Yes (n=134)	94 (70)	40 (30)	1.8	1.1-3.2	0.006*
Ultrasound Fellowship Training					
No (n=130)	78 (60)	52 (40)	REF		
Yes (n=25)	24 (96)	1 (4)	1.6	1.4-1.9	<0.001*
Practice Setting					
Community (n=22)	17 (77)	5 (23)	REF		
Academic (n=126)	79 (63)	47 (38)	1.2	0.9-1.6	0.231

*significant difference, p<0.05
CI, confidence interval; *REF,* reference group.

graduated since 2012 and responded that they did not receive POCUS training, may have answered that way because they either did not receive high quality POCUS training or they may not have had enough training in the use of POC echo during cardiac arrest to feel comfortable with its use during resuscitation. This finding suggests that there may be educational deficiencies preventing the use of POC echo, and that more work is needed to determine what these deficiencies in training are and how they can be overcome. Of note, recent literature suggests that general POC echo knowledge during cardiopulmonary resuscitation may not be sufficient since the use of POC echo can decrease compression ratio during cardiac arrest; an understanding of how to minimize echo time during chest compression pauses, or institutional protocols for the same purpose, may be necessary; the use of transesophageal echocardiography (TEE) rather than transthoracic echocardiography (TTE) also improves compression ratio since there is no time spent during pauses searching for an adequate cardiac window.[22-26]

In this pilot study, we also found no difference in POC use between academic and community settings. The number of community physicians that participated was much smaller than the number of academic physicians; so this trend may not persist in a larger study. There may be more perceived barriers to POC echo use in the community setting (eg, fewer personnel for assistance); thus, if future work does find that this trend persists, it may suggest that EPs who are adequately trained in either setting understand the importance of using POC echo during cardiac arrest and will incorporate it into their practice despite the presence of perceived barriers. Remarkably, all seven participants who responded that they never used POC echo were from academic centers; it is likely that a larger community sample would have non-users as well.

The purpose of this pilot study was to provide the first-ever characterization of the utilization and the potential barriers to the use of POC echo during cardiac arrest among EPs. To this end the study has fulfilled its purpose. However, as a pilot study this investigation had an inherently small sample size, especially among community EPs, and should not be misconstrued as being widely generalizable. Our group is currently planning a larger study using national organization listservs to recruit a more representative sample of both academic and community EPs nationwide. This pilot has also provided some external validity to the survey tool. The free-text answers (Appendix B) suggest that the survey questions were well understood overall, but they elucidated some minor changes that can still be made to provide further clarity. In addition, the response variability from this pilot will be used to calculate sample size in future studies. We hope that this further work will be valuable in identifying barriers to POC

echo utilization and will help guide interventions to overcome those barriers.

LIMITATIONS

The primary limitations of this study were the small sample size and the response rate. Although small, the sample size was appropriate for this pilot study; our primary aim was to characterize the use of POC echo among a convenience sample of EPs. Although our response rate was higher than anticipated, it still leaves room for non-response bias. It is possible that participants in this study were more experienced with POC echo and were thus more interested or more comfortable in answering a survey on the topic; this may be particularly true of the community ED group where all of our participants reported using POC echo at least some of the time during cardiac arrest. However, there was no temporal difference in how participants responded to the question regarding frequency of POC echo use; this finding suggests that non-response bias may have been minimized since participants who required multiple reminders before responding submitted similar responses to early participants.

CONCLUSION

In our pilot survey of emergency physicians, only a small minority never use point-of-care echocardiography during cardiac arrest in clinical practice. Lack of training, competency, or credentialing was reported as the leading barriers to utilization among those who do not use POC echo during cardiac arrest cases. Participants who do not always use ultrasound are less likely to have received ultrasound training during residency.

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Effectiveness of Mechanical Chest Compression Devices over Manual Cardiopulmonary Resuscitation: A Systematic Review with Meta-analysis and Trial Sequential Analysis

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Introduction: Our goal was to systematically review contemporary literature comparing the relative effectiveness of two mechanical compression devices (LUCAS and AutoPulse) to manual compression for achieving return of spontaneous circulation (ROSC) in patients undergoing cardiopulmonary resuscitation (CPR) after an out-of-hospital cardiac arrest (OHCA).

Methods: We searched medical databases systematically for randomized controlled trials (RCT) and observational studies published between January 1, 2000–October 1, 2020 that compared mechanical chest compression (using any device) with manual chest compression following OHCA. We only included studies in the English language that reported ROSC outcomes in adult patients in non-trauma settings to conduct random-effects metanalysis and trial sequence analysis (TSA). Multivariate meta-regression was performed using preselected covariates to account for heterogeneity. We assessed for risk of biases in randomization, allocation sequence concealment, blinding, incomplete outcome data, and selective outcome reporting.

Results: A total of 15 studies (n = 18474), including six RCTs, two cluster RCTs, five retrospective case-control, and two phased prospective cohort studies, were pooled for analysis. The pooled estimates' summary effect did not indicate a significant difference (Mantel-Haenszel odds ratio = 1.16, 95% confidence interval, 0.97 to 1.39, P = 0.11, I2 = 0.83) between mechanical and manual compressions during CPR for ROSC. The TSA showed firm evidence supporting the lack of improvement in ROSC using mechanical compression devices. The Z-curves successfully crossed the TSA futility boundary for ROSC, indicating sufficient evidence to draw firm conclusions regarding these outcomes. Multivariate meta-regression demonstrated that 100% of the between-study variation could be explained by differences in average age, the proportion of females, cardiac arrests with shockable rhythms, witnessed cardiac arrest, bystander CPR, and the average time for emergency medical services (EMS) arrival in the study samples, with the latter three attaining statistical significance.

Conclusion: Mechanical compression devices for resuscitation in cardiac arrests are not associated with improved rates of ROSC. Their use may be more beneficial in non-ideal situations such as lack of bystander CPR, unwitnessed arrest, and delayed EMS response times. Studies done to date have enough power to render further studies on this comparison futile. [West J Emerg Med. 2021;22(4)810–819.]

INTRODUCTION

Sudden out-of-hospital cardiac arrests (OHCA) are significant causes of morbidity and mortality both in the US and worldwide. About 326,200 OHCAs are resuscitated annually by emergency medical services (EMS) with a survival rate of approximately 12% in the US.[1] Early and high-quality cardiopulmonary resuscitation (CPR) has been identified as a critical factor for survival during resuscitation.[2] To achieve high quality, the American Heart Association recommends a chest compression rate of 100–120 per minute and a compression depth of at least 5 centimeters during CPR.[1] However, various challenges in the field settings threaten to make the CPR delivered by EMS personnel suboptimal. These include a lack of enough human resources, fatigue, competing tasks on arrival, and the challenge of continuing CPR in a moving ambulance.

In the early 2000s, two mechanical compression devices (AutoPulse [Zoll Medical Corporation, Chelmsford, MA] and LUCAS [Physio-Control/Jolife AB, Lund, Sweden]) were approved by the US Food and Drug Administration (FDA) to help surmount these challenges. The AutoPulse device is a load-distributing band device in which a wide band fits circumferentially around the chest wall. This band is automated to shorten and lengthen alternately to provide compressions. The LUCAS device belongs to a different category of piston devices: A piston mounted on a circumferential frame uses a power source to move up and down forcefully, simulating manual compressions.

Theoretically, these mechanical devices should help eliminate the problems associated with fatigue, manpower, and CPR consistency, whether in the field or during transport. They also help free up the ambulance crew for other tasks related to resuscitation. Studies done on porcine models have shown improved coronary perfusion and end-tidal CO_2 achieved with mechanical compressions during transport.[3] However, results from clinical trials have been conflicting. Some studies have shown a benefit, while others demonstrated no difference in outcomes using mechanical compressions. Our goal in this systematic review was to synthesize studies comparing outcomes from mechanical and manual CPR during OHCA regardless of presenting rhythm.

METHODS

Search Strategy

We used a prespecified protocol and a clear, reproducible plan for a literature search and synthesis as per the Preferred Reporting Items for Systematic Reviews and Metaanalyses (PRISMA) statement.[4] The review protocol has not been registered. PubMed, Embase, Scopus, Google Scholar, CINAHL, and Cochrane databases were systematically searched for related articles published between January 1–October 1, 2020. In all electronic databases, the following search strategy was implemented, and these phrases were queried (in the title/abstract, keywords and their MeSH subheadings) with appropriate restrictions: "Cardiopulmonary resuscitation" AND "out-of-hospital cardiac arrests" AND "mechanical compression devices" AND "return of spontaneous circulation." We scanned the included studies' reference lists or relevant reviews identified through the search along with available gray literature to ensure saturation. We concluded the inquiry on November 5, 2020.

Eligibility Criteria

We included peer-reviewed human studies of adult (age >18 years) cardiac arrests (CA) comparing mechanical vs manual compression outcomes in out-of-hospital settings, reported in English, only from North American and European countries with comparable advanced EMS. We excluded case reports, narrative reviews, commentaries, letters, abstracts, mannequin/animal studies, and studies using mechanical devices other than Autopulse or LUCAS for resuscitation. The cases were patients in non-trauma settings who received chest compressions with a mechanical device, and controls included similar patients who received them manually. Authors (MS, JC) participated in each phase of the review (screening, eligibility, and inclusion). Titles and abstracts were individually evaluated by two authors (MS, JC) to identify and assess key articles. Two authors (MS, JC) independently reviewed the entire manuscript and registered justification for exclusions. Discrepancies were addressed by arbitration by a third reviewer.

Outcome

We chose ROSC for 20 minutes or more after resuscitation in an OHCA as the primary outcome. Our presumption was this outcome most directly reflects the acute effects of the CPR. Long-term outcomes, such as survival to discharge and neurological outcomes, were more likely influenced by post-resuscitation care.

Data Collection

Two authors (MS, JC), using a standardized data extraction method, extracted information from each study independently; conflicts were resolved by consensus. The following data points were extracted: name of the first author; year of study; sample size; number of participants per treatment arm; study design; type of device used; time delay in mechanical compressions; inclusion and exclusion criteria; average age, gender (percentage female); percentage of witnessed arrests; the percentage receiving bystander CPR; percentage with an initial shockable rhythm; time in minutes of EMS arrival; and primary outcome (ROSC).

Risk of Bias Assessment

We used the Newcastle-Ottawa scale (NOS) to measure the risk of bias in observational studies.[5] The following classes were rated per study: low bias risk (8–9 points); moderate bias risk (5–7 points); and high bias

risk (0–4 points). The modified Cochrane risk of bias tool was used to assess risk of bias in randomized controlled trials (RCT).[6] This tool considers selection, performance, detection, attrition, reporting, and other biases. Three reviewers (MC, JC, RC) evaluated the likelihood of bias independently, and any conflict was resolved by consensus.

Statistical Analysis

The RCTs and observational studies included compared outcomes of mechanical and manual compressions during OHCA resuscitations. Meta-analysis was performed for studies reporting ROSC of patients in both groups assuming independence of results from other reported endpoints. Due to anticipated heterogeneity, we calculated summary statistics using a random-effects model. In all cases, meta-analyses were performed using the Mantel–Haenszel (M-H) method for dichotomous data to estimate pooled odds ratios (OR). Statistical heterogeneity was assessed using Q-values and I^2 statistics. We performed the metanalysis, metaregression, and assessment of publication bias using Comprehensive Meta-Analysis software (Biostat Inc., Englewood, NJ).[7]

Next, we performed trial sequence analysis (TSA) to assess the quality of available data and conclusions from the meta-analysis. This applies sequential monitoring boundaries to a meta-analysis by calculating sample sizes contributed by included studies, known as information size (IS). A Z-curve is constructed by cumulative evidence of trials added over time. If this curve crosses the alpha boundary of significance, then sufficient evidence favoring the intervention has been achieved. However, if it crosses the futility boundary, the cumulative evidence is adequate to indicate no effect for the intervention examined.[8] Applying TSA boundaries guard against the risk of false-positive (type-I error) and false-negative (type-II error) results. We maintained the two-sided type-I error rate at 5% (alpha boundary) and calculated the required IS with 80% power, assuming a 20% relative risk reduction for mechanical compressions. We conducted the analysis using TSA software, Copenhagen Trial Unit, version 0.9.5.10 Beta[9] (Centre for Clinical Intervention Research, Copenhagen, Denmark).

To explore intrinsic differences between studies expected to influence the effect size, we performed random effects (maximum likelihood method) univariate and multivariate meta-regression analyses. The potential sources of variability defined a priori were average age, gender (percentage female), percentage of witnessed arrests, the percentage receiving bystander CPR, percentage with an initial shockable rhythm, and time in minutes of EMS arrival.

RESULTS

Study Selection

The search identified 398 articles (Figure 1), which were culled to 201 potentially eligible studies after removing duplicates. No articles were added from a manual search of references; however, one was added through gray literature sources (www.clinicaltrials.gov). In all, we excluded 180 studies (120 irrelevant to the present context, 28 case reports, eight conference abstracts without full publication, 19 pre-clinical or mannequin studies, and five commentaries) after review of their titles and abstracts. We excluded 16 after full-text assessments of the remaining 31 articles because 11 were meta-analyses, four were studies conducted in inpatient settings, and one used cerebral perfusion as the resuscitation outcome.[10] And we excluded all four articles reporting inpatient CA including one by Koster et al that considered resuscitations in the emergency department as OHCA resuscitations.[11] A resulting total of 15 studies were included in meta-analysis for the primary outcome. Altogether, these studies consisted of 8685 resuscitations in the mechanical compression arm and 9789 in the manual compression arm.

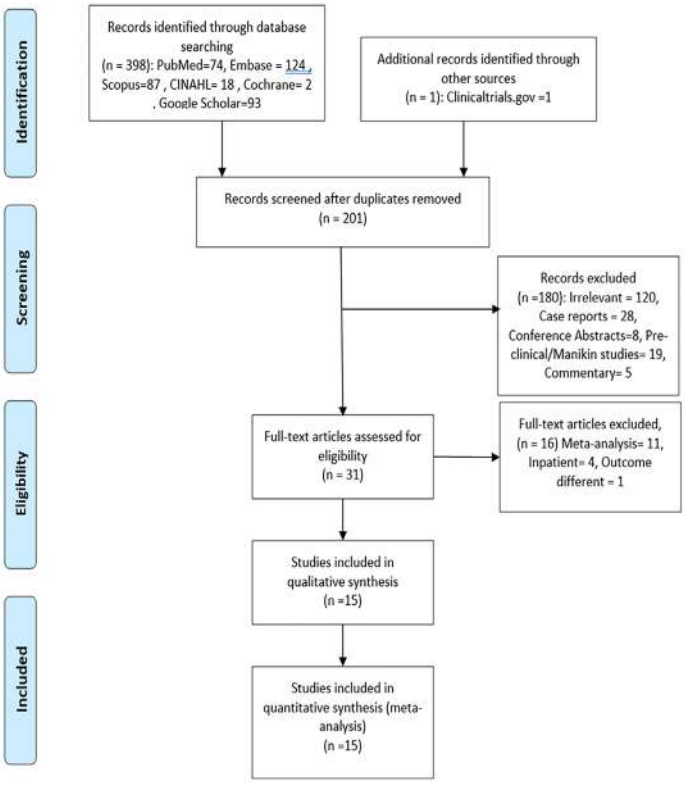

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

Study Characteristics

Of the 15 studies selected (Table 1), six were RCTs and nine were observational studies. Of the RCTs, three were conducted using the AutoPulse device (n = 5119),[12 13 14] and the remainder involved the LUCAS device (n = 7209).[15 16 17] Of the nine observational studies, two were cluster RCTs,[18 19]

Table 1. Types of studies included.

Name	n	Device	Study	Exclusion criteria
Hallstrom et al 2006 (ASPIRE)	767	Autopulse	RCT	<18, Trauma, recent surgery, prisoners, DNR
Smekal et al 2011	149	LUCAS	RCT	<18, Trauma, pregnancy
Wik et al 2014 (CIRC)	4219	Autopulse	RCT	<18, Trauma, pregnancy,prisoner, DNR, large for device, EMS arrival >16 mins
Rubertsson et al 2014 (LINC)	2589	LUCAS	RCT	<18, Trauma, pregnancy
Perkins et al 2015 (PARAMEDIC)	4471	LUCAS	RCT	<18, Trauma, pregnancy
Gao et al 2016	133	Autopulse	Prospective RCT	<14>90, Trauma, pregnant, advanced cancer
Castner et al 2005	262	Autopulse	Retrospective case-control	None
Axelsson et al 2006	328	LUCAS	Cluster RCT	Witnessed OHCA, <18, trauma, pregnancy, hypothermia,intoxication, discharge, hanging, drowning, ROSC before arrival
Ong et al 2006	783	Autopulse	Phased prospective cohort	Trauma, <18, mentally disabled, prisoners, pregnant women
Steinmetz et al 2008	791	Autopulse	Retrospective case-control	None
Jennings et al 2012	286	Autopulse	Retrospective case-control	None
Ong et al 2012	1101	Autopulse	Phased prospective cohort	Trauma, <18, Non-cardiac
Satterlee et al 2013	572	LUCAS	Restrospective case series	Pregnant, <18, Non-cardiac
Axelsson et al 2013	1170	LUCAS	Cluster RCT	None
Zeiner et al 2015	948	LUCAS/Autopulse	Restrospective case-control	None

RTC, randomized controlled trial; *DNR*, do not resuscitate; *EMS*, emergency medical services; *OHCA*, out-of-hospital cardiac arrest.

two were phased prospective cohort studies,[20 21] and the rest were retrospective case-control studies.[22 23 24 25 26] Four of the observational studies used the LUCAS device (n = 3018), and the remaining five (n = 3508) used AutoPulse. All studies were published between 2006–2016 and had sample sizes ranging from 133 to 4471.

Risk of Bias Assessment

Most observational studies were found to have a low or moderate risk of bias according to the NOS scale (Appendix 1). The studies that had a comparably higher risk of bias in the group failed to control for any confounding factors by design, thereby losing out on the "comparability" score.[26 24] The RCTs, however, collectively had a higher risk of bias (Appendix 2). Randomized sequence generation was adequately performed in only two trials,[13 27] and allocation sequence concealment was adequate in only one.[13] Given the nature of the intervention, blinding participants in the field is not possible, resulting in increased performance bias in all studies. However, the PARAMEDIC trial achieved low assessor bias by blinding research nurses.[15] Attrition bias was low overall for the ROSC outcome. Also noteworthy is that the ASPIRE trial had high "other" biases because it was stopped early due to interim evidence of worse outcomes in the intervention arm.[12]

Primary Outcome

Meta-analysis summary statistics showed that mechanical chest compressions did not significantly improve ROSC (relative risk (RR) 0.80, 95% confidence interval (CI), 0.61, 1.04, $P = 0.10$; $I^2 = 65\%$) (Figure 2) when compared with manual chest compressions in patients undergoing resuscitation after OHCA (M–H odds ratio (OR) = 1.16, 95% CI, 0.97, 1.39, $P = 0.11$). Heterogeneity was high with $I^2 = 83.07\%$ and Q-value of 82.74.

Multivariate Meta-regression Model

Multivariate meta-regression, performed to try to explain high between-studies variations in association between ROSC and mechanical vs manual CPR, revealed that the following covariates had an effect: average age (log OR = -0.02, standard error [SE] = 0.02); gender distribution (log OR = 0.02, SE = 0.01); percentage of witnessed arrests (log OR = 0.01, SE= 0.01); percentage of bystander CPR (log OR = -0.03, SE = 0.00); time lag for EMS arrival (log OR

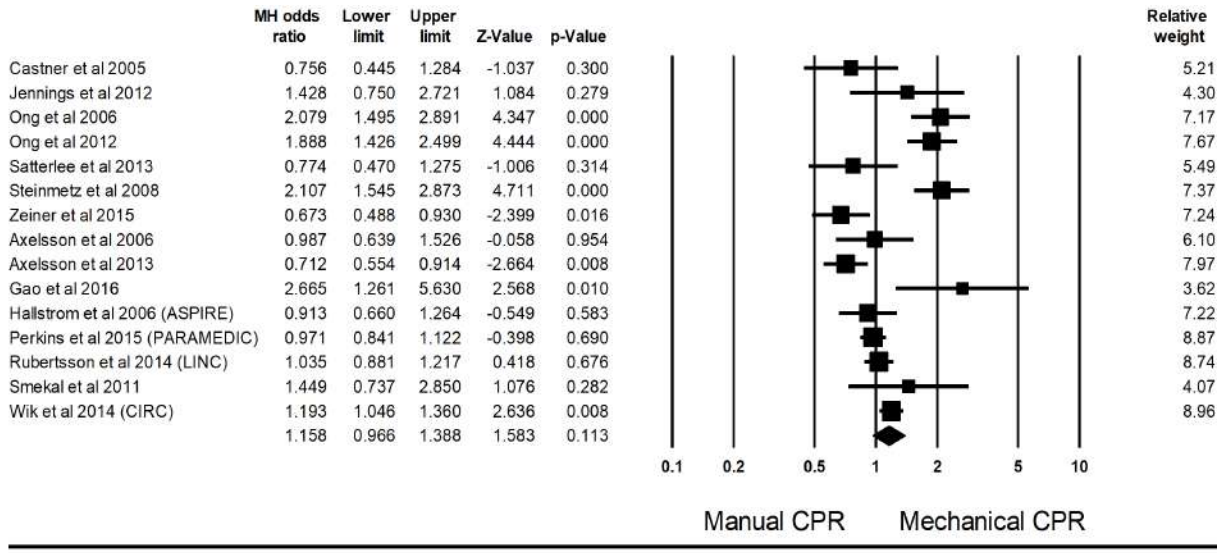

Figure 2. Forest plot for meta-analysis comparing manual vs mechanical cardiopulmonary resuscitation. Heterogeneity: Tau^2=9.1%, SE= 0.056, I^2=83.079%, df=14 (p=0.00),Q=82.74
ROSC, return of spontaneous circulation.

= 0.14, SE = 0.04); and percentage of shockable rhythm (log OR = -0.02, SE = 0.01) (Appendix 3). Only three of these, the percentage of witnessed OHCA, the percentage receiving bystander CPR, and time lag for EMS arrival, achieved significance at the P <0.05 level (Figure 3). There was a decreasing benefit of mechanical over manual CPR for ROSC with increasing percentages of witnessed arrests and increasing percentage of bystander CPR; however, the benefit increased with delays in EMS response. Altogether, they explained 100% of the between-study heterogeneity.

Trial Sequence Analysis

Applying the TSA boundaries to favorable ROSC outcomes showed that an IS of 25933 was required to achieve 80% power. This IS could not be acquired from the pooled studies. However, the Z-curve crossed the futility boundary even though it failed to cross the conventional or TSA boundaries (Figure 4). This indicates firm cumulative power from the available literature to support the lack of association between outcome and intervention.

Publication Bias

Visual inspection of the SE and precision plots for the analysis (Figure 5) suggest asymmetry with an under-representation of negative studies with lesser precision and smaller effect sizes. Classic fail-safe N analysis (alpha = 0.05) placed the number of missing studies at 31. Corroborating inspection findings, Egger's regression test with the null hypothesis of no small study effects was not rejected at P <0.05 (estimated bias coefficient = 0.75 ± 1.31). Overall, we assessed some risk of publication bias, especially for smaller studies.

DISCUSSION

Summary of Findings

The overall proportion of successful resuscitations in OHCA remains dismal. Although mechanical chest compression devices have been around for the last 40 years, we have seen a recent surge in interest because of FDA and American Hospital Association approvals of their usage, resuscitation guidelines stressing correct delivery of compressions, and lighter and more portable devices, making them more user-friendly and less time-consuming.[28]

We synthesized studies performed in the last 20 years only, assuming that the effects of resuscitations can be captured only in the context of guiding protocols. Because earlier protocols for chest compressions were different from present-day protocols, this would have introduced pipeline bias into the analysis. To maintain uniformity of guidelines, we excluded studies from outside of North America and Europe. Finally, we excluded studies using non-FDA approved compression devices such as the Thumper (Michigan Instruments, Grand Rapids, MI) and mechanical life-vest or nonautomated ones such as the impedance threshold device, assuming non-comparability of outcomes.[29]

Our analysis failed to demonstrate a significant advantage in using mechanical devices. Meta-regression, however, showed greater benefit over manual CPR in the absence of witnesses at the time of arrest, lack of bystander CPR, or delay in EMS arrival. Thus, we derive that they do have a place in non-ideal resuscitations where early initiation of quality CPR has not been possible. Trial sequence analysis suggested that sufficient evidence has already been accumulated to refute superiority of

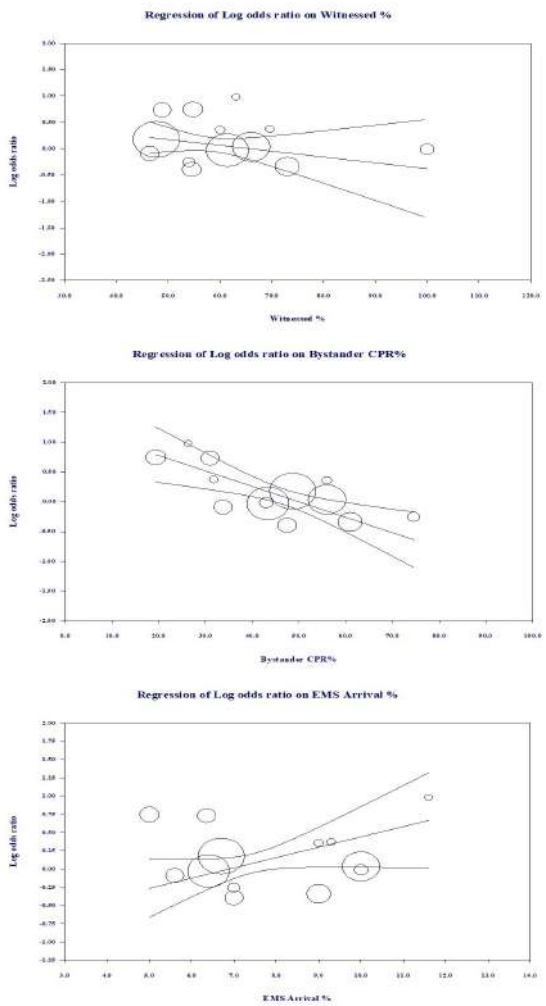

Figure 3. Results of meta-regression.
Y = 1.0934 - 0.0121 * Witnessed % - 0.0239 * Bystander CPR% + 0.1079 * EMS Arrival %

mechanical over manual compressions convincingly. It indicates the futility in further investigations into the improvement of ROSC with use of mechanical devices.

Strengths

The main strength of our analysis was the inclusion of a large number of studies that increased its statistical power. To our knowledge, this is the first meta-analysis to use TSA to confirm the sufficiency of accumulated evidence. Moreover, the study has high external validity from including studies from various European and North American countries.

Prior Studies

Most notable, of the prior studies synthesizing evidence for or against mechanical compression devices, is the Cochrane systematic review by Wang et al published in 2011 and updated twice in 2016 and 2018.[30] They included all RCTs that were ever done and concluded that CPR with mechanical devices did not result in improved ROSC. Ong et al synthesized 10 studies that included only one RCT, with four evaluating compression adequacy and six evaluating survival outcomes. They reported that, although compressions adequacy was better, outcomes were similar to those of mechanical devices.[31] Westfall et al synthesized 11 observational and one pilot RCT and concluded that mechanical devices with load distributing bands had better ROSC outcomes than manual CPR.[32] Although they also performed meta-regression, unlike our study, none of their covariates significantly accounted for between-study variations. However, this study was funded by Zoll, the manufacturers of the AutoPulse device, and therefore its findings may be called into question. Gates et al included five RCTs in their study and performed subgroup analysis for the type of device used, either LUCAS or AutoPulse. They found no difference in outcomes for either device vs manual compressions.[33]

Bonnes et al performed a subgroup analysis of five RCTs and 15 observational studies. While observational studies showed some advantages from mechanical compressions, the RCTs did not indicate any difference. Contrary to our meta-regression analysis, they showed a decreasing benefit of mechanical compressions with longer EMS response delay.[34] Tang et al analyzed the same fivc RCTs but conducted subgroup analysis for outcomes. They found worse outcomes for ROSC from using mechanical CPR and advised against it.[35] Li et al summarized the effects from nine studies, both RCTs and observational in the out-patient settings, and three in the inpatient settings. They concluded that manual compressions were more likely to achieve ROSC when compared to load-distributing bands.[36] Khan et al performed a Bayesian network meta-analysis of seven RCTs comparing the safety and efficacy of both types of CPR; manual compression was found to be more effective than AutoPulse and had a lesser risk of adverse effects.[37] Zhu et al synthesized nine RCTs and six cohort studies and found no difference in a variety of resuscitation outcomes between manual and mechanical CPR. Their subgroup analyses for the type of device used (AutoPulse and LUCAS) also resulted in a similar conclusion as ours.[38]

Of note, this metanalysis attains the largest sample size to date, primarily from including the Buckler et al observational study that uses the CARES registry.[39] Lameijer et al and Couper et al conducted meta-analyses of studies conducted only in inpatient settings and reported a definite advantage using mechanical compression.[40,41] Appendix 4 contains studies that we considered but eventually excluded from our meta-analysis with the respective exclusion criteria.

LIMITATIONS

The primary limitation was the necessity for using observational studies. Even though these are considered

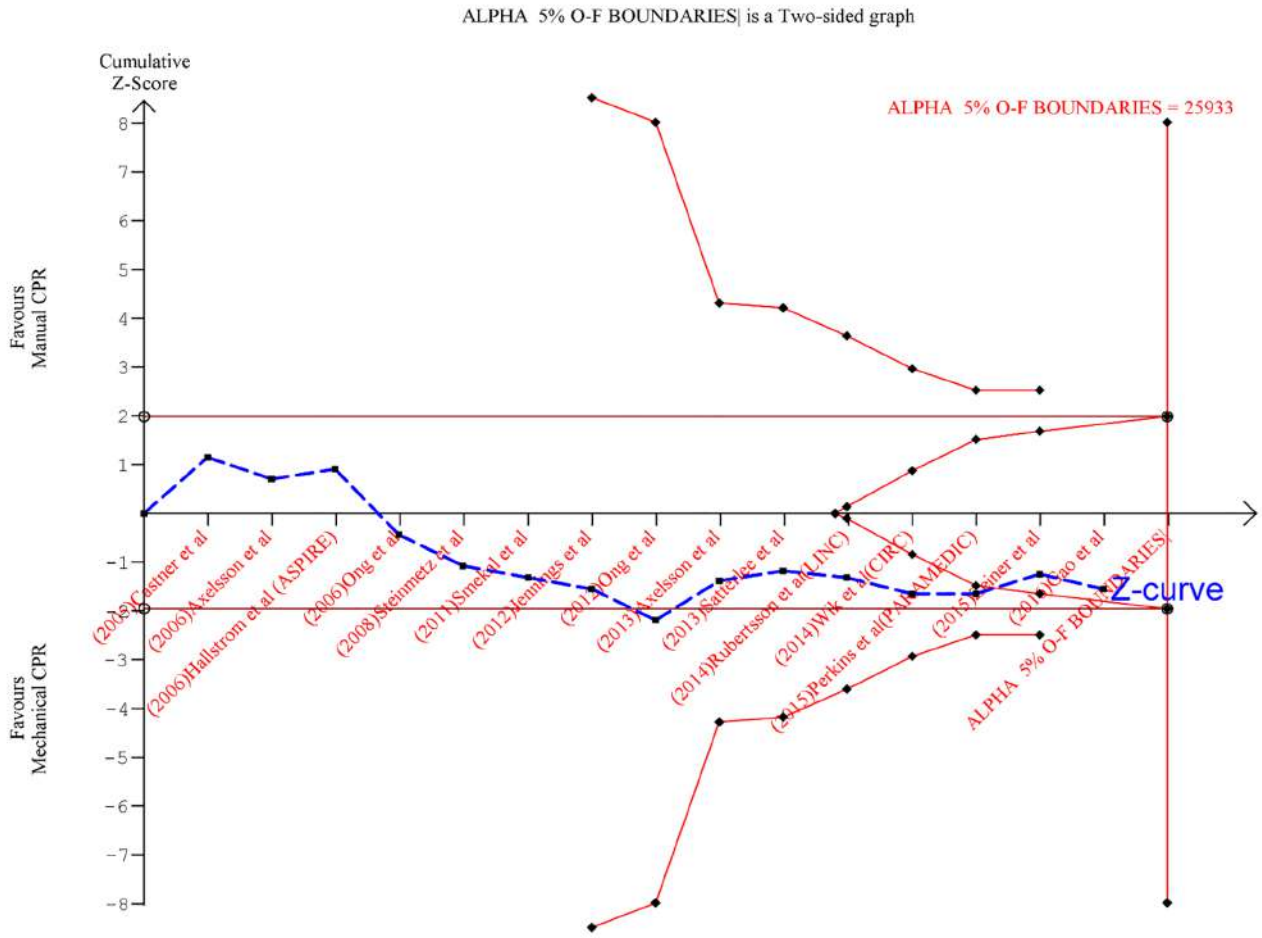

Figure 4. Trial sequential analysis for favorable return of spontaneous circulation (ROSC) outcome. The diversity-adjusted information size (sample size) equal to 25,933 (vertical red line). The cumulative Z-curve (blue line with small black squares representing each trial) failed to cross both the traditional (horizontal maroon line), trial sequential monitoring boundary (concave red line). But it crosses the futility boundary (red triangle), indicating firm evidence supporting the lack of favorable ROSC outcomes with mechanical compressions during cardiopulmonary resuscitation.

inferior to RCTs, the nature of our question makes both types comparable. Of all the RCTs we considered, none included blinding of the participant because it is impossible for EMS personnel not to know when they are using a compression device and when they are performing manual compressions. Selection bias in RCTs was comparable to observational studies, with most using clusters rather than true randomizations. Because ROSC was considered as the only outcome, there was almost no attrition bias in either RCTs or observational studies. One could argue about inherent calculation bias in observational studies; however, almost all considered here were of high quality with low risk of bias.

Second, the design of each study was different. There was no uniform protocol for CPR administration and an absence of data regarding CPR quality in all studies. Indicators of quality CPR such as cerebral perfusion, resuscitative tracheoesophageal echocardiography, and end tidal CO_2 were absent from all studies considered. Third, there were also differences in composition of teams of first responders. The initial response could occur with teams of only police/firefighters or with more advanced paramedics/physician teams. There were differences in regional policies governing such teams and training regarding usage of mechanical compression devices.

Fourth, field conditions for each study were different. Logistic differences such as location of the arrest, distance from the hospital, traffic negotiated by ambulance, and safety of manual compressions in transit were not accounted for. Fifth, equipment factors for the ambulance

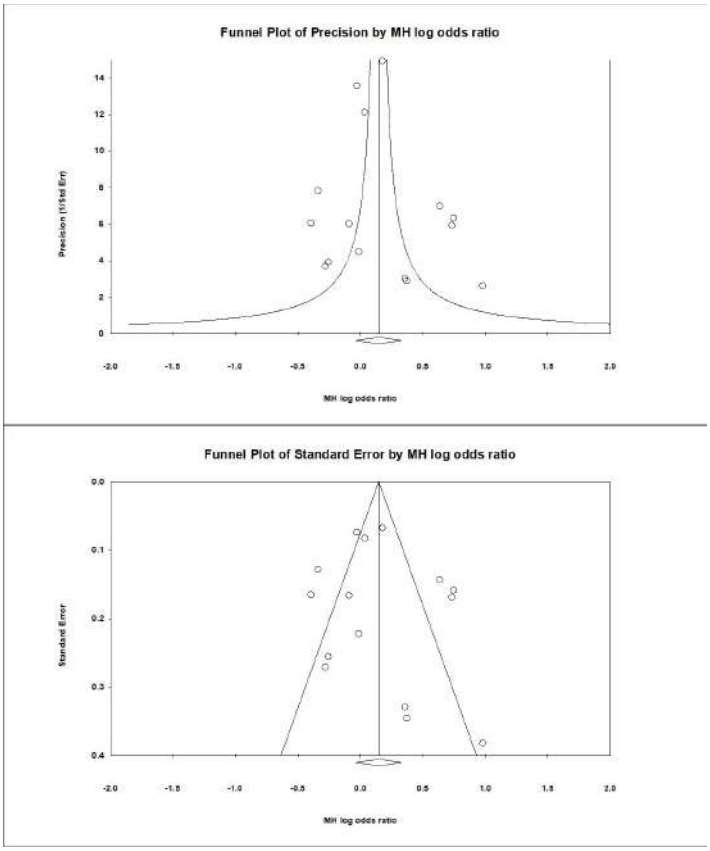

Figure 5. Funnel plots of precision and standard error demonstrating publication bias.

and compression devices were very different. The type of ambulance, its average capacity and speed, time to deployment of mechanical compression after starting resuscitation, the possibility of a patient randomized to the mechanical arm not fitting in the device could have added to the heterogeneity. Finally, even though it made sense to include only nonpregnant adults because of the uniform size of the machines, stratification by age and gender would have yielded more credible results.

CONCLUSION

The use of mechanical devices during CPR does not lead to improvement in ROSC outcomes even though it improves the quality of CPR. Nevertheless, we do recommend the availability of these devices as an option to EMS personnel as insurance against fatigue, lack of manpower, and other situations in the field precluding early initiation of high-quality manual CPR. We established futility of additional trials to determine the utility in the context of out-of-hospital cardiac arrest; nevertheless, we recommend high-quality random controlled trials in inpatient settings. Positive results from a recent pilot study for the COMPRESS trial by Couper et al has been an encouraging development in this direction.[42]

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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.

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Randomised Controlled Trial Assessing Head Down Deep Breathing Method Versus Modified Valsalva Manoeuvre for Treatment of Supraventricular Tachycardia in the Emergency Department

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Introduction: Supraventricular tachycardia (SVT) is commonly encountered in the emergency department (ED). Vagal manoeuvres are internationally recommended therapy in stable patients. The head down deep breathing (HDDB) technique was previously described as an acceptable vagal manoeuvre, but there are no studies comparing its efficacy to other vagal manoeuvres. Our objective in this study was to compare the rates of successful cardioversion with HDDB and the commonly practiced, modified Valsalva manoeuvre (VM).

Methods: We conducted a randomised controlled trial at an acute hospital ED. Patients presenting with SVT were randomly assigned to HDDB or modified VM in a 1:1 ratio. A block randomisation sequence was prepared by an independent biostatistician, and then serially numbered, opaque, sealed envelopes were opened just before the intervention. Patients and caregivers were not blinded. Primary outcome was cardioversion to sinus rhythm. Secondary outcome(s) included adverse effects/complications of each technique.

Results: A total of 41 patients were randomised between 1 August, 2018–1 February, 2020 (20 HDDB and 21 modified VM). Amongst the 41 patients, three spontaneously cardioverted to sinus rhythm before receiving the allocated treatment and were excluded. Cardioversion was achieved in six patients (31.6%) and seven patients (36.8%) with HDDB and modified VM, respectively (odds ratio1.26, 95% confidence interval, 0.33, 4.84, P = 0.733) . Seventeen (89.5%) patients in the HDDB group and 14 (73.7%) from the modified VM group did not encounter any adverse effects. No major adverse cardiovascular events were recorded.

Conclusion: Both the head down deep breathing technique and the modified Valsalva manoeuvre appear safe and effective in cardioverting patients with SVT in the ED. [West J Emerg Med. 2021;22(4)820–826.]

INTRODUCTION

Supraventricular tachycardia (SVT) is a common clinical condition seen in the emergency department (ED). It accounts for an an estimated 50,000 visits each year in the USA.[1] In haemodynamically stable patients presenting with regular narrow complex (QRS ≤ 120 milliseconds) tachycardias, either atrioventricular re-entrant tachycardia (AVRT) or atrioventricular nodal re-entrant tachycardia

(AVNRT) is the most common mechanism. In the absence of an established diagnosis at the ED and after ruling out irregular narrow complex tachycardias which are usually due to atrial fibrillation, vagal manoeuvres are recommended as acute therapy for this group of patients.[2] Previously, we have described the head down deep breathing (HDDB) technique as a reasonable and simple alternative to other vagal manoeuvres for the management of paroxysmal SVT at the ED.[3] In this study, we assessed the HDDB method with the commonly practised, modified Valsalva manoeuvre (REVERT study)[4,5] and compared the rates of successful cardioversion of SVT to sinus rhythm between the two groups. Our hypothesis is that HDDB is a safe and efficacious method for conversion of stable SVT.

Population Health Research Capsule

What do we already know about this issue?
Head down deep breathing (HDDB) is a vagal manoeuvre that can be used to cardiovert supraventricular tachycardia (SVT).

What was the research question?
What is the efficacy and safety of HDDB, and how does it compare to the modified Valsalva manoeuvre?

What was the major finding of the study?
Our findings suggest that HDDB is safe and effective for cardioversion of SVT. However, further study is needed to confirm this.

How does this improve population health?
A simple, non-pharmacological treatment, HDDB, may be self-administered by patients with recurrent SVT. This would be especially useful in low-resource settings.

METHODS

Study Design

This was a randomised clinical trial assessing HDDB method vs modified Valsalva manoeuvre (VM) for the treatment of SVT presenting to the ED. The study was approved by the Singhealth Centralised Institutional Review Board (CIRB) and received funding from a hospital research grant. All patients provided written informed consent in English. Consent was taken in a standardized manner with provision of study participant patient information sheets. Verbal translation of the consent was provided at the bedside when necessary. Neither patients nor the public were involved in the design, conduct, reporting, or dissemination plans of this study.

Study Setting and Population

We conducted the study in the ED of an acute hospital in a regional healthcare cluster with an emergency medicine academic clinical programme. The ED has an annual attendance of more than 130,000. Adults 21 years old and above who presented at the ED with paroxysmal SVT on 12-lead electrocardiogram (ECG) during office hours were eligible. They had to be hemodynamically stable, not in imminent danger and able to provide informed consent. The exclusion criteria were as follows: 1) special patient groups: pregnant women, prisoners; 2. hemodynamically unstable patients: low blood pressure: systolic blood pressure (SBP) < 90 milligrams mercury (mm Hg) or mean arterial pressure (MAP) <65 mm Hg, or high blood pressure: SBP ≥ 160 mm Hg and/or diastolic blood pressure (DBP) ≥ 100 mm Hg, ongoing angina pectoris, presence of pulmonary edema; 3) risk from raised intracranial pressure, raised intrathoracic or intra-abdominal pressure; 4) history of hemorrhagic stroke, cerebral arteriovenous malformation, intracranial space-occupying lesion or mass, intracranial aneurysm; 5) history of vascular aneurysm, vascular dissection; 6) unable to perform either manoeuvre (eg, due to inability to lie flat and have legs lifted to assume a head-down tilt position, recent surgery (cardiac surgery or procedures); and 7) use of drugs which inhibit the effects of the vagus nerve, such as atropine. Clinical research coordinators (CRC) and study investigators consented and enrolled patients who were referred to them by emergency physicians.

Sample Size Calculation

We estimated the success rate at cardioverting SVT to a sinus rhythm at 43% for modified VM and 20% for the HDDB method. For the study to have 80% power with significance level of 5%, the minimum number of patients to be recruited into each trial therapy was 63 to be able to detect at least a 23% difference of success rate between two arms. To account for a 20% dropout rate, we planned to recruit 75 patients per arm (total 150 patients) into the study.

Study Protocol

Patients were recruited based on a convenience sampling method due to logistical feasibility. Recruited patients were randomly assigned to either one of the methods, HDDB or modified VM, in a 1:1 ratio. For each assigned treatment method, the patient underwent two attempts with a one-minute interval after each attempt to observe for successful cardioversion. The study ended after two attempts, and this was followed by routine care per clinician discretion.

The modified VM required the participants to be seated at a 45° angle and perform a standardised strain for 15 seconds.

Forced expiration through disposable tubing against a digital manometer at a pressure of 40 mm Hg was maintained for 15 seconds. Following this, the patient was laid flat, and his legs raised to a 45° angle for 15 seconds by the ED staff. Lastly, the participant was returned to a 45° semi-recumbent position for 45 seconds. This comprised one attempt. The HDDB method required the participant to lie on a flat bed with a head-down tilt of 30-45°. Five deep breathing and breath holding repetitions were carried out in one attempt. The patients were instructed to take full deep breaths and hold them by counting to 10 before exhaling. This was to encourage breath holding during full inspiration for as long as the patient could tolerate or by the count of 10 (see Figure 1).

The duration of subject participation was the ED consultation at the time of visit with no subsequent trial scheduled visits or follow-up. Patients could have been recruited more than once if they re-presented at the ED with another episode of paroxysmal SVT fulfilling the inclusion/exclusion criteria of the study. A block randomization sequence was prepared by an independent biostatistician. Serially numbered, opaque, sealed envelopes were prepared according to the randomisation list. Study team members opened the envelopes immediately before the procedure. Patients and treating clinicians were not masked to allocation. The study was stopped when the following occurred: 1) success of manoeuvre with cardioversion to normal sinus rhythm; 2) deterioration of patient's condition or haemodynamic instability (unstable SVT) which demanded the stoppage of vagal manoeuvre to conduct other treatment methods such as electrical cardioversion; 3) adverse effects of the method and request by the patient to stop the particular intervention; and 4) catastrophic event such as cardiopulmonary arrest, malignant arrhythmia, acute myocardial infarction, or stroke. Adverse events, if any, were reported to the approving CIRB within the stipulated timeframe. All pre- and post-study ECGs were reviewed by VH Tan and HC Lim to confirm that SVT (not atrial fibrillation or atrial flutter) was the initial rhythm and that it was cardioverted to sinus rhythm in successful cases.

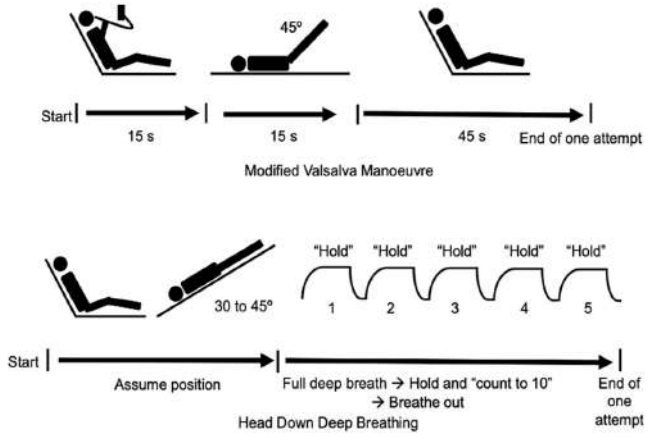

Figure 1. Modified Valsalva manoeuvre and head down deep breathing methods.

Outcomes

The primary outcome of interest was conversion to sinus rhythm. Secondary outcome(s) studied included adverse effects and /or complications associated with each method.

Data Analysis

We present collected data as frequency (percentage) for categorical variables. The Shapiro-Wilk test showed normal distribution was met; hence, continuous variables were presented as mean (standard deviation). We compared subject baseline characteristics between groups using chi-square test or Fisher's exact test for categorical variables, and independent t-test was performed for continuous variables. Analysis was performed in accordance with intention-to-treat principle and missing data were omitted from the analysis. We assessed the association between treatment arm and successful cardioversion as well as adverse event using binary logistic regression model, and results are presented as odds ratios (OR) with 95% confidence intervals (CI). We performed all statistical analyses using SPSS Statistics for Window, version 20 (IBM Corporation, Armonk, NY), and a two-tailed, $P < 0.05$ was set to be considered as statistically significant. No interim data analysis was planned.

RESULTS

During the period 1 August ,2018–1 February, 2020, based on *International Classification of Diseases, 10th Modification* coding, the department attended to 186 patients with SVT. The number of patients who were assessed for eligibility was not recorded. A total of 41 patients were recruited and randomised. No patient was enrolled more than once. The recruitment did not reach the intended sample size of 150 patients due to slow recruitment. This limitation was then compounded by challenges related to policy changes amid the COVID-19 pandemic which resulted in cessation of all CRC activities in the department. Due to the small sample size, inadequate statistical power prevented us from conducting an effective comparison between the two methods, and the study findings are hereby descriptively analyzed.

Among the 41 patients randomised, three (one in the HDDB group and two in the modified VM group) spontaneously cardioverted before receiving the allocated treatment. They were excluded from the final analysis. Two cases in the modified VM group (DBP > 100 mm Hg) and one case in the HDDB group (SBP > 160 mm Hg) were non-compliant to the study protocol because the patients' blood pressure exceeded what was stated in the exclusion criteria. The protocol breach did not result in patient harm, and it was reported to the CIRB with the implementation of a preventive action plan. All three patients were included in the analysis.

In total, 38 patients were analyzed: 19 (50%) in the HDDB group and 19 in the modified VM group (Figure 2). Table 1 displays the baseline characteristics of the sample. Despite the small number of patients, the baseline features appeared sufficiently similar. All patients had initial rhythm SVT, and patients in both groups had comparable initial mean heart rate.

For the primary study outcome, cardioversion was achieved in six patients (31.6%) in the HDDB group and seven patients (36.8%) in the modified VM group. Four (21.1%) patients in the HDDB group and five (26.3%) patients in the modified VM group cardioverted during the first attempt. Modified VM was more likely to have successful cardioversion as compared to HDDB, but the association was not significant (OR: 1.26, 95% CI, 0.33, 4.84; $P = 0.733$]; a similar result was observed for successful cardioversion at first attempt (OR: 1.34, 95% CI, 0.30, 6.02; $P = 0.703$).

A total of 17 (89.5%) patients from the HDDB group and 14 (73.7%) from the modified VM group, respectively, did not encounter any adverse effects. However, patients who received the modified VM had three times the odds of experiencing an adverse effect as compared to HDDB, but the association was not significant (OR: 3.04, 95% CI, 0.51, 18.11; $P = 0.223$). There were no serious adverse events, such as cardiac arrest or malignant arrhythmia, which would have required immediate resuscitation among the patients in both groups. Minor adverse effects such as nausea, sweatiness, and giddiness were reported (Table 2).

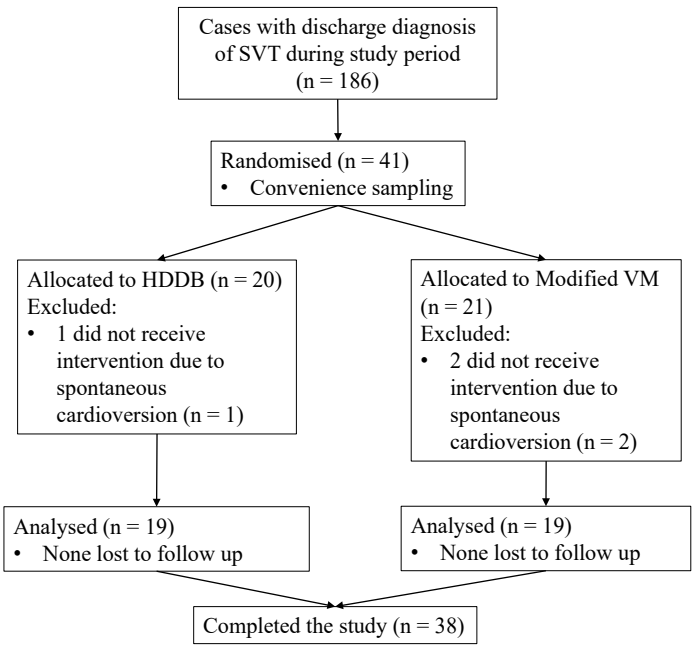

Figure 2. Patient flow diagram.
SVT, supraventricular tachycardia; *HDDB*, head down deep breathing; *VM*, Valsalva manoeuvre.

Two patients in the modified VM group had chest pain. One of them had pain during the first attempt which cardioverted the SVT successfully. Post-conversion ECG did not reveal acute ST-segment changes and he was admitted for observation. The other patient had pain during the second attempt but was able to complete the study without successful cardioversion. The attending doctor then attempted standard VM which also failed, and eventually intravenous (IV) adenosine was successful. The patient was subsequently discharged without any adverse outcome.

Twenty-five (65.8%) patients remained in SVT at the end of the study. Table 3 describes the treatment methods used when the study interventions had failed. Six patients received crossover treatment. All of them underwent the treatment immediately when the study ended as part of usual care. One patient from the modified VM group who received HDDB was successfully cardioverted. The most common drug therapy used was IV adenosine. It demonstrated a high success rate with 17 out of 20 patients (85%) who received this treatment successfully cardioverted. Eventually, all except two (5.3%) patients were cardioverted at the ED. One patient was given IV amiodarone and oral bisoprolol and was admitted for further management. The other patient was discharged against medical advice. The majority of the patients, 73.7% (n = 28) were discharged. Ten patients were admitted; their mean age was 61.1 years.

DISCUSSION

Vagal manoeuvres such as the modified VM slow down conduction in the atrioventricular (AV) node, resulting in the termination of AV nodal dependent reentrant tachycardias such as AVNRT and AVRT, which constitute the majority of regular narrow complex tachycardias. In the ED, the VM is commonly used on patients presenting with SVT. Even in the absence of a manometer, one can use a 10 milliliter Terumo syringe (Terumo Medical Canada Inc., Vaughan, Ontario, Canada) to provide the required 40 mm Hg pressure and achieve the standardised strain needed in a good VM.[6] A Cochrane systematic review did not find sufficient evidence to support or refute the effectiveness of VM for termination of SVT.[7] However, Appelboam et al found that postural modification to the standard VM (REVERT study) had a high success rate of 43% and recommended it as routine first treatment for SVT patients.[4] Another vagal manoeuvre, the carotid sinus massage is less commonly performed due to the risk of cerebrovascular accident and, in rare instances, ventricular tachycardia.[8] It should be avoided in patients with previous transient ischaemic attack or stroke, and in patients with carotid bruits.[2] A study comparing the VM and carotid sinus massage for SVT treatment found similar success rates for the two methods.[9]

We describe the HDDB technique which does not require the patient to execute a VM, removing the need to rely on the patient's effort and ability to deliver a good

Table 1. Baseline characteristics and initial vital signs.

Characteristic	Head down deep breathing group (n = 19) n (%)	Modified Valsalva manoeuvre group (n = 19) n (%)	*P* value
Gender			
Male	8 (42.1)	11 (57.9)	0.330
Female	11 (57.9)	8 (42.1)	
Race			
Chinese	7 (36.8)	12 (63.2)	0.330
Malay	6 (31.6)	2 (10.5)	
Indian	1 (5.3)	1 (5.3)	
Others	5 (26.3)	4 (21.1)	
Age in years, mean (SD)	50.2 (19.0)	54.5 (14.3)	0.433
BMI, n	6	9	0.824
Mean (SD)	24.8 (2.4)	24.2 (5.9)	
History of			
Diabetes mellitus	5 (26.3)	2 (10.5)	0.405
Hypercholesterolaemia	5 (26.3)	4 (21.1)	1.000
Stroke, transient ischaemic attack	0 (0.0)	1 (5.3)	1.000
Atrial fibrillation	1 (5.3)	0 (0.0)	1.000
Initial vital signs			
SBP, mean (SD)	123 (18.9)	126 (17.4)	0.583
DBP, mean (SD)	84 (12.8)	83 (11.7)	0.875
Heart rate, mean (SD)	174 (23.6)	173 (23.5)	0.880
Initial ECG			
SVT	19 (100.0)	19 (100.0)	NA
Values reported as mean (+/- SD) or n (%).			

BMI, body mass index; *SD*, standard deviation; *SBP*, systolic blood pressure; *DBP*, diastolic blood pressure; *ECG*, electrocardiogram; *SVT*, supraventricular tachycardia.

Table 2. Primary and secondary outcomes.

	Head down deep breathing group (n = 19) n (%)	Modified Valsalva manoeuvre group (n = 19) n (%)	Odds ratio (95% CI) REF = HDDB	*P* value
Primary outcomes				
Successful cardioversion	6 (31.6)	7 (36.8)	1.26 (0.33, 4.84)	0.733
Successful cardioversion (at first attempt)	4 (21.1)	5 (26.3)	1.34 (0.30, 6.02)	0.703
Un-sustained cardioversion observed	3 (15.8)	1 (5.3)		
Secondary outcomes				
Adverse effects	2 (10.5)	5 (26.3)	3.04 (0.51, 18.11)	0.223
Types of chest pain/discomfort	0 (0.0)	2 (10.5)		
Nausea	0 (0.0)	2 (10.5)		
Increased palpitation	0 (0.0)	1 (5.3)		
Sweatiness	1 (5.3)	0 (0.0)		
Giddiness	1 (5.3)	0 (0.0)		

CI, confidence interval; *REF*, referecnce; *HDDB,* head down deep breathing.

Table 2. Continued

	Head Down Deep Breathing Group (n = 19) n (%)	Modified Valsalva Manoeuvre Group (n = 19) n (%)	Odds ratio (95% CI) REF = HDDB	*P* value
Serious adverse events (cardiac arrest, malignant arrhythmia)	0 (0.0)	0 (0.0)		
No adverse effect	17 (89.5)	14 (73.7)		

CI, confidence interval; *REF*, referecnce; *HDDB,* head down deep breathing.

quality VM repeatedly. It also avoids the issue of the lack of standardisation as to how the VM is performed.[10] Waxman et al have previously described the capacity of deep inspiration and dependent body position to terminate tachycardia in 11 patients with recurrent paroxysmal SVT.[11] Drawing from their experience, we have reported success with the HDDB technique.[3] It is believed that during inspiration, pulmonary stretch receptors inhibit the efferent vagal tone. By deep breathing in a head down position, venous return to the heart is increased and contributes to a gradual elevation of blood pressure. During expiration, the removal of pulmonary stretch enhances the efferent vagal tone which is also accentuated by the baroreceptors due to raised blood pressure. From our experience, HDDB patients are able to follow our instructions well, to draw full deep breaths and hold their breaths while we count with them at the bedside.

In our study, both HDDB and modified VM showed good success rates. The incidence of cardioversion with HDDB at 31.6% was higher than our anticipated value of 20%. Unfortunately, the minimum number of subjects that needed to be enrolled was not reached; so there was insufficient statistical power to analyse the data for a treatment effect. Both methods were found to be safe and did not result in any major adverse cardiovascular events. The most common choice of drug in accordance with national resuscitation guidelines was IV adenosine, which was effective at cardioverting most patients who failed vagal manoeuvres safely. We conclude that HDDB is a simple technique which is a useful addition to the current repertoire of vagal manoeuvres for the acute ED management of stable SVT. Further studies are needed to outline its safety and clinical efficacy.

LIMITATIONS

Limitations include a small sample size which prevented effective comparison of treatment effects between the two techniques. Additionally, due to the convenience sampling method, not every patient who presented with paroxysmal SVT was assessed for eligibility. This could have led to selection bias. Finally, adverse effects were reported by patients and not consistently verified by the investigators and CRCs with a checklist. This may potentially have resulted in under-reporting.

CONCLUSION

Our study found that both head down deep breathing technique (31.6% success) and modified Valsalva manoeuvre

Table 3. Treatment methods used and the success rates when study interventions failed.

*Treatment methods used	Head down deep breathing group (n = 13) n (%)	Modified Valsalva manoeuvre group (n = 12) n (%)	*P* value
†Crossover to modified VM or HDDB	5 (38.5)	1 (8.3)	0.160
Successful cardioversion	0 (0.0)	1 (100.0)	
IV adenosine	11 (84.6)	9 (75.0)	0.645
Successful cardioversion	10 (90.9)	7 (77.8)	
Carotid massage	3 (23.1)	2 (16.7)	1.000
Successful cardioversion	1 (33.3)	1 (50.0)	
Standard VM	2 (15.4)	2 (16.7)	1.000
Successful cardioversion	1 (50.0)	1 (50.0)	
IV verapamil	0 (0.0)	1 (8.3)	1.000
Successful cardioversion	0 (0.0)	1 (100.0)	

*Total number of treatment methods exceed the number of patients because several patients needed more than one method for cardioversion. Two patients did not have cardioversion to sinus rhythm.
†All patients who received crossover treatments had it immediately when the study ended as part of usual care.
VM, Valsalva manoeuvre; *HDDB*, head down deep breathing; *IV*, intravenous.

described by the REVERT study (36.8% success) were effective in cardioverting ED patients with supraventricular tachycardia. Both methods were safe and did not result in any major adverse cardiovascular events. This suggests that the HDDB method is a simple technique and a useful addition to the current repertoire of vagal manoeuvres for the acute management of stable SVTs, especially in low-resource settings. However, this is a preliminary study with small numbers, and further studies are needed to outline its safety and clinical efficacy.

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Quality Improvement Initiative to Increase Rate of and Time to Post-intubation Analgesia in the Emergency Department

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Introduction: Intubation and mechanical ventilation are common interventions performed in the emergency department (ED). These interventions cause pain and discomfort to patients and necessitate analgesia and sedation. Recent trends in the ED and intensive care unit focus on an analgesia-first model to improve patient outcomes. Initial data from our institution demonstrated an over-emphasis on sedation and an opportunity to improve analgesic administration. As a result of these findings, the ED undertook a quality improvement (QI) project aimed at improving analgesia administration and time to analgesia post-intubation.

Methods: We performed a pre-post study between January 2017–February 2019 in the ED. Patients over the age of 18 who were intubated using rapid sequence intubation (RSI) were included in the study. The primary outcome was the rate of analgesia administration; a secondary outcome was time to analgesia administration. Quality improvement interventions occurred in two phases: an initial intervention focused on nursing education only, and a subsequent intervention that included nursing and physician education.

Results: During the study period, 460 patients were intubated in the ED and met inclusion/exclusion criteria. Prior to the first intervention, the average rate of analgesia administration was 57.3%; after the second intervention, the rate was 94.9% (P <0.01). Prior to the first intervention, average time to analgesia administration was 36.0 minutes; after the second intervention, the time was 16.6 minutes (P value <0.01).

Conclusion: This QI intervention demonstrates the ability of education interventions alone to increase the rate of analgesia administration and reduce the time to analgesia in post-intubation patients. [West J Emerg Med. 2021;22(4):827–833.]

INTRODUCTION

Rapid sequence intubation (RSI) and mechanical ventilation are common interventions performed in the emergency department (ED). These interventions cause pain and discomfort to patients.[1,2] Patients generally require pharmacologic interventions to tolerate ongoing mechanical ventilation. These medications are generally categorized as analgesics or sedatives.

Multiple studies have demonstrated risks with excessive sedation. A landmark study in 2000 by Kress et al coined the term "sedation vacation" and correlated reduced sedation with decreased days spent on the ventilator and in the intensive care unit (ICU).[3] Further studies demonstrated a relationship between deep sedation and worse patient outcomes including delayed extubation, increased delirium, and increased mortality.[4,5] A follow-up, multicenter, randomized controlled trial indicated

that goal-directed sedation was "feasible, appeared safe, achieved early light sedation, minimized benzodiazepines and propofol, and decreased the need for physical restraints."[6] The risks of sedation extend to the ED, with one prospective cohort study showing a significant mortality association with "early deep sedation" in patients intubated in the ED.[7]

Recent critical care literature has shown that minimizing sedation via development of a nursing or pharmacist protocol leads to improvement in patient-centered outcomes such as decreased number of intubated days and decreased hospital length of stay.[8,9] Research also suggests that sedation can be minimized by switching to an analgesia-first model. A comparative study in Cambridge, UK, showed that protocols emphasizing analgesia can lower sedation requirements for mechanically ventilated patients.[10] Additional studies demonstrate similar findings, including one ICU clinical trial.[11,12]

An initial analysis of the use of post-intubation pharmacologic agents in our institution's ED indicated an overemphasis on sedation and an opportunity to increase analgesic administration. We collected data on a sample of 390 intubated and mechanically ventilated patients between January 2016–October 2017 in the ED. During this period, 30% of patients received sedation without analgesia and 13% received neither analgesia nor sedation, seemingly inconsistent with the research presented above that demonstrates improved patient outcomes with analgesia followed by light, goal-directed sedation. As a result of these initial findings, the ED undertook a quality improvement (QI) project aimed at improvement of analgesia administration and time to analgesia post-intubation.

Population Health Research Capsule

What do we already know about this issue?
Excessive sedation has been correlated with negative patient outcomes post-intubation; emphasizing analgesia has been shown to reduce patient sedation requirements.

What was the research question?
Can a quality improvement project increase the rate of analgesia administration and reduce time to analgesia post-intubation?

What was the major finding of the study?
A cross-functional education intervention successfully improved both measures.

How does this improve population health?
Increasing timely analgesia post-intubation can help reduce sedation requirements, a recognized contributor to negative patient outcomes.

METHODS

Study Design

This pre-post interventional study evaluated the rate of analgesia administration and time to analgesia following RSI in the ED. This study evaluated outcomes both prior to and following two separate interventions. As a QI project, this study was deemed exempt from institutional review board approval.

Study Setting

This study was conducted at a large, academic, tertiary care center in the Midwest.

Patient Selection

Patients over the age of 18 who were intubated in the ED using RSI from January 2017 –February 2019 were included in the study. Both induction and paralytic agents must have been given to the patients to make them eligible for participation.. We excluded patients who were in cardiac arrest or profound shock (defined as mean arterial pressure < 65 millimeters mercury in the peri-intubation phase of care and/or those on vasopressors). We also excluded patients who were trauma activations because initial resuscitation for these patients is managed jointly between the ED and trauma team at this institution, and our intervention efforts were designed to target ED staff only.

Data Collection and Measures

A dataset of patients meeting inclusion criteria was generated via a query of our electronic health record (EHR) system Epic (Epic Systems Corporation, Verona, WI). We collected data on the date, time, and medications given in the peri-intubation phase of care. For each patient, the induction and paralytic agents were identified, and we recorded the first analgesic and/or sedative given after intubation. Induction agents included etomidate, ketamine, propofol, and midazolam. Paralytic agents included rocuronium, succinylcholine, and vecuronium. The first dose of fentanyl or ketamine after the induction agent, if given, was recorded as an analgesic agent. The first dose of propofol, midazolam, ketamine, lorazepam, or dexmedetomidine, if given, was recorded as a sedative agent.

After collecting the data, we calculated how many patients received no analgesia; analgesia only; no sedation; sedation only; and those who received both analgesia and sedation. We also calculated the time to administer the analgesic from the time the induction agent was given. As a subanalysis, we were interested in the subset of patients who received rocuronium during RSI, as these patients experience longer durations of paralysis, which can have implications on timing of analgesia and sedation.

Interventions

During the study period, two interventions were completed: a nursing-only education intervention in November 2017 followed by a broader physician and nursing

education intervention in May 2018. A systems improvement, in the form of a new EHR order-set that centralized post-intubation analgesia and sedation options with laboratory and imaging orders (eg, post-intubation chest radiograph [CXR] and arterial blood gas) was initially planned as part of the second intervention; however, due to information technology (IT) delays, this systems improvement was developed and implemented later. The order-set was ultimately implemented in February 2019 after our post-implementation evaluation period. Any improvement tied to the systems enhancement was intentionally not included in our results below. For the purposes of this study, the pre-intervention timeframe included patients from January 1–October 31, 2017, post-intervention 1 from December 1, 2017–April 30, 2018, and post-intervention 2 from June 1, 2018– February 28, 2019.

The first intervention included nursing-only education focused broadly on all elements of intubation and occurred between November 1–November 30, 2017. During this period, all ED nurses were required to complete education and could choose from an in-person class or self-study with a subsequent test. Thirty-one nurses chose to attend in-person, and 94 chose self-study. Topics in person and via self-study were identical and are included in Table 1. A test of proficiency was created in house; nurses were required to score 80% or better and could retake the test until achieving that score.

Table 1. Nursing training topics.

- Rapid sequence intubation (RSI)
  - 7 Ps of RSI (preparation, preoxygenation, pretreatment, paralysis, protection, placement, post-intubation management)
  - RSI medications (induction agents, paralytics)
  - The failed airway
- Detailed post-intubation management
  - Analgesia and sedation
  - Medications (analgesics, sedatives)
  - Ventilator management

The second intervention targeted education of both nurses and physicians and took place during May 2018. For the nursing staff, the second intervention served as an opportunity to review the material described above. Seventy ED nurses attended an in-person class; understanding was again tested using the identical online test of proficiency. Physician education interventions focused more heavily on residents (than attendings) and included the following: (1) one hour off-line, self-study topic for residents using outside sources in preparation for weekly didactics on May 23, 2018; (2) journal club discussion on the topic during weekly didactics on May 23, 2018; and (3) an interactive live presentation reviewing ED post-intubation analgesia and sedation performance during resident didactics on May 23, 2018. Attending physicians received the same presentation (#3 described above) during the May 2018 ED faculty staff meeting. Finally, the findings from #3 were summarized and emailed to all resident and attending physicians for offline review. Physician interventions did not include a test of understanding/proficiency. Table 2 provides a detailed list of source materials for resident didactics and journal club.

Table 2. Physician training topics.

Off-line, Self-Study Topics	• A New Paradigm for Post-Intubation Pain, Agitation and Delirium (PAD)[13] • Management of Pain, Agitation and Delirium in the ICU[14]
Journal Club Articles	• Analgosedation Practices and the Impact of Sedation Depth on Clinical Outcomes Among Patients Requiring Mechanical Ventilation in the ED: A Cohort Study.[7] • Impact of an Analgesia-Based Sedation Protocol on Mechanically Ventilated Patients in a Medical Intensive Care Unit[11]

ICU, intensive care unit; *ED,* emergency department.

These interventions were undertaken with the support but not the mandate of departmental and residency leadership. We did not analyze the performance or behavioral change of individual providers as part of this project. Moreover, providers were informed that aggregate, rather than individual, performance would be reported. There were no additional incentives, explicit or implicit, for providers to implement these changes.

Statistics

We summarized categorical variables with frequency and percentages. Due to non-normal distribution, continuous variables were summarized by means, medians and interquartile range. We tested associations between categorical variables using chi-square test. We used analysis of variance and, where appropriate, we used non-parametric Wilcoxon rank-sum test and Kruskal-Wallis test to make global comparisons of continuous variables across groups. Two-sided *P*-values less than 0.05 were considered statistically significant. Data management and statistical analyses were performed using SAS software (version 9.4) (SAS Institute Inc., Cary, NC).

RESULTS

A total of 192 intubations occurred during the pre-intervention period, 90 during post-intervention period 1, and 178 during post-intervention period 2. Patient characteristics are shown in Table 3. Vital signs represent first recorded after intubation. Analysis showed a statistical difference in paralytic used across the three study time

Table 3. Patient characteristics.

Characteristic	Pre-intervention (N = 192)	Post-intervention 1 (N = 90)	Post-intervention 2 (N = 178)	P-value **
Age (years)	58.5, 60 (20.5)	60.6, 61.5 (26)	59.4, 60.5 (21)	0.60
Male (%)	55.7	52.2	51.1	0.66
Weight (kg)	84.7, 80.7 (32.1)	81.2, 76 (31.8)	80.5, 78.7 (32)	0.23
Induction Agent (%)				0.33
Etomidate	84	82	83	
Ketamine	13	11	12	
Propofol	2	7	4	
Midazolam	2	0	1	
Paralytic Agent (%)				<0.01
Rocuronium	68	88	91	
Succinylcholine	32	12	9	
Post intubation Systolic (mm Hg)	141, 138 (45)	147, 148 (51)	148, 142 (49)	0.29
Post-intubation Diastolic (mm Hg)	85, 85 (33)	88, 88 (32)	91, 88 (31)	0.06
Post-intubation Mean Arterial Pressure (mm Hg)	98, 98 (35)	102, 101 (26)	106, 102 (32)	0.09
Post-intubation Heart Rate (per minute)	107, 107 (39)	108, 109 (27)	110, 107 (39)	0.61
Post-intubation Respiratory Rate (per minute)	18, 17 (6)	19, 18 (5)	18, 17 (6)	0.48
Post-intubation SpO_2 (percent)	97.3, 99 (2)	98.4, 100 (1)	98.2, 100 (1)	0.21

-- Mean, median (interquartile range) unless specified otherwise.
** P-values based on analysis of variance. Gender and paralytic agent P-values are based on chi-square test. Induction agent P-value is based on Fisher's exact test.
kg, kilograms; *mm Hg,* millimeters mercury; *SpO_2,* oxygen saturation.

periods. Analysis otherwise showed no statistically significant difference between patients in each group for the characteristics collected.

Table 4 presents rates of analgesia and/or sedation. Data includes the number of patients in each group prior to any intervention and after each intervention. The rate for groups 2 (analgesia without sedation) and 4 (analgesia and sedation) increased after each intervention, whereas a reverse trend was seen in the other groups (*P*-value <0.01).

Table 4. Rates of analgesia and sedation.

Administration of Analgesia and/or Sedation	Pre-intervention (N = 192)	Post-intervention 1 (N = 90)	Post-intervention 2 (N = 178)
No Analgesia or Sedation	16 (8.33%)	3 (3.33%)	2 (1.12%)
Analgesia without Sedation	4 (2.08%)	3 (3.33%)	20 (11.24%)
Sedation without Analgesia	66 (34.38%)	22 (24.44%)	7 (3.93%)
Analgesia and Sedation	106 (55.21%)	62 (68.89%)	149 (83.71%)

Given a focus on analgesia administration in this QI project, Figure 1 summarizes total analgesia rate for each time period. Total sedation rate is included for comparison. The percent of intubated patients receiving analgesia increased after each intervention. This improvement in analgesia administration rate was statistically significant (*P* <0.01). Sedation rate minimally increased after the first intervention and then decreased after the second intervention. However, these changes in sedation rates were not statistically significant (*P* = 0.35).

Statistically, there was no difference in rates of analgesia (*P* = 1.0) between months 1-2 (95%) and months 8-9 (95%) during the post-intervention 2 time period. Similarly, there was no difference in rates of sedation (*P* = 0.14) between the same months (95% and 85%, respectively).

In addition to improving analgesia rate, this QI project aimed to improve the time to analgesia administration (time from administration of induction agent to administration of analgesic agent). Comparisons were made pairwise between pre-intervention and post-intervention groups. Figure 2 summarizes these comparisons. For all paralytics, time to analgesia increased comparing pre-intervention and post-intervention 1 groups (36.0 minutes to 39.8 minutes,

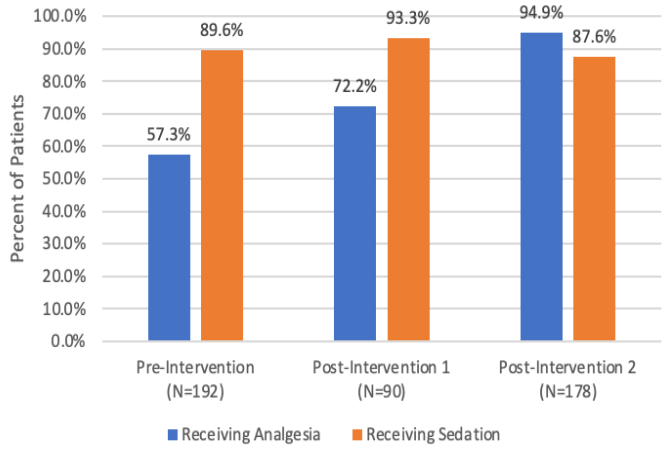

Figure 1. Percent of patients receiving analgesia, sedation.

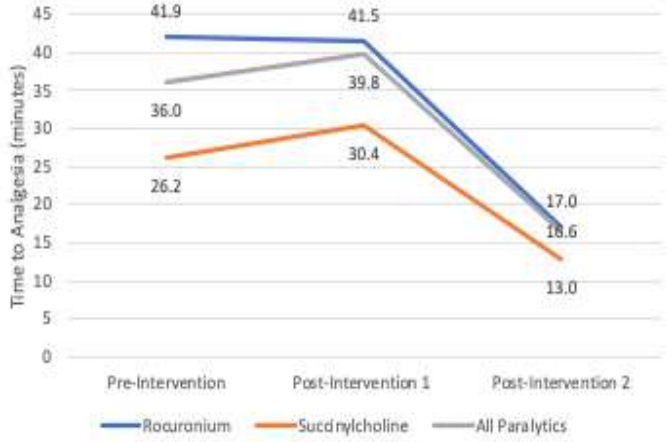

Figure 2. Time to analgesia (induction agent to analgesic agent).

respectively) but was not statistically significant ($P = 0.27$). For all paralytics, time to analgesia decreased comparing post-intervention 1 and post-intervention 2 groups (39.8 minutes to 16.6 minutes, respectively) and was statistically significant ($P < 0.01$). Finally, for all paralytics, time to analgesia also decreased comparing pre-intervention and post-intervention 2 groups (36 minutes to 16.6 minutes, respectively) and was also statistically significant ($P < 0.01$).

Figure 2 also breaks down time to analgesia by agent for each time period. After both interventions, time to analgesia for rocuronium-induced intubations decreased (41.9 minutes vs 17.0 minutes) and succinylcholine-induced intubations decreased (26.2 minutes vs 13.0 minutes).

DISCUSSION

Following the first intervention, the rate of analgesia administration increased from 57.3% to 72.2% as a result of nursing-focused education.[15] Despite demonstrating an improvement, the magnitude of change was smaller than desired. Moreover, time to analgesia demonstrated no statistically significant change. In examining the intervention, impediments to improvement were thought to be as follows:

1. *Narrow scope.* Training during the first intervention was limited to nursing staff and excluded other material stakeholders, namely resident and attending physicians.
2. *Ordering complexity.* The ordering process (via EHR) required ordering medications for RSI and post-sedation care individually or using multiple order-sets.
3. *Inconsistent pain assessment.* The existing ventilator pain assessment tool seemed to be inconsistently used and rarely documented by nursing.

Interestingly, providers' average choice of paralytic agent before and after the first intervention were statistically different. This nursing-focused intervention did not favor or emphasize one paralytic over another. We assume that rather than being the result of the intervention, this change in behavior correlates with the availability of rocuronium's reversal agent sugammadex in our ED. However, the increasing use of rocuronium does create additional complexity in post-intubation analgesia and sedation. Theoretically, delays in pharmacologic administration could occur as paralysis is mistaken for lack of agitation or pain. One medical center noted a delay in administration of analgesia or sedation by about 30 minutes on average post-intubation following use of rocuronium.[16] The duration of action of rocuronium can likely explain this discrepancy, as typical triggers for sedation and analgesia are blocked by the longer acting paralytic. One ED in Tucson, AZ, was able to use a pharmacist-led education program to eliminate this delay.[17]

Based on the small magnitude of change following our first intervention, a second intervention was intended to address the shortcomings identified above, first by broadening the scope of education and training to include physicians. Second, the intervention intended to simplify the ordering process through the creation of a new single EHR order-set that centralized post-intubation analgesia and sedation options and included RSI medication orders with related laboratory and imaging orders (eg, post-intubation CXR and arterial blood gas). As discussed above, due to IT delays, this improvement was rolled out later as a third intervention. The order-set was ultimately implemented in February 2019 after our post-implementation evaluation period. Any improvement tied to this system enhancement is not included in our results. Moreover, outside of the study authors and the department chair, no participating nurse, resident, or attending physician was involved in or aware of the planned order-set, thus limiting any confounding effect. Finally, the second intervention intended to reinforce (during a second round of nursing training) the hospital process and tool for

ventilator pain assessment. These included not only more consistently assessing patient pain but also an emphasis on better documentation.

Following the second intervention, the rate of analgesia administration increased to 94.9%, and time to analgesia improved from 36.0 minutes pre-intervention to 16.6 post-intervention. This represents an improvement in both primary and secondary variables. Further, analysis comparing the first two to the last two months of this period demonstrated no statistically significant fatigue in adherence to training.

Some of the key factors that contributed to the ultimate success of this project included establishing a multidisciplinary team that included representatives from each major stakeholder group including nursing, pharmacists, resident physicians, and attending physicians. While the first intervention was narrowly focused on nursing education, a second broader intervention built on and expanded this initial work; a third intervention will incorporate EHR/systems changes. Key to the success of this project was using an iterative cycle to conduct multiple tests of change. This approach is known as the plan-do-study-act (PDSA) cycle. "[PDSA] cycles are the building blocks of iterative healthcare improvement. Each cycle combines prediction with a test of change (in effect, hypothesis testing), analysis and a conclusion regarding the best step forward—usually a prediction of what to do for the next PDSA cycle."[18] Finally, a balanced set of interventions targeting people, process, and technology was central in driving success.

LIMITATIONS

A primary limitation of this QI effort was that the study's data collection periods were unequal, subjecting results to potential differing effects of seasonality and potential differing degrees of adherence to training. Second, the study's key outcome variables did not directly measure clinical outcomes. Measuring a primary patient outcome such as time to target pain score (eg, Critical Care Pain Observation Tool score) would be preferable but was problematic due to incomplete and/or inaccurate data). A subsequent QI project could target improving the capture and reporting of this data. Additionally, measuring primary patient outcomes such as post-extubation assessment of pain during a period of intubation and mechanical ventilation was designed to be out of scope due to the logistical difficulty and cost to collect such data. That said, based on the research cited in the introduction to this manuscript, we believe faster and more complete analgesia leads to improved patient experience and outcomes.

Third, the study demonstrated no statistical change in the rates of sedation before and after intervention but did not report the effect of the QI intervention on time to sedation. Theoretically, a focus on time to analgesia could have an unintended consequence on time to sedation. Third, the study excluded trauma activations from the study during the design phase due to dual management of these patients between ED and trauma teams. In addition, because this was a retrospective chart review the results are subject to potential issues related to validity and reliability inherent to this study type, including inaccurate or incomplete information in the medical chart. As a non-blinded, pre-post study, the results are subject to the Hawthorne effect and lack of comparison arm inherent to this study type. Finally, this study was performed at a single hospital and single ED, which inherently limits its generalizability.

CONCLUSION

This quality improvement initiative was successful in increasing the rate of analgesia administration and reducing the time to analgesia in post-intubation patients in a single academic ED. The use of an iterative, plan-do-study-act process yielded improvements after each intervention. Areas for further study would include (1) assessing the impact of a new EHR order-set on the study's primary variables and (2) determining the clinical significance of improving rates of analgesia and time to analgesia.

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Conflicts of Interest: By the WestJEM 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.

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Comparing Drugs for Out-of-hospital, Shock-refractory Cardiac Arrest: Systematic Review and Network Meta-analysis of Randomized Controlled Trials

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Introduction: The benefit of medications used in out-of-hospital, shock-refractory cardiac arrest remains controversial. This study aims to compare the treatment outcomes of medications for out-of-hospital, shock-refractory ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT).

Methods: The inclusion criteria were randomized controlled trials of participants older than eight years old who had atraumatic, out-of-hospital, shock-refractory VF/pVT in which at least one studied group received a medication. We conducted a database search on October 28, 2019, that included PubMed, Scopus, Web of Science, CINAHL Complete, and Cochrane CENTRAL. Citations of relevant meta-analyses were also searched. We performed frequentist network meta-analysis (NMA) to combine the comparisons. The outcomes were analyzed by using odds ratios (OR) and compared to placebo. The primary outcome was survival to hospital discharge. The secondary outcomes included the return of spontaneous circulation (ROSC), survival to hospital admission, and the neurological outcome at discharge. We ranked all outcomes using surface under the cumulative ranking score.

Results: We included 18 studies with 6,582 participants. The NMA of 20 comparisons included 12 medications and placebo. Only norepinephrine showed a significant increase of ROSC (OR = 8.91, 95% confidence interval [CI], 1.88-42.29). Amiodarone significantly improved survival to hospital admission (OR = 1.53, 95% CI, 1.01-2.32). The ROSC and survival-to-hospital admission data were significantly heterogeneous with the I2 of 55.1% and 59.1%, respectively. This NMA satisfied the assumption of transitivity.

Conclusion: No medication was associated with improved survival to hospital discharge from out-of-hospital, shock-refractory cardiac arrest. For the secondary outcomes, norepinephrine was associated with improved ROSC and amiodarone was associated with an increased likelihood of survival to hospital admission in the NMA. [West J Emerg Med. 2021;22(4)834–841.]

INTRODUCTION

Cardiac arrest remains one of the major causes of disability and mortality. The worldwide incidence of adult out-of-hospital cardiac arrest (OHCA) treated by emergency medical services was estimated at 62.3 per 100,000 person-years.[1] However, the overall survival rate of OHCA is less

than 10%.[2] Four electrocardiographic rhythms in cardiac arrest include ventricular fibrillation (VF), ventricular tachycardia (VT), asystole, and pulseless electrical activity (PEA). According to the American Heart Association (AHA) guidelines, defibrillation is recommended for VF and pulseless VT (pVT). Shock-refractory VF/pVT is defined as VF or pVT resistant to one or more defibrillations.[3,4] The AHA guidelines for Advanced Cardiac Life Support (ACLS) also recommend the use of epinephrine, amiodarone, and lidocaine after failing one or more defibrillations.[3,4] However, due to the lack of compelling evidence, these agents are not strongly recommended (Class-IIb recommendations).[3]

The benefits of medications for refractory, shockable cardiac arrest remain controversial. In one network meta-analysis (NMA) of vasopressors, the combination of epinephrine, vasopressin, and methylprednisolone was associated with good neurological outcome at discharge and the return of spontaneous circulation (ROSC).[5] While this NMA found no benefit of epinephrine, another meta-analysis showed an increased rate of ROSC and survival to hospital discharge for OHCA.[6] Two NMAs of antiarrhythmic drugs found that lidocaine and amiodarone could improve the survival-to-hospital discharge rates of individuals with out-of-hospital, shock-refractory VF/pVT.[7,8] In contrast, another meta-analysis found increased short-term and long-term survival with nifekalant, but not amiodarone treatment.[9]

To our knowledge, there has been no attempt to perform a NMA comparing different classes of medications for out-of-hospital, shock-refractory VF/pVT patients. The previous two NMAs only compared the benefit among antiarrhythmic drugs in those patients.[7,8] Another NMA compared vasopressors in adults with both out-of-hospital and in-hospital cardiac arrest, but the subgroup analysis of shock-refractory VF/pVT was not explored.[5] For these reasons, we conducted a NMA comparing the benefit of any medications in patients with out-of-hospital, shock-refractory VF/pVT.

METHODS

This systematic review was reported in accordance with the "PRISMA Extension Statement for Reporting of Systematic Reviews Incorporating Network Meta-analyses of Health Care Interventions: Checklist and Explanations."[10] The protocol of this study was prospectively registered on the PROSPERO website (registration ID: CRD42020149976).

Inclusion Criteria for a Trial

The inclusion criteria were as follows; 1) any randomized controlled trial (RCT) not applying a crossover design; 2) participants > 8 years old who had atraumatic, out-of-hospital, shock-refractory VF or pVT; 3) at least one studied group received a medication; and 4) a report of ROSC, survival to hospital admission, survival to hospital discharge, or neurological outcome at discharge. Good neurological outcome was defined by the cerebral performance category score of 1-2 or modified Rankin scale score of 0-3. The participants' criteria were selected only from those aged eight or older because the pediatric cardiac arrest algorithm ends at eight years of age, and the automated external defibrillator can only be applied to those older than eight.

Study Selection and Search Strategy

We performed a database search on October 28, 2019, that included PubMed, Scopus, Web of Science, Cochrane CENTRAL, Academic Search Complete, and CINAHL Complete. Citations from relevant meta-analyses were also searched.[5,8] We searched the databases from their inceptions to the final search date, with no language limitation. The Medical Subject Headings terms included a combination of search terms with various spellings and endings: "shock-refractory," "ventricular fibrillation," "ventricular tachycardia," "cardiac arrest'," "heart arrest," "cardiopulmonary resuscitation," "prehospital," and "out-of-hospital." The detailed search terms are provided in the supplementary data (see Appendix). We collected the search results obtained from these databases and removed the duplicates. Non-duplicated citations were imported into the Rayyan QCRI website, and the abstracts of the citations were independently screened and selected by two authors (KS and TT). Any discrepancy was resolved by a consensus discussion.

Data Extraction and Trial Quality Assessment

We designed a data extraction form to collect the age, eligible criteria, setting, gender, details of drug interventions, additional interventions, and the per-protocol outcomes (ROSC, survival to hospital admission, survival to hospital discharge, and neurological outcome at discharge). Three authors (KS, CK, and SS) independently extracted the data. The quality of the included study was also independently assessed by three authors (KS, SK, and WC) using the RoB2, a revised tool for assessing the risk of bias in randomized trials.[11] The quality aspects assessed by this scale included randomization, deviations from the intended interventions, missing outcome data, measurement of the outcomes, and selection of reported results. Any discrepancy was resolved by a consensus discussion.

Statistical Analysis

We estimated the odds ratios (OR) and their 95% confidence intervals (CI) of the outcome difference between each pair of intervention groups. The pairwise ORs were estimated using the following equation:

$$OR = \frac{events\ occurred\ in\ the\ first\ arm}{participants\ without\ an\ event\ in\ the\ first\ arm} \times \frac{participants\ without\ an\ event\ in\ the\ second\ arm}{total\ participants\ in\ the\ second\ arm}$$

An OR higher than one inferred the superior effect size of the first arm compared to the second arm. However, for the studies with more than two arms, we estimated the ORs in every pair of interventions. We excluded the analysis of interventions in addition to the randomized interventions, assuming that this study design could ameliorate the confounding effect.

We performed the frequentist NMA to compare the outcomes among the medications. Conventional meta-analysis provides a result from trials of head-to-head comparisons of two or more tests or interventions resulting in "direct evidence." Thus, this issue makes it impossible to assess the relative treatment effect between comparators. A NMA helps to create an "indirect effect" when studies test interventions that have been compared with a common comparator but not directly against one another.[12] The application of variance structure was determined by the levels of heterogeneity (fixed-effect model for $I^2 < 50\%$ and random-effect model for $I^2 \geq 50\%$). The NMA was conducted using the inverse variance method. And we ranked the outcomes by the surface under the cumulative ranking curve (SUCRA) method, the estimated summary result of treatment outcomes for ranking all of the competitive treatment, which is beneficial for a decision-making perspective, for example, selecting the treatment with the best credible evidence. The transitivity assumption of each NMA was evaluated by the node-splitting method. We used Egger's test for funnel plot asymmetry to assess the publication bias. Any *P*-value of less than 0.05 was considered statistically significant.

We performed the NMA using the netmeta package in RStudio (RStudio, PBC, Boston, MA).[13] The netmeta, netsplit, netrank, and funnel.netmeta functions were used for NMA, node-splitting analysis, the SUCRA score calculation, and the publication bias assessment, respectively.

RESULTS

Study Selection

We found 501 relevant citations (Figure 1). After removing the duplicates, 285 citations remained. Of these, we excluded 244 articles by abstract screening, and an additional 23 articles were then excluded after full-text screening. In the conclusion. We included 18 studies with a total of 6,582 participants in this systematic review (see Appendix).[14–31] This NMA compared 12 medications with placebo, which derived from 20 direct comparisons (Figure 2).

Characteristics and Quality of the Included Studies

From all of the 18 included studies (Appendix), one study consisted of three experimental arms. Seven out of 10 antiarrhythmic drug trials administered epinephrine before the randomization. Out of 18 studies, 17 were conducted in Europe and America, while one was conducted in Japan. Participants were 60 years of age and older. The publication years of the trials ranged from 1981 to 2016.

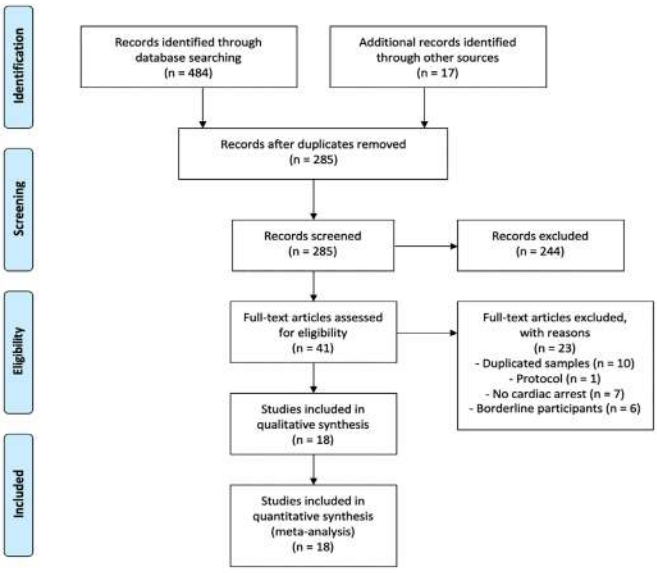

Figure 1. The PRISMA flow diagram.

Non-pharmaceutical interventions, such as defibrillation and bystander Basic Life Support, were concurrently given in all trials. Using the RoB2, we found that 12 studies had a low risk of bias whereas the other six studies had some concerns.

Survival to Hospital Discharge

The NMA of survival to hospital discharge consisted of 18 studies, including 20 pairwise comparisons. Because no significant heterogeneity was found ($I^2 = 0\%$) we conducted the NMA using a fixed-effect model. Among 13 medications compared to placebo, no medication significantly improved the survival to hospital discharge (Figure 3). Norepinephrine was the first ranking in survival to hospital discharge (SUCRA score = 0.85), followed by vasopressin (SUCRA score = 0.76) and epinephrine (SUCRA = 0.76). The head-to-head comparisons and the ORs of included medications are presented in the supplementary data. The NMA satisfied the assumption of transitivity as there was no significant difference between direct and indirect comparisons found by the node-splitting method. We did not find a significant publication bias using Egger's test for funnel plot asymmetry ($P = 0.46$).

Return of Spontaneous Circulation

The NMA of ROSC consisted of 14 studies, including 16 pairwise comparisons. High heterogeneity was found ($I^2 = 55.1\%$), so we conducted the NMA using a random-effect model. Among the 11 medications compared to placebo, only norepinephrine significantly improved the ROSC (OR = 8.91, 95% CI, 1.88-42.29) (Figure 4). Norepinephrine was also in the first ranking among the included medications (SUCRA score = 0.99), followed by epinephrine (SUCRA score = 0.76) and vasopressin (SUCRA score = 0.73). The head-to-head comparisons are presented in the supplementary data. The

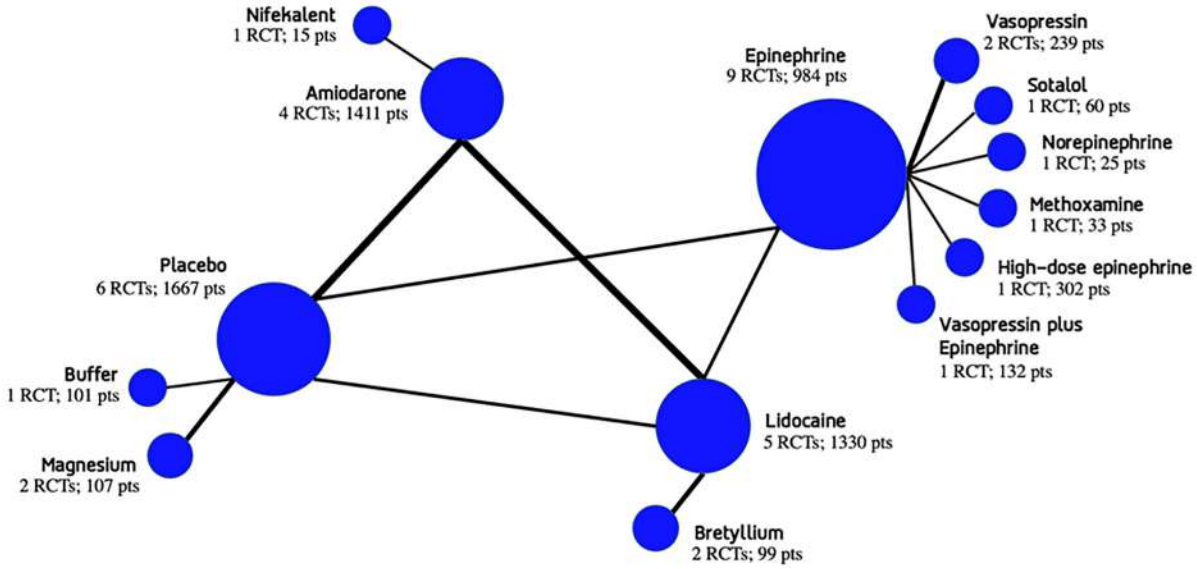

Figure 2. Network graph of 12 medications and placebo. The width of the lines is proportional to the sample size.

NMA satisfied the assumption of transitivity as there was no significant difference between direct and indirect comparisons found by the node-splitting method. Neither did we find a significant publication bias using Egger's test for funnel plot asymmetry *(P* = 0.39).

Survival to Hospital Admission

The NMA of survival to hospital admission consisted of 13 studies, including 18 pairwise comparisons. High heterogeneity was found (I^2 = 59.1 %), so we conducted the NMA using a random-effect model. Among the 10 medications compared to placebo, only amiodarone (OR = 1.53, 95% CI, 1.01-2.32) significantly improved the survival to hospital admission (Figure 5). Moreover, amiodarone was the first ranking among the included medications (SUCRA score = 0.76), followed by vasopressin (SUCRA score = 0.75) and epinephrine (SUCRA score = 0.68). The head-to-head comparisons are presented in the supplementary data. The NMA satisfied the assumption of transitivity as there was no significant difference between direct and indirect comparisons found by the node-splitting method. Significant publication bias was found using Egger's test for funnel plot asymmetry (*P* = 0.03).

Good Neurological Outcome at Discharge

The NMA of good neurological outcome at discharge consisted of only three studies, including five pairwise comparisons. Heterogeneity analysis was not applicable due to the insufficiency of the data. No intervention could improve the neurological outcome at discharge (Figure 6). Magnesium sulfate was the first ranking among four medications (SUCRA score = 0.72). We could not perform the node-splitting method due to the data inadequacy. Publication bias analysis was also not appropriate due to the small number of included studies.

DISCUSSION

We conducted this NMA to compare the treatment outcomes of multiple different medication classes in out-of-hospital, shock-refractory VF or pVT. This systematic review included moderate- and high-quality studies. The ROSC and survival to hospital admission data were highly heterogeneous. No medications improved survival to hospital discharge or neurological outcomes at discharge. Norepinephrine not only improved the ROSC but also demonstrate some benefit for survival to hospital discharge. Amiodarone was superior to placebo for the increased survival to hospital admission. All NMAs satisfied the assumption of transitivity. However, the publication bias of the survival to hospital admission might come from the fact that some studies did not report that outcome.

Despite comparing the different mechanisms of medication (antiarrhythmic drugs, vasopressors, steroid, etc.), NMA was a type of statistical approach designed to search for potential treatments that might not be directly compared. Besides, all NMAs in our study met the assumption of transitivity, which meant that potential treatment-effect modifiers were identified and balanced across the comparisons. The outcomes of antiarrhythmic drugs were inconsistent with the results of a previous NMA,[8] as lidocaine and amiodarone were not associated with improved rates of survival to hospital discharge for out-of-hospital, shock-refractory VF or pVT. While a previous meta-analysis found benefit of nifekalant on short-term and long-term survival,[9] the present NMA did not find its benefit on any outcomes.

These contrasting findings might be caused by the study designs of the included studies (the previous meta-analysis included RCTs, observational studies, and retrospective studies whereas our NMA included only RCTs). In contrast with the

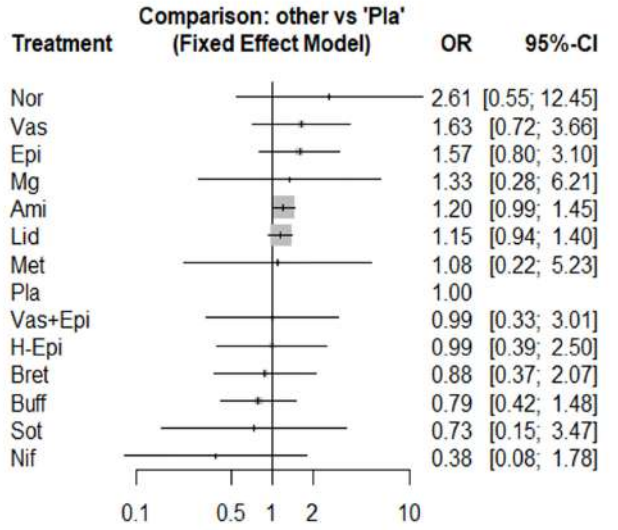

Figure 3. The forest plot of the network meta-analysis comparing the odds ratios on the survival to hospital discharge among the medications.
OR, odds ratio; *CI,* confidence interval; *Ami,* amiodarone; Bret, bretylium tosylate; *Buff,* buffer; Epi,epinephrine; *H-Epi,* high-dose epinephrine; *Lid,* lidocaine; *Met,* methoxamine; *Mg,* magnesium sulfate; *Nif,* nifekalant; *Nor,* norepinephrine; *Pla,* placebo; *Sot,* sotalol; *Vas,* vasopressin.

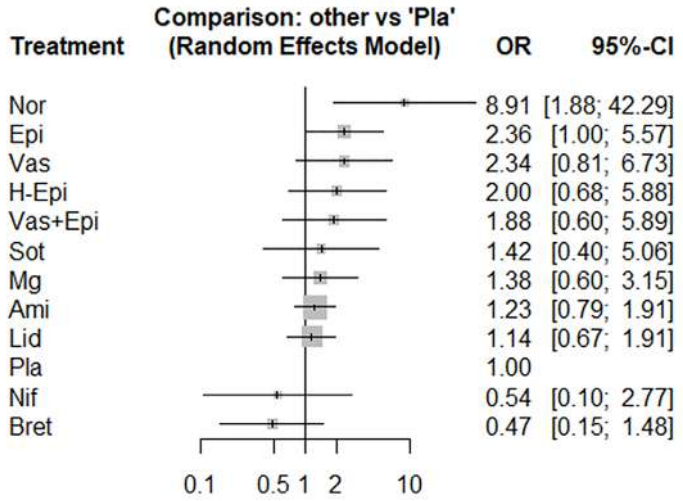

Figure 4. The forest plot of the network meta-analysis comparing the odds ratios on the return of spontaneous circulation among medications.
OR, odds ratio; *CI,* confidence interval; *Ami,* amiodarone; *Bret,* bretylium tosylate; *Epi,* epinephrine; *H-Epi,* high-dose epinephrine; *Lid,* lidocaine; *Mg,* magnesium sulfate; *Nif,* nifekalant; *Nor,* norepinephrine; *Pla,* placebo; *Sot,* sotalol; *Vas,* vasopressin.

outcomes of antiarrhythmic drugs, the results of vasopressors were consistent with those of a previous NMA.[5] A previous NMA did not find that norepinephrine significantly improved ROSC.[5] Epinephrine was also inefficient for out-of-hospital, shock-refractory VF/pVT. Earlier evidence confirmed that epinephrine given within two minutes after the onset of shockable cardiac arrest decreased odds of ROSC and survival to hospital discharge.[32] The current international guidelines for shockable, pulseless cardiac arrest recommend the use of epinephrine after the first defibrillation[4]; however, based on our findings epinephrine may not improve outcomes in this condition.

Current guidelines recommend two anti-arrhythmic agents for refractory, shockable cardiac arrest including amiodarone and lidocaine; however, a growing body of literature demonstrates the benefits of novel potential interventions – both pharmaceutical (ie, beta-blockers) and non-pharmaceutical (ie, switching pads location, double sequential defibrillation). Our included studies also included sotalol, which binds non-selectively to beta-adrenergic receptors. Nevertheless, sotalol did not exhibit positive effects in our study.

We propose three possible explanations for our findings. First, vasoconstriction may increase the likelihood of ROSC in those receiving cardiopulmonary resuscitation (CPR). Vasoconstriction increases coronary perfusion pressure (CPP) and myocardial blood flow, which have been posited as potential determinants of ROSC.[33] However, nonspecific vasoconstriction may worsen post-resuscitation outcomes, which was consistent with our findings. One animal study demonstrated that endothelin-1, an intense vasoconstrictor, plus epinephrine improved CPP during CPR but had negative results in the post-resuscitation period.[34] That norepinephrine, another powerful vasoconstrictor, improves ROSC would be supported by this explanation.

β2-adrenergic receptor agonists may be deleterious to shock-refractory VF/pVT. A preclinical study showed that β2- but not β1-adrenergic receptors increase calcium ion transients.[35] As a result, the change in cytosolic calcium ion levels could perpetuate VF. β2-adrenergic receptor agonists, which have also been associated with cardiac arrest.[36] This may explain why norepinephrine, which has predominate alpha receptor agonist, with lesser β1-agonism and no β2- agonism, was superior to epinephrine. Additionally, the benefits of amiodarone may further support this explanation as amiodarone is an antiarrhythmic drug with mild calcium channel blocker and beta-blocker properties. Its use during cardiac arrest as part of the current ACLS protocol could therefore ameliorate the β2-adrenergic effects induced by epinephrine.

As a third mechanism for medication effects, sodium channel activity has been associated with ventricular fibrillation. A preclinical study suggested that sodium channel activity could help maintain VF.[37] The Na^+ accumulated in the cytosolic can drive Ca^{2+} entry through the Na^+-Ca^{2+} exchanger, and causes cytosolic and mitochondrial Ca^{2+} overload and eventual decline in myocardial function.[38,39] This may explain why amiodarone and lidocaine, which are sodium channels blockers, could improve the outcomes of shock-refractory VF/pVT.

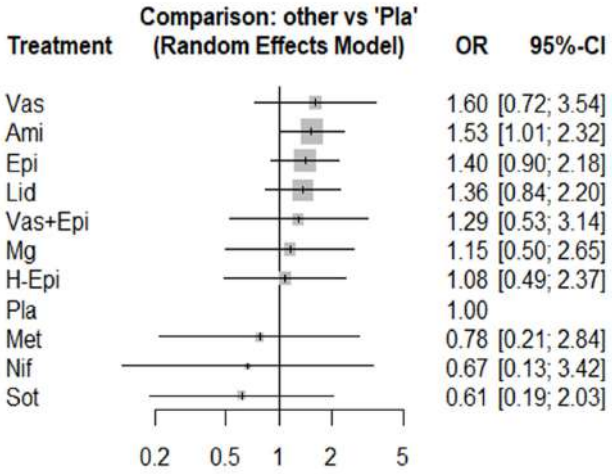

Figure 5. The forest plot of the network meta-analysis comparing the odds ratios on the survival to hospital admission among the medications.
OR, odds ratio; *CI,* confidence interval; *Ami,* amiodarone; *Epi,* epinephrine; *H-Epi,* high-dose epinephrine; *Lid,* lidocaine; *Met,* methoxamine; *Mg,* magnesium sulfate; *Nif,* nifekalant; *Pla,* placebo; *Sot,* sotalol; *Vas,* vasopressin.

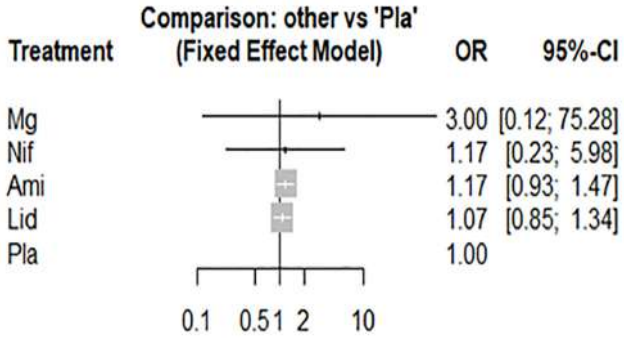

Figure 6. The forest plot of the network meta-analysis comparing the odds ratio of survival with good neurological outcomes among the pharmaceutical interventions.
OR, odds ratio; *CI,* confidence interval; *Ami,* amiodarone; *Lid,* lidocaine; *Mg,* magnesium sulfate; *Nif,* nifekalant; *Pla,* placebo.

LIMITATIONS

There are several limitations in our study. First, we encountered an insufficiency of data, especially for the neurological outcome at discharge. For example, the trial studying the treatment outcomes of norepinephrine did not provide the rate of survival to hospital admission and the neurological outcome at discharge.[26] Second, the included trials were conducted in different years. As a result, ACLS algorithms and resuscitation qualities might vary among the studies. Third, because this NMA only compared the treatment outcomes of randomized drugs we could not take into account any add-on medication. Epinephrine was administered before the randomization of antiarrhythmic drugs in some studies. Thus, the treatment outcomes of amiodarone or lidocaine without epinephrine remains unknown.

Fourth, most comparisons had small sample sizes. Only one trial had more than 1000 participants.[24] Moreover, the ROSC and survival to hospital admission were highly heterogeneous. Such heterogeneity might arise from the differences of additional treatments and the definitions of ROSC and survival to hospital admission. Furthermore, although norepinephrine demonstrated significant improvement in ROSC, only one study consisting of 50 participants in 1991 was included in the NMA, which resulted in an extremely wide range of CIs.[26] Therefore, the results regarding norepinephrine might be inconcludable. Besides, the included trials had applied different protocols of intervention that might have resulted in variances in prehospital treatments among studies. Lastly, some comparisons in our NMA were not directly compared. So, these findings should be considered only as hypotheses. Large RCTs of direct comparisons are warranted to confirm the results.

CONCLUSION

In this present study comparing different classes of agents administered during out-of-hospital, shock-refractory VF/pVT, no medication was associated with improved survival to hospital discharge. For the other outcomes, norepinephrine was associated with improved ROSC, and amiodarone was associated with an increased likelihood of survival to hospital admission in the NMA. Non-pharmaceutical interventions, such as defibrillation and bystander Basic Life Support, are still the mainstay treatment for this condition. Large, randomized controlled trials of medications for out-of-hospital, shock-refractory VF/pVT are warranted.

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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.

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Reduction in Emergency Department Presentations in a Regional Health System during the Covid-19 Pandemic

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Introduction: Nationally, there has been more than a 40% decrease in Emergency Department (ED) patient volume during the coronavirus disease 2019 (Covid-19) crisis, with reports of decreases in presentations of time-sensitive acute illnesses. We analyzed ED clinical presentations in a Maryland/District of Columbia regional hospital system while health mitigation measures were instituted.

Methods: We conducted a retrospective observational cohort study of all adult ED patients presenting to five Johns Hopkins Health System (JHHS) hospitals comparing visits from March 16 through May 15, in 2019 and 2020. We analyzed de-identified demographic information, clinical conditions, and ICD-10 diagnosis codes for year-over-year comparisons.

Results: There were 36.7% fewer JHHS ED visits in 2020 compared to 2019 (43,088 vs. 27,293, P<.001). Patients 75+ had the greatest decline in visits (-44.00%, P<.001). Both genders had significant decreases in volume (-41.9%, P<.001 females vs -30.6%, P<.001 males). Influenza like illness (ILI) symptoms increased year-over-year including fever (640 to 1253, 95.8%, P<.001) and shortness of breath (2504 to 2726, 8.9%, P=.002). ICD-10 diagnoses for a number of time-sensitive illnesses decreased including deep vein thrombosis (101 to 39, -61%, P<.001), acute myocardial infarction (157 to 105, -33%, P=.002), gastrointestinal bleeding (290 to 179, -38.3%, P<.001), and strokes (284 to 234, -17.6%, P=0.03).

Conclusion: ED visits declined significantly among JHHS hospitals despite offsetting increases in ILI complaints. Decreases in presentations of time-sensitive illnesses were of particular concern. Efforts should be taken to inform patients that EDs are safe, otherwise preventable morbidity and mortality will remain a problem. [West J Emerg Med. 2021;22(4)842–850.]

INTRODUCTION

According to the Johns Hopkins Coronavirus Resource Center, the United States experienced over 1.6 million coronavirus disease 2019 (COVID-19) infections and more than 125,000 deaths as of June 29, 2020.[1] The pandemic has created a public health emergency due to a combination of factors including high transmissibility, asymptomatic infectious carriers, and without widespread testing, a difficult-to-calculate infection fatality rate (IFR).[2]

Nationally, there has been a greater than 40% decrease in emergency department (ED) patient volume during this crisis.[3-5] Reports have suggested that certain time sensitive presentations

requiring immediate medical attention, have decreased as well.[6-8] Investigators in Italy reported an increase in out-of-hospital-cardiac arrests (OHCA) that appears strongly correlated with an increasing incidence of COVID-19 in the community.[9] Similarly, in California, EMS reported sudden increases in out of hospital cardiac arrests (OHCA) in COVID-19 negative patients, as well as patients arriving too late to receive tissue plasminogen activator for ischemic strokes.[4] Another Italian report highlights a significant decrease in ischemic stroke presentations at hospitals.[10] While each of these is a concern in and of itself, there has been few detailed analyses characterizing the variance in the multiplicity of patient conditions associated with the ED volume loss.

We sought to determine and characterize the change in ED presentations during a period while public health mitigation orders were in effect in Maryland and D.C. (March 16, 2020 school closures to May 15, 2020 non-essential businesses reopen in Maryland; March 24, 2020 non-essential business closures to May 29, 2020 Phase One re-opening in D.C.).[11-15] We compared patient volumes, demographics and clinical conditions from March 16th through May 15, 2020 to corresponding dates in 2019 for five regionally dispersed EDs in our health system.

Population Health Research Capsule

What do we already know about this issue?
During the first wave of the coronavirus disease 2019 (COVID-19) pandemic in the US, there were dramatic decreases in the number of patients presenting to emergency departments.

What was the research question?
Were there any changes in the clinical conditions presenting to a regional health system during the Covid-19 pandemic?

What was the major finding of the study?
At the onset of the Covid-19 pandemic, many patients with critical and even fatal illnesses failed to seek emergency care.

How does this improve population health?
This study highlights the need for widespread communication to the public regarding the safety of emergency departments and the serious implications of avoiding emergency care.

METHODS

Study Design and Setting

We conducted a multi-center retrospective observational cohort study of all registered adult ED patients presenting to any of our five Johns Hopkins Health System hospitals in the mid-Atlantic region. Four of the hospitals are in Maryland and one is in the District of Columbia. The regional hospitals include: a large inner-city academic medical center, an urban community-oriented teaching affiliate, and three community-based non-teaching hospitals. (Figure 1) The study was accepted by the Johns Hopkins Institutional Review Board.

Study Population

All patients aged 15 years or older who presented to each of our five health-system adult EDs from March 16 through May 15, in 2019 and 2020, respectively, were included. Patients who registered but left without being seen were included. Patients younger than 15 years were excluded from the data set.

Data Collection, Outcomes, and Analysis

To identify historical patterns, patient volumes for the 2-month period of interest were obtained for the years 2016-2020 for all sites. All data were abstracted from the EPIC electronic medical records (EMR) of our institutions by an experienced data analyst. For 2019 and 2020, we collected de-identified demographic information such as age, sex, race, ethnicity, as well as presenting chief complaints, dispositions, triage assessments (Emergency Severity Index, HopScore), and primary ICD-10 codes. HopScore is an outcomes-based emergency triage system.[17]

Chief complaints with fewer than 15 occurrences were compiled into the "General" category. This included the autoimmune, cancer, dialysis, endocrine metabolic, mass, and transplant categories. Trends over time in visits were calculated for each hospital. For both study periods (2019 and 2020), differences in results across all JHHS EDs was judged as relatively minor. Accordingly, aggregated data was used to identify generalizable trends and to make specific year-over-year comparisons.

Decreases from year to year were calculated both as absolute reductions and percentage changes. As the rate of visits to EDs typically follows a Poisson distribution we used the two-sided Poisson test of two means to assess whether the rate of visits over the two-month study period in 2020 was statistically discernable from 2019.[18-20]

RESULTS

Patient volumes from 2016 to 2019 averaged 42,775 and no year deviated by more than 1.5% over the corresponding two-month study timeframe in any other year, until 2020. In 2019, there were in aggregate 43,088 visits in all five EDs, and 27,293 for the same study time period in 2020, representing a 37% decrease (P<.001). Decreases across all five EDs ranged from 27.7% to 40.3%. (Figure 2). Similar decreases were seen across almost all demographic groups. There was a decline in visits across all age groups, with the largest decrease in those

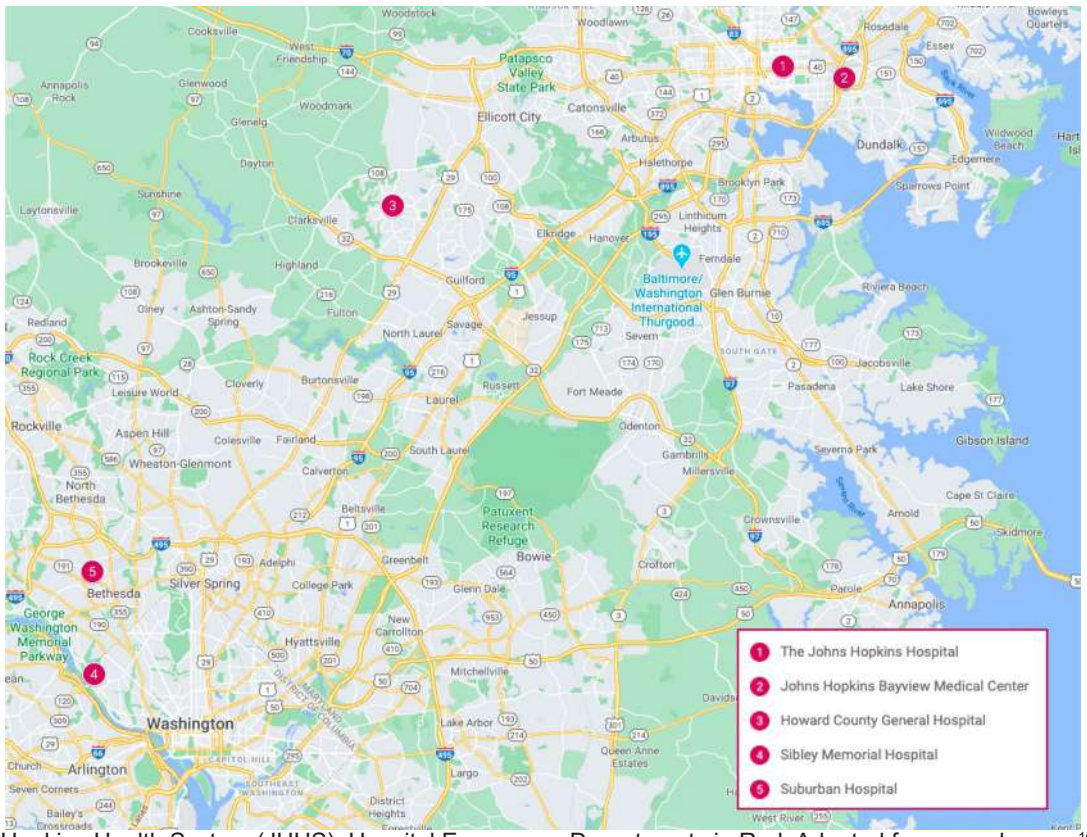

Figure 1. Johns Hopkins Health System (JHHS). Hospital Emergency Departments in Red. Adapted from google map.[16]

over the age of 75 (-44.00%, P<.001). During the same time period, there was a greater decrease in patients identifying as females (-41.9%, P<.001) than males (-30.6%, P<.001). There were decreases in all self-identified racial groups who had more than 30 visits. There was no appreciable difference in visits amongst those identifying as Hispanic or Latinx 0.7% (P=0.79) compared to significant declines amongst other self-identified ethnicities (Table 1).

Most clinical conditions, with the exception of pulmonary, influenza-like illness (ILI) and penetrating trauma decreased. Conditions decreasing 60% or greater year-over-year were allergy (311 to 108, -65.3%, P<.001), back pain (1192 to 435, -63.5%, P<.001), cardiovascular (69 to 15, -78.3%, P<.001), collision (1117 to 416, -62.8%, P<.001), dizziness (865 to 335, -61.3%, <.001), edema (501 to 193, -61.5%, <.001), head trauma (248 to 95, -61.7%, <.001), isolated musculoskeletal trauma (961 to 347, -63.9%, P<.001), skin/nail/hair (587 to 175, -70.2%, P<.001) as well as surgical wound (319 to 94, -70.5%, P<.001).

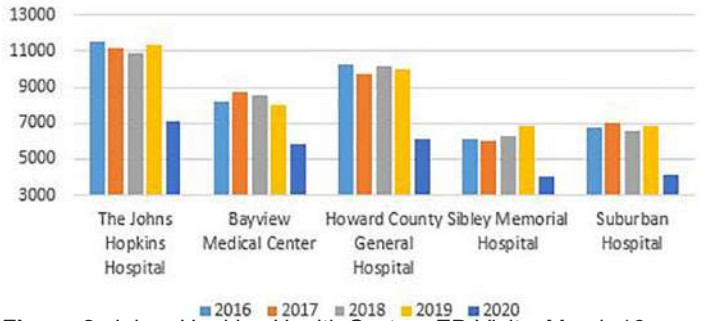

Figure 2. Johns Hopkins Health System ED Visits, March 16 - May 15, 2016 – 2020, respectively.

Clinical conditions related to pulmonary complaints and ILI increased during the comparison periods: fever (640 to 1253, 95.8%, P<.001), lower respiratory infectious symptoms (609 to 1260, 106.9%, P<.001), shortness of breath (2504 to 2726, 8.9%, P=.002) and upper respiratory infectious symptoms (827 to 1825, 120.7%, P<.001) (Table 2).

Year-over-year comparisons of time-sensitive illness based on ICD-10 codes ranged from a decrease of 11.9% (P=0.53) for Acute Cholecystitis, to a drop of 61.4% (P<.001) for Deep Vein Thrombosis (DVT). The diagnosis of Acute Myocardial Infarction (MI) including Acute Coronary Syndrome (ACS), ST-elevation MI, and Non-ST elevation MI) decreased 33% (157 to 105, P=.002). Diagnoses of Cardiac Arrest decreased 39.0% (59 to 36, P=0.02), Gastrointestinal Bleeding by 38.3% (290 to 179, P<.001), all stroke syndromes (hemorrhagic and ischemic) by 17.6% (284 to 234, P=0.03), Pulmonary Embolism (PE) decreased 18.3% (115 to 94, P=0.17), Appendicitis by 15.1% percent (126 to 107, P=0.24) and Seizures diagnoses by 22.0% (41 to 32, P=0.35) (Table 3).

Table 1. Patient demographics by age, gender, race, and ethnicity for time period, March 16 to May 15; 2019 compared with 2020.

	03/16/19 to 05/15/19	03/16/20 to 05/15/20	Change in patient visits, 2019 to 2020		P -Value
	N =	N =	N =	(% =) *	
Total	43,088	27,293	-15,795	(-36.7%)	<.001
Age					
15-24	4,233	2,395	-1,838	(-43.4%)	<.001
25-34	7,705	4,970	-2,735	(-35.5%)	<.001
35-44	6,552	4,525	-2,027	(-30.9%)	<.001
45-54	6,607	4,327	-2,280	(-34.5%)	<.001
55-64	6,691	4,508	-2,183	(-32.6%)	<.001
65-74	5,035	3,050	-1,985	(-39.4%)	<.001
75+	6,246	3,498	-2,748	(-44%)	<.001
Unknown	19	20	1	(5.3%)	1.00
Sex					
Male	19,917	13,814	-6,103	(-30.6%)	<.001
Female	23,164	13,462	-9,702	(-41.9%)	<.001
Other or not specified	7	17	10	(142.9%)	0.06
Race (self-identified)					
American Indian or Alaska Native	60	34	-26	(-43.3%)	0.01
Asian	1,492	930	-562	(-37.7%)	<.001
Black or African American	16,889	10,918	-5,971	(-35.4%)	<.001
Native Hawaiian or Pacific Islander	27	28	1	(3.7%)	1.00
White or Caucasian	19,562	10,989	-8,573	(-43.8%)	<.001
Two or more races	699	485	-214	(-30.6%)	<.001
Other or not specified	4,359	3,909	-450	(-10.3%)	<.001
Ethnicity (self-identified)					
Hispanic or Latino	3,253	3,275	22	(0.7%)	0.79
Not Hispanic or Latino	39,235	23,693	-15,542	(-39.6%)	<.001
Other or not specified	600	325	-275	(-45.8%)	<.001

*Represents change in percent within column category.

DISCUSSION

Our study underscores the disturbing finding that patients with time-sensitive and critical conditions such as AMI, cardiac arrest, stroke, venous thrombotic events, and GI bleeding failed to seek emergency medical care during the period of time when public health mitigation measures were in force in Maryland and D.C. While others have highlighted a few specific conditions and general disease categories, our study included all patient clinical presentations and focused on year-over-year trends of a number of the most common time-sensitive illnesses.[3,5,7-9] The rapid onset of the Covid-19 pandemic caused hospital emergency department patient volumes to plummet throughout the nation, and this trend was evident in the Maryland and Washington, D.C. metro area as well.[3] Others have provided general evidence of increased morbidity and mortality not attributable to Covid-19, including out of hospital arrest.[4-9] Based on our results, it appears likely that these previous observations were not isolated occurrences.

During the month of March, 2020, public health emergencies were declared in both Maryland and D.C., and executive stay-at-home orders closing all schools and non-essential businesses were put in place.[11-13] Declines in ED patient volumes were subsequently seen across all age groups and genders, with the greatest decline among those 75+. Some of this decrease likely reflected public awareness of reports of increased morbidity and mortality with increasing age.[21] Additionally, in Maryland, a Johns Hopkins disaster response program called Go Team partnered with the National Guard, Maryland Department of Health, and the University of Maryland to provide stabilizing care to COVID-19 infected nursing home patients in situ which resulted in a reduction in the number of residents who required

Table 2. Patients' chief complaints for time period, March 16 - May 15; 2019 compared with 2020.

	03/16/19 - 05/15/19	03/16/20 - 05/15/20	Change in volume, 2019 to 2020	P-value
	N =	N =	Percent change =	
Abdominal pain	4,742	2,512	-47.0%	<.001
Abnormal finding	456	271	-40.6%	<.001
Abscess	250	110	-56.0%	<.001
Allergic	311	108	-65.3%	<.001
Altered mental status	628	508	-19.1%	<.001
Arrest (cardiac and/or respiratory)	78	51	-34.6%	0.02
Back pain	1,192	435	-63.5%	<.001
Blunt trauma	2,525	1,399	-44.6%	<.001
Burn	144	91	-36.8%	<.001
Cardiovascular (general)	69	15	-78.3%	<.001
Chest pain	3,102	2,042	-34.2%	<.001
Collision	1,117	416	-62.8%	<.001
Constitutional symptoms	264	169	-36.0%	<.001
Dental	352	176	-50.0%	<.001
Device	224	129	-42.4%	<.001
Dizziness	865	335	-61.3%	<.001
Dysrhythmia	526	283	-46.2%	<.001
Edema	501	193	-61.5%	<.001
Ear, nose and throat symptoms (not epistaxis)	338	109	-67.8%	<.001
Environmental	48	24	-50.0%	0.01
Epistaxis	137	63	-54.0%	<.001
Fever	640	1,253	95.8%	<.001
General	580	399	-31.0%	<.001
Genitourinary	1,415	713	-49.6%	<.001
Gastrointestinal (including bleeding)	459	222	-49.4%	<.001
Glucose, abnormal	281	133	-52.7%	<.001
Head trauma	248	95	-61.7%	<.001
Headache	1,165	542	-53.5%	<.001
Hematologic	29	21	-27.6%	#N/A
Hypertension	383	189	-50.7%	<.001
Hypotension	85	36	-57.6%	<.001
Lower respiratory infectious symptoms	609	1,260	106.9%	<.001
Medication management	159	96	-39.6%	<.001
Musculoskeletal (isolated trauma)	961	347	-63.9%	<.001
Musculoskeletal (non-traumatic)	3,323	1,359	-59.1%	<.001
Neurologic	657	422	-35.8%	<.001
Nausea, vomiting and diarrhea	1,244	630	-49.4%	<.001
Ophthalmologic	754	343	-54.5%	<.001
Penetrating trauma	70	75	7.1%	0.74
Pregnancy-related	447	214	-52.1%	<.001
Psychiatric	2,052	1,295	-36.9%	<.001
Referral	92	66	-28.3%	0.05
Seizures	375	247	-34.1%	<.001

Table 2. Continued.

Shortness of breath	2,504	2,726	8.9%	0.002
Sickle cell	196	103	-47.4%	<.001
Skin, nails and hair	587	175	-70.2%	<.001
Social issues	123	81	-34.1%	0.00
Substance abuse	1,170	674	-42.4%	<.001
Syncope	591	308	-47.9%	<.001
Upper respiratory infectious symptoms	827	1,825	120.7%	<.001
Weakness	830	537	-35.3%	<.001
Wound	677	343	-49.3%	<.001
Wound check	404	263	-34.9%	<.001
Wound surgery	319	94	-70.5%	<.001
Blank, null, or missing (not mapped)	963	768	-20.2%	<.001
TOTAL	43, 088	27, 293	-36.7%	<.001

transport to local EDs for treatment. While patient volumes fell across most racial and ethnic categories, there was no decrease seen in Hispanic or Latinx visits presenting to JHHS EDs. This is not entirely surprising since Hispanic communities in the US and our region have been found to suffer disproportionately higher rates of COVID-19 infection. Despite significant barriers to healthcare access, low rates of medical insurance, and reluctance to seek care, it should be expected that many in this community would turn to emergency care when symptomatic with a possible COVID-19 infection.[22-24]

Corresponding to an overall volume decline, was a decrease in most clinical conditions presenting to emergency departments. The exceptions to these downward trends were increased presentations of conditions likely related to COVID-19 such as fever, shortness of breath, and respiratory infections. These complaints, which are potentially indicative of COVID-19 infection, essentially doubled during our study, further accentuating the profound decrease in virtually all other conditions. Our most worrisome finding, however, relates to the significant declines in time-sensitive disease diagnoses. Other researchers have noted similar findings and, indeed, there may be some reasonable explanations for reductions in certain, potentially life-threatening ED presentations.[3,7-10,25] For instance, patients in isolated settings may not be exerting themselves or confronting significant stressors and, therefore, incidence of acute cardiac events may have decreased. Additionally, studies have demonstrated that people can survive undiagnosed PEs, and there is even some evidence to suggest that conditions as serious as acute appendicitis are over-treated with surgical intervention.[26-29] Taken together, these explanations may elucidate a portion of the decrease in ED volumes of life-threatening conditions. Yet, such possibilities could not reasonably account for the reductions across the numerous time-sensitive illnesses noted in this study.

A more likely explanation is that people suffered serious medical crises and failed to seek appropriate care. A recent article noted that emergency medical services (EMS) in Lodi, CA reported a 45% increase in field cardiac arrest calls, and patients with strokes were arriving too late to receive tissue plasminogen activator (tPA).[4] Even serious, COVID-19 related complications may have presented to EDs too late for lifesaving care, or patients may have died at home. In Italy, for instance, it was found that a significant percentage of patients who had out-of-hospital cardiac arrests, were also COVID-19+.[9] Researchers looking at data from the initial COVID-19 outbreak in China, observed that the inflammatory response to the virus can lead to increased rates of thrombosis.[30] This COVID-19 induced coagulopathy has likely resulted in acute myocardial infarctions, pulmonary embolisms and strokes that did not make it to an ED.

It is highly probable that public health mitigation measures substantially reduced conditions and behaviors that often result in ED visits for occupational injuries, motor vehicle collisions, non-violent trauma, and complications from elective surgeries.[31] What is more, the expansion of telemedicine services during the pandemic may have provided opportunities for ready access to medical care that previously resulted in ED visits.[32] Fear, however, likely had the greatest impact on patients failing to seek emergency care. It has been observed anecdotally that anxiety about contracting the Covid-19 infection has caused a significant number of patients to delay or avoid seeking medical care.[4,29,33] What our study has clarified is the extent to which ED patients have not sought emergency treatment for time-sensitive, potentially-fatal, medical conditions during the Covid-19 pandemic.

LIMITATIONS

There are several limitations to our study. First, although the data included all adult patients presenting to our regional

Table 3. Comparison of emergency department visits for severe illness across Johns Hopkins Health System for time period, March 16 to May 15; 2019 compared with 2020.

	ICD10 Code	03/16/19 to 05/15/19	03/16/20 to 05/15/20	Change in patient visits, 2019 to 2020		P-Value
		N =	N =	N =	(% =)*	
Acute myocardial infarction (MI)						
ST- elevation MI	I21.02-I21.3	48	33	-15	(-31.3%)	0.12
Non-ST-elevation MI	I21.4	89	59	-30	(-33.7%)	0.02
Acute coronary syndrome	I21.9, I24.9	20	13	-7	(-35%)	0.30
Total acute for MI		157	105	-52	(-33.1%)	0.002
Cardiac arrest	I46.8-I46.9	59	36	-23	(-39%)	0.02
Stroke						
Hemorrhagic	I60.0-I62.9	83	70	-13	(-15.7%)	0.33
Ischemic	I63.0-I63.9	201	164	-37	(-18.4%)	0.06
TOTAL FOR STROKE		284	234	-50	(-17.6%)	0.03
Appendicitis	K35-K37	126	107	-19	(-15.1%)	0.24
Venous thromboembolism						
Deep venous thrombosis	I82.4-I82.6	101	39	-62	(-61.4%)	<.001
Pulmonary embolism	I26	115	94	-21	(-18.3%)	0.17
TOTAL FOR VTE		216	133	-83	(-38.4%)	<.001
Acute cholecystitis	K81	67	59	-8	(-11.9%)	0.53
Seizures	G40	41	32	-9	(-22%)	0.35
Gastrointestinal bleed	K92	290	179	-111	(-38.3%)	<.001

*Represents change in percent within column category.

hospitals during the prescribed time periods, as with all clinical studies, some data misclassification may have occurred. Second, data from other health systems in the State of Maryland were not analyzed and, therefore, the results of this study may not be generalizable across the state or region. While there was wide geographic distribution amongst the study sites, all hospitals were located within relatively populous areas, the Eastern Shore and Western Maryland may have had different experiences.

CONCLUSION

ED visits in our health system by patients with time-sensitive conditions that should not have been influenced by the pandemic or public health orders, decreased substantially compared to a previous similar time period. We experienced a significant decline in volumes despite doubling of presentations consistent with Covid-19 symptoms. The reasons are likely multifactorial including: public health stay-at-home orders, closure of non-essential businesses and schools, discontinuation of non-emergent surgical procedures, availability of alternative care options and, perhaps the highest contributor, the generalized fear about contracting the illness.

Hospitals and public health officials need to find a way to better communicate the serious implications of refusing or avoiding emergency medical care. EDs are safe, certainly safer than congregant locations and general indoor public venues. Until the misperception of the risks associated with seeking care at hospital emergency departments are addressed, it is likely that preventable morbidity and mortality will remain a problem.

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The Impact of COVID-19 Pandemic on Emergency Department Visits at a Canadian Academic Tertiary Care Center

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Introduction: Public health response to the coronavirus 2019 (COVID-19) pandemic has emphasized social distancing and stay-at-home policies. Reports of decreased emergency department (ED) visits in non-epicenters of the outbreak have raised concerns that patients with non-COVID-19 emergencies are delaying or avoiding seeking care. We evaluated the impact of the pandemic on ED visits at an academic tertiary care center.

Methods: We conducted an observational health records review between January 1–April 22, 2020, comparing characteristics of all ED visits between pre- and post-pandemic declaration by the World Health Organization. Measures included triage acuity, presenting complaints, final diagnoses, disposition, and mortality. We further examined three time-sensitive final diagnoses: stroke; sepsis; and acute coronary syndrome (ACS).

Results: In this analysis, we included 44,497 ED visits. Average daily ED visits declined from 458.1 to 289.0 patients/day (-36.9%). For the highest acuity triaged patients there was a drop of 1.1 patients/day (-24.9%). Daily ED visits related to respiratory complaints increased post-pandemic (+14.1%) while ED visits for many other complaints decreased, with the greatest decline in musculoskeletal (-52.5%) and trauma (-53.6%). On average there was a drop of 1.0 patient/day diagnosed with stroke (-17.6%); a drop of 1.6 patients/day diagnosed with ACS (-49.9%); and no change in patients diagnosed with sepsis (pre = 2.8 patients/day; post = 2.9 patients/day).

Conclusion: Significant decline in ED visits was observed immediately following formal declaration of the COVID-19 pandemic, with potential for delayed/missed presentations of time-sensitive emergencies. Future research is needed to better examine long-term clinical outcomes of the decline in ED visits during pandemics. [West J Emerg Med. 2021;22(4)851–859.]

INTRODUCTION

On March 22, 2020, the World Health Organization (WHO) designated the outbreak of a novel coronavirus (SARS-CoV-2) first reported in January 2020 as an international pandemic causing coronavirus disease 2019 (COVID-19).[1-3] COVID-19 was thought to spread from person-to-person by respiratory droplets and contaminated surfaces or fomites, with asymptomatic transmission suspected.[4-6] In an effort to "flatten the curve" public health response to COVID-19 encouraged social distancing, self-isolation, and stay-at-home policies, employing media campaigns that highlighted the experiences in Lombardy, Italy, and New York City, NY, where hospitals were overwhelmed by COVID-19.[7]

Shortly after the WHO's pandemic declaration, anecdotal reports of emergency department (ED) visits plummeting occurred in many cities that were not overwhelmed by COVID-19 outbreaks. At our own tertiary care hospital in Canada's capital, Ottawa, we observed daily ED visits drop to as low as ~50% compared to the same time period the prior

year. At our center, confirmed COVID-19 admissions were limited (as of April 22, 2020, Ottawa had eight COVID-19 patients in intensive care, and 22 COVID-19 patients on inpatient wards[8]) and had not overwhelmed acute hospital capacity. The sudden drop in ED visits caused concern that patients with non-COVID-19 emergencies were delaying or avoiding seeking appropriate ED care during this pandemic.

We sought to rapidly review the immediate impact of the COVID-19 pandemic on ED visits at a tertiary care hospital not overwhelmed with COVID-19 admissions. We aimed to characterize and compare trends of pre- vs post-COVID-19 ED populations in terms of the Canadian Triage Acuity Score (CTAS) level, presenting complaints, discharge/admission diagnoses, and patient flow metrics. In addition, we sought to examine the effect of the pandemic on ED visits and mortality rates of three time-sensitive diagnoses: stroke; sepsis; and acute coronary syndrome (ACS).

Population Health Research Capsule

What do we already know about this issue?
Responses to the coronavirus disease 2019 (COVID-19) pandemic have emphasized social distancing and stay-at-home policies with subsequent reports of decreased emergency department (ED) visits.

What was the research question?
We evaluated the impact of the pandemic on ED visits at a center not overwhelmed with COVID-19 admissions.

What was the major finding of the study?
Decline in ED visits including time-sensitive emergencies was observed after declaration of a pandemic.

How does this improve population health?
Public health responses to pandemics affect ED visit behaviors. Further research is needed to examine long-term clinical outcomes of the decline in ED visits.

METHODS

Design

We conducted a retrospective observational electronic health records (EHR) review.

Setting

The Ottawa Hospital (TOH) is a 1202-bed academic tertiary care hospital with the ED receiving >174,000 visits per year. It is the main regional referral center for specialized services including trauma, stroke, neurosurgical, thoracic, oncological, and vascular emergencies. Adjacent to TOH is the regional cardiac center, the Ottawa Heart Institute, which receives prehospital Code STEMI (ST-elevation myocardial infarct) cases bypassing TOH EDs. It was not included in this study.

Patient Population and Time Period

We included all patients presenting to TOH ED between January 1, 2019–April 22, 2020. We excluded all patients who were "direct-to-service," which included patients already assessed at another hospital/outpatient clinic being transferred directly for admission to a specialized service at TOH. We used the date March 11, 2020, when the WHO declared COVID-19 to be an official pandemic, to define pre- and post-pandemic periods.

Measures

We collected ED visit characteristics including patient demographics, presenting complaints, final diagnoses, and disposition. Mortality rates were observed for the entirety of patients' ED or in-patient stays. We also collected data on patients' CTAS, which is a triage tool used internationally to allow EDs and their staffs to prioritize patient care requirements upon arrival to the ED. Levels of CTAS range from 1 (most acute) to 5 (least acute).[9]

For presenting complaints and final diagnoses, two authors independently reviewed all primary chief complaints listed for each ED visit, as well as final discharge/admission diagnoses, and assigned them into the most appropriate categories based on symptom- or specialty-related headings. Any discrepancies were resolved with discussion between the reviewers, with arbitration by the third author if necessary. We used a similar process to critically review all discharge/admission diagnoses for three time-sensitive emergencies: stroke; sepsis; and ACS.

Data Collection

The Ottawa Hospital transitioned to Epic EHR (Epic Systems Corporation, Verona, WI) in June 2019. A quality improvement coordinator with Epic-reporting expertise pulled the required data elements from the EHR using integrated reporting functionalities and entered the data into a Microsoft Excel database (Microsoft Corporation, Redmond, WA) for further analysis. We retrieved historical patient volume data from TOH's previous performance-measurement data warehouse.

Data Analysis

We present patient demographics, CTAS acuity, presenting complaints, final diagnoses, process measures, time metrics, and mortality using descriptive statistics. For comparison between pre- and post-pandemic periods, we examined the total number of ED visits within each

time period, as well as the number of ED visits per day. We plotted relevant results temporally to provide visual trends over time, with annotation to provide context around specific milestones. We assumed normal distributions and performed statistical analysis using Student's two-sided t-test to compare pre- vs post-pandemic periods, and chi-squared test for comparison of proportions, with *P*-value of <0.05 considered to be significant.

Ethical Considerations

We obtained research ethics approval for this project by the Ottawa Hospital Research Institute Research Ethics Board, dated Apr 24, 2020, protocol ID# 20200262-01H.

RESULTS

A total of 44,497 ED visits met our inclusion/exclusion criteria during the study period (32,068 in pre-pandemic; 12,429 in post-pandemic) (Table 1). The mean age was 49.9 years old with 46.5% being male patients. Overall, average daily ED visits declined from 458.1 patients/day in the pre-pandemic period, to 289.0 patients/day in the post-pandemic period (-36.9%). There was a significant decrease in the proportion of patients with incomplete ED visits (ie, leaving without being seen, etc), from 8.6% in the pre-pandemic period to only 3.5% in the post-pandemic period.

Relative CTAS levels distribution remained stable throughout the study period, with the exception of an increase in the proportion of CTAS 5 patients (pre: 4.5%, post: 5.0%). For the most severe and critical CTAS 1 acuity patients, on average there was a significant drop of 1.1 patients/day (-24.9%) in the post-pandemic period. For the second most critical CTAS 2 acuity patients, on average there was a significant drop of 45.9 patients/day (-37.7%). There was a sharp drop in overall ED visits immediately following the WHO declaration of a pandemic, followed by a second acute sustained drop in ED visits immediately after the city's local

Table 1. Patient and emergency department visit characteristics between pre- and post-COVID-19 pandemic status.

		Total # of ED visits			Average # of ED visits per day		
	All Patients	Pre-pandemic	Post-pandemic	P-value	Pre-pandemic	Post-pandemic	P-value
Total ED Visits (N)	44,497	32,068	12,429		458.1	289.0	
Mean Age (yrs)	49.9	49.8	50.2	<0.05			
Gender, n(%)							
Male	20,678(46.5)	14,701(45.8)	59,77(48.1)	<0.05	210.0	139.0	<0.05
Female	23,761(53.5)	17,326(54.0)	64,35(51.8)	<0.05	247.5	149.7	<0.05
No gender documented	58(0.0)	41(0.0)	17(0.0)	1	0.6	0.4	0.22
CTAS acuity level, n(%)							
1	450(1.0)	308(1.0)	142(1.1)	0.35	4.4	3.3	<0.05
2	11,767(26.4)	8,513(26.5)	3,254(26.2)	0.52	121.6	75.7	<0.05
3	22,325(50.2)	16,112(50.2)	6,213(50.0)	0.71	230.2	144.5	<0.05
4	7,153(16.1)	5,103(15.9)	2,050(16.5)	0.12	72.9	47.7	<0.05
5	2,064(4.6)	1,445(4.5)	619(5.0)	<0.05	20.6	14.4	<0.05
No acuity documented	738(1.7)	587(1.8)	151(1.2)	<0.05	8.4	3.5	<0.05
Chief Presenting Complaint, n(%)							
Abdominal/Gastrointestinal	6,735(15.1)	4,972(15.5)	1,763(14.2)	<0.05	71.0	41.0	<0.05
Cardiac	5,315(11.9)	3,842(12.0)	1,473(11.9)	0.77	54.9	34.3	<0.05
Infectious	1,034(2.3)	725(2.3)	309(2.5)	0.21	10.4	7.2	<0.05
Mental Health	2,651(6.0)	1,865(5.8)	786(6.3)	<0.05	26.6	18.3	<0.05
Musculoskeletal	4,403(9.9)	3,408(10.6)	995(8.0)	<0.05	48.7	23.1	<0.05
Neurological	3,820(8.6)	2,772(8.6)	1,048(8.4)	0.50	39.6	24.4	<0.05
Obstetrical/Gynecological	885(2.0)	650(2.0)	235(1.9)	0.50	9.3	5.5	<0.05
Other	5,530(12.4)	4,045(12.6)	1,485(11.9)	<0.05	57.8	34.5	<0.05
Respiratory	5,593(12.6)	3,288(10.3)	2,305(18.5)	<0.05	47.0	53.6	<0.05
Trauma/Environmental	5,402(12.1)	4,204(13.1)	1,198(9.6)	<0.05	60.1	27.9	<0.05
Urological	1,153(2.6)	853(2.7)	300(2.4)	0.08	12.2	7.0	<0.05

ED, emergency department; CTAS, Canadian Triage Acuity Scale.

Table 1. Continued.

		Total # of ED visits			Average # of ED visits per day		
	All Patients	Pre-pandemic	Post-pandemic	P-value	Pre-pandemic	Post-pandemic	P-value
Vascular	67(0.2)	45(0.1)	22(0.2)	<0.05	0.6	0.5	0.43
General Weakness/Medical	1,852(4.2)	1,359(4.2)	4,93(4.0)	0.34	19.4	11.5	<0.05
Undefined	57(0.1)	40(0.1)	17(0.1)	1	0.6	0.4	0.18
Final ED Discharge / Admission Diagnosis, n(%)							
Abdominal/Gastrointestinal	5,367(12.1)	3,894(12.1)	1,473(11.9)	0.56	55.6	34.3	<0.05
Cardiac	4,294(9.7)	3,047(9.5)	1,248(10.0)	0.11	43.5	29.0	<0.05
General Medical	1,563(3.5)	1,112(3.5)	451(3.6)	0.61	15.9	10.5	<0.05
Hematological	434(1.0)	337(1.1)	97(0.8)	<0.05	4.8	2.3	<0.05
Infectious	6,732(15.1)	4244(13.2)	2,488(20.0)	<0.05	60.6	57.9	<0.05
Mental Health	2,168(4.9)	1,489(4.6)	679(5.5)	<0.05	21.3	15.8	<0.05
Musculoskeletal	8,337(18.7)	6,465(20.2)	1,872(15.1)	<0.05	92.4	43.5	<0.05
Neurological	3,413(7.7)	2,502(7.8)	911(7.3)	0.08	35.7	21.2	<0.05
Obstetrical/Gynecological	1,086(2.4)	778(2.4)	308(2.5)	0.54	11.1	7.2	<0.05
Oncological	362(0.8)	264(0.8)	98(0.8)	1	3.8	2.3	<0.05
Other	3,225(7.2)	2,249(7.0)	976(7.9)	<0.05	32.1	22.7	<0.05
Respiratory	2,109(4.7)	1,357(4.2)	752(6.1)	<0.05	19.4	17.5	0.07
Toxicological	615(1.4)	404(1.3)	211(1.7)	<0.05	5.8	4.9	0.10
Urological	1,199(2.7)	874(2.7)	325(2.6)	0.56	12.5	7.6	<0.05
Vascular	183(0.4)	113(0.4)	70(0.6)	<0.05	1.6	1.6	0.96
Undefined	3,410 (7.7)	2,939(9.2)	471(3.8)	<0.05	42.0	11.0	<0.05
ED Disposition, n(%)							
Admission to hospital	7,186(16.1)	4,910(15.3)	2,276(18.3)	<0.05	70.1	52.9	<0.05
Discharge from ED	34,118(76.7)	24,398(76.1)	9,720(78.2)	<0.05	348.5	226.0	<0.05
Incomplete (LBT, LWBS, LAMA, eloped, etc)	3,193(7.2)	2,760(8.6)	433(3.5)	<0.05	39.4	10.0	<0.05
Time Metrics, hr min (mean)							
Physician initial assessment	2:31	3:10	1:10	<0.05			
ED length of stay for pts discharged from the ED	5:40	6:18	4:06	<0.05			
ED length of stay for pts admitted from the ED	19:04	22:44	11:09	<0.05			
Inpatient hospital length of stay	207:49						

ED, emergency department; *LBT,* left before triage; *LWBS,* left without being seen; *LAMA,* left against medical advice; *pts,* paients; *hr,* hours; *min,* minutes.

announcement of social distancing policies (Figure 1).

The distribution of chief complaints presenting to the ED remained similar between the pre-/post-pandemic periods except for a number of categories (Table 1). The only categories that increased in proportion relative to all presenting complaints were *respiratory* (pre: 10.3%, post: 18.5%), *mental health* (pre: 5.8%, post: 6.3%), and *vascular* (pre: 0.1%, post: 0.2%). The top five presenting complaint categories with the greatest absolute numbers of decline in average daily ED visits were the following: 1) *trauma/environmental* with a drop of 32.2 patients/day (-53.6%); 2) *abdominal pain/gastrointestinal (GI)* with a drop of 30.0 patients/day (-42.3%); 3) *musculoskeletal* with a drop of 25.5 patients/day (-52.5%); 4) *other* with a drop of 23.3 patients/day (-40.2%); and 5) *cardiac* with a drop of 20.6 patients/day (-37.6%).

There was a volume decline in all presenting complaint categories except for *respiratory* complaints, which rose acutely following the WHO declaration of the COVID-19 pandemic (Figure 2). At its peak on March 12, 2020, there were 131 ED

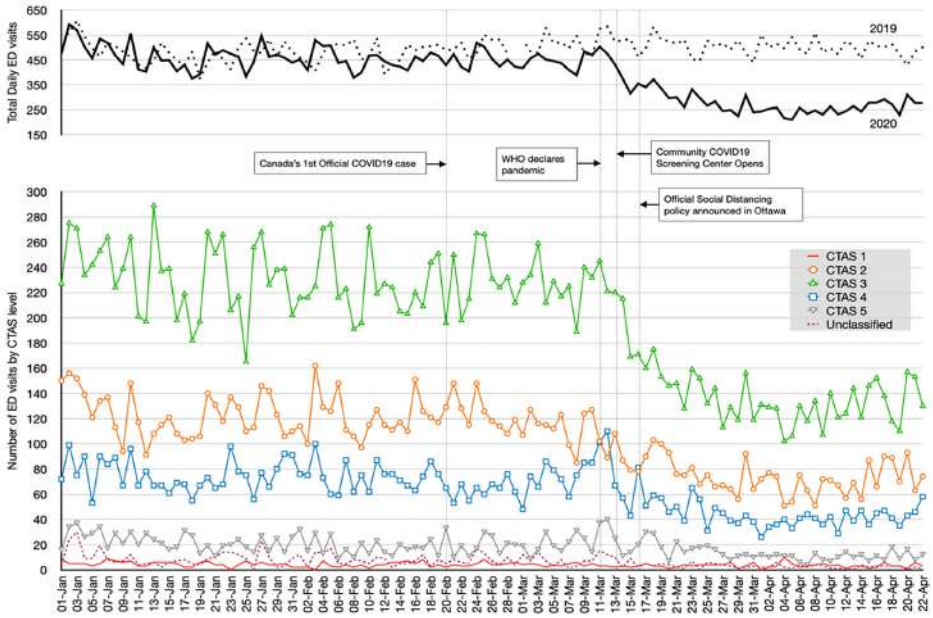

Figure 1. Number of emergency department (ED) visits according to triage CTAS level over time.
The floating graph summarizes total daily ED visits for the study year (2020) compared to historical volumes from previous year (2019).
ED, emergency department; *CTAS,* Canadian Triage Acuity Scale.

visits related to *respiratory* complaints (27.6% of all ED visits) that day. There was a subsequent drop in patients presenting with *respiratory* complaints two days later, coinciding with the opening of Ottawa's first community COVID-19 screening center. By the end of March, all complaints had sustained decline in volume compared to pre-pandemic levels.

The distribution of final diagnoses also changed following the WHO pandemic declaration. Diagnoses related to *respiratory complaints* increased from 4.2% to 6.1% of all diagnoses; *infectious* increased from 13.2% to 20.0%; and *mental health* increased from 4.6% to 5.5%. The top five final diagnosis categories with the greatest absolute numbers

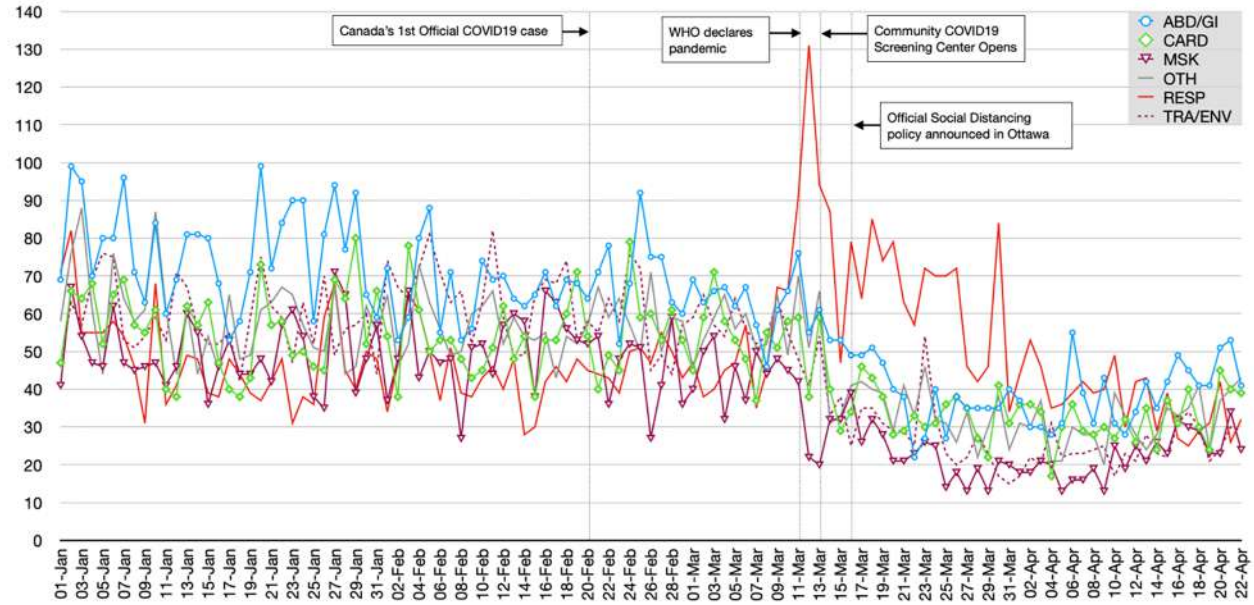

Figure 2. Number of emergency department (ED) visits according to chief presenting complaint over time.
The bold red line represents the only chief complaint (respiratory) that increased in the post-pandemic period. [The other lines represent the top five chief complaints that demonstrated the greatest drop in absolute average number of daily ED visits in the post-pandemic period.]
ABD/GI, abdominal pain/gastrointestinal; *CARD,* cardiac; *MSK,* musculoskeletal; *NEURO,* neurological; *OTH,* other; *RESP,* respiratory; *TRA/ENV,* trauma/environmental.

of decline in average daily ED visits were the following: 1) *musculoskeletal* with a drop of 48.8 patients/day (-52.9%); 2) *abdominal pain/GI* with a drop of 21.4 patients/day (-38.4%); 3) *neurological* with a drop of 14.6 patients/day (-40.7%); 4) *cardiac* with a drop of 14.5 patients/day (-33.3%); and 5) *other* with a drop of 9.4 patients/day (-29.4%).

Patients diagnosed with *infection*-related issues spiked immediately after WHO's declaration of the COVID-19 pandemic, peaking at 168 ED visits (35.4%) on March 12, 2020 (Figure 3). The number of patients diagnosed with *mental health* and *respiratory*-related issues appeared to be stable over time. Diagnoses related to *musculoskeletal*, *abdominal/GI*, and *neurological* issues had sustained declines in the post-pandemic study period.

There was a significant increase in overall mortality rate for all ED visits in the post-pandemic period (pre: 1.1%, post: 1.6%), but no difference in mortality within the three subgroups of *stroke, ACS,* and *sepsis* (Table 2). There was a significant drop in average daily ED visits for *stroke* (5.8 patients/day in pre-pandemic; 4.8 patients/day in post-pandemic) and *ACS* (3.3 patients/day in pre-pandemic; 1.7 patients/day in post-pandemic), but no significant change in average daily number of ED patient diagnoses with *sepsis* (2.8 patients/day in pre-pandemic; 2.9 patients/day in post-pandemic).

Patient flow metrics significantly improved in the post-pandemic period. Physician initial assessment, defined as time from patient arrival to the ED to the time when first seen by a physician, improved by one hour (hr) and 50 minutes (min) (pre: 3hr 00 min, post: 1hr 10 min). Average ED length of stay for both discharged and admitted patients also significantly improved by 2 hr 12 min, and 11 hr 35 min, respectively. Finally, average total hospital length of stay for admitted patients decreased by 21 hr 39 min (pre: 214 hr 35 min, post: 192 hr 54 min).

DISCUSSION

Following WHO's declaration of COVID-19 as an official pandemic, we found a significant drop in overall visits to our ED. Patients presenting to the ED with respiratory and infectious issues sharply increased, while visits related to many other complaints decreased. Musculoskeletal- and trauma-related complaints appear to be the most impacted; this may in part have been due to social distancing and stay-at-home public health messaging resulting in fewer outdoor activities and vehicles on the road. It is important to note the drop in absolute numbers of patients who presented to the ED with potentially life-threatening CTAS 1 and 2 acuities (-47 patients/day; a 37.3% decline), strokes (-1.0 patient/day; a 17.6% decline), and myocardial infarction (MI) (-1.6 patients/day; a 49.9% decline). This a concerning proportion of patients with time-sensitive emergencies who were not presenting to the ED immediately following the pandemic declaration, given that there are no known physiological reasons for the prevalence of these conditions to be lower.

Interestingly, the number of patients diagnosed with sepsis appears to have remained stable, which may reflect the fact that septic patients often present to the ED via prehospital emergency

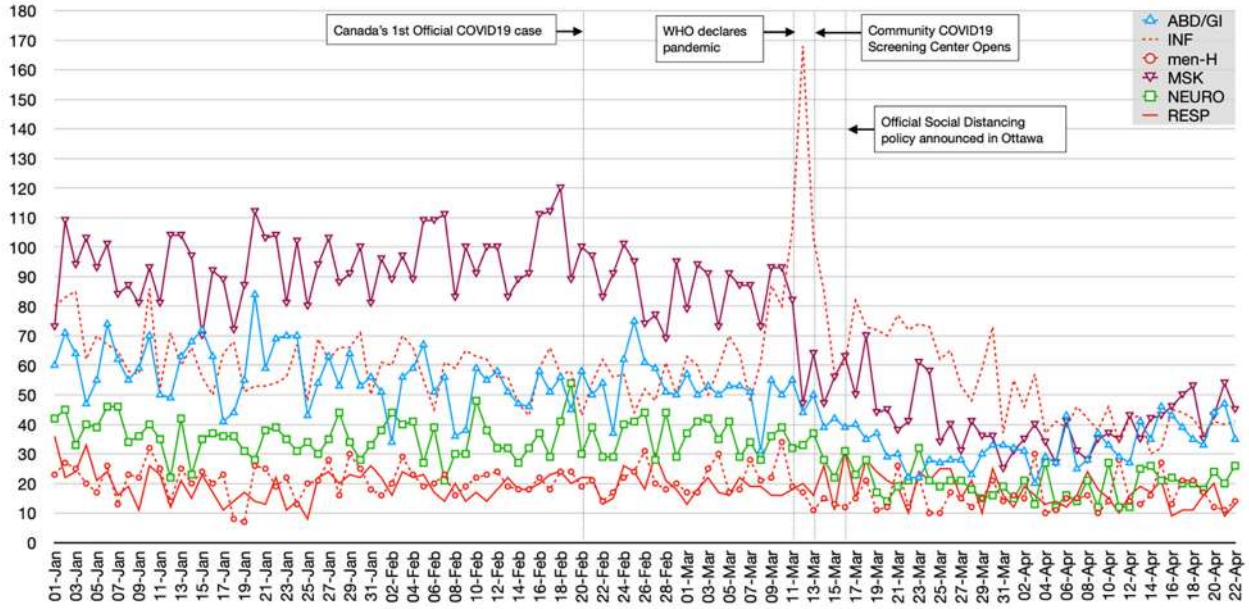

Figure 3. Number of emergency department (ED) visits according to final diagnosis over time.
The red lines (bold, dashed, and dotted) represent the final diagnosis categories that experienced an increase in the post-pandemic period. The other colored lines represent the top three final diagnosis categories that experienced the greatest drop in absolute average number of daily ED visits in the post-pandemic period.
ABD/GI, abdominal pain/gastrointestinal; *INF,* infectious; *men-H,* mental health; *MSK,* musculoskeletal; *NEURO,* neurological; *RESP,* respiratory.

Table 2. Overall mortality rates and average mortality per day between pre- and post-COVID-19 pandemic status for patients diagnosed with stroke, acute coronary syndrome, and sepsis.

		Total # of ED visits n(%)			Average # of ED visits per day		
	All Patients n(%)	Pre-pandemic	Post-pandemic	P-value	Pre-pandemic	Post-pandemic	P-value
All Diagnoses	44,497(100)	32,068(100)	12,429(100)		458.1	289.0	<0.05
Overall Mortality	550(1.2)	354(1.1)	196(1.6)	<0.05	5.1	4.6	0.28
in ED	54(0.1)	37(0.1)	17(0.1)	1	0.5	0.4	0.32
in Hospital	496(1.1)	317(1.0)	179(1.4)	<0.05	4.5	4.2	0.40
Stroke	613(100)	407(100)	206(100)		5.8	4.8	<0.05
Overall Mortality	59(9.6)	38(9.3)	21(10.2)	0.72	0.5	0.5	0.69
in ED	5(0.8)	4(1.0)	1(0.5)	0.52	0.1	0.0	0.73
in Hospital	54(8.8)	34(8.4)	20(9.7)	0.28	0.5	0.5	0.64
ACS	306(100)	234(100)	72(100)		3.3	1.7	<0.05
Overall Mortality	39(22.5)	26(11.1)	13(18.1)	0.12	0.4	0.3	0.50
in ED	26(8.5)	17(7.3)	9(12.5)	0.17	0.2	0.2	0.71
in Hospital	13(4.2)	9(3.8)	4(5.6)	0.51	0.1	0.1	0.57
Sepsis	316(100)	193(100)	123(100)		2.8	2.9	0.76
Overall Mortality	36(11.4)	22(11.4)	14(11.4)	1	0.3	0.3	0.92
in ED	3(0.9)	2(1.0)	1(0.8)	0.86	0.0	0.0	0.87
in Hospital	33(10.4)	20(10.4)	13(10.6)	0.95	0.3	0.3	0.87

*"in ED," mortalities within the emergency department; "in Hospital," after admission into hospital.
ACS, acute coronary syndrome.

medical services (EMS), and thus may be less affected by an individual's fear of coming to the ED.[10,11] Among patient groups whose volume of ED visits did not appear to be affected by the pandemic were those presenting with mental health-related issues. Anecdotally, physicians in our group reported seeing escalating cases of anxiety-related cases due to the COVID-19 pandemic; this may have been further augmented by closure of regular mental health community supports. Finally, we noticed significant improvements in all ED crowding and flow metrics. This is likely a result of the drop in hospital occupancy and improved internal operations after non-essential healthcare services were ceased during the pandemic period.

A decline in the number of non-COVID-19 patients presenting for emergency care has been anecdotally observed elsewhere, with numerous news media articles citing concerns of unintended consequences in North America.[12,13] A regional hospital in Germany reported total ED visits to their center dropped by 23% within four weeks of admitting their first COVD-19 patient.[14] Although the article did not report details on acuity levels, presenting complaints, or clinical outcomes, it did note a respective 53% and 30% decline in the hospital's cardiology- and neurology-related ED populations. The authors postulated that these unintended consequences may have been a result of individuals' extreme reactions to *dread risks*, defined as "low-probability events in which many people are killed at the same time," such as the COVID-19 pandemic. Wong et al described a similar drop in overall ED visits in a community hospital in California, and interviews with patients confirmed *fear* as the overarching theme affecting decisions to avoid ED visits.[15] There are few other studies examining the ED population as a whole, although more reports are being published with respect to how the COVID-19 pandemic may be affecting specific diagnoses such as acute MIs and strokes.[16,17]

Our findings also support the risk-avoidance behavior of ED patients with non-COVID-19 related issues in the setting of this pandemic. However, we did not power the study to robustly examine mortality rates for all subgroups of patients (due to limited time frame), and it is difficult to fully understand meaningful clinical impact. We did note an increased overall mortality rate in our study population, but this may simply be a reflection of the drop in non-emergent ED visits in the post-pandemic period rather than a true increase in severity of disease. Of note, our national statistics agency StatsCan found no increase in "excess deaths" between January 1–March 31, 2020 when compared to the same time period in the previous year.[18] It is very difficult to accurately attribute any potential delayed/avoided ED visit directly to patients' fears and behaviors in response to the pandemic. Future studies are needed to help identify this subgroup of patients who delayed ED presentation as a result of the pandemic, and to further examine relevant clinical consequences.

LIMITATIONS

There are a number of important limitations to our study. Firstly, this was a single-center study in North America and may not reflect nuances around ED visit behaviors of patients in other healthcare systems. Although our center is the regional referral center for specialized emergencies including stroke code bypass, STEMI cases identified in the field by EMS are redirected to a separate cardiac center and thus were not included in this study. As a result, our findings may underestimate the potential impact on ED visits related to cardiac and ACS presentations noted in our findings. Secondly, our findings reflect a center with relatively low COVID-19 burden in terms of admissions and critical care resources, and thus should be interpreted in relation to similar centers that were not epicenters of the COVID-19 pandemic. Thirdly, the pre-/post-design was limited by our institution's recent switch from paper charts to full Epic EHR; thus, we were unable to directly compare data from the same time period from previous year(s) without extensive manual chart review. However, we do not believe there are any seasonal variation factors between January-March vs March-April that would significantly invalidate our data. Finally, given the nature of a timely rapid review our study period was limited to just over a month past the WHO declaration of pandemic status. Future research with more detailed individual chart reviews are needed to assess delayed findings and clinical significance.

CONCLUSION

Significant decline in ED visits was observed immediately following declaration of global pandemic status, with potential for delayed/missed presentations of time-sensitive emergencies. We believe it is important for public health communication strategies to take our findings into account, as messaging regarding staying at home may have created potential extreme reactions to dread risks. Future research is needed to examine long-term and impactful clinical outcomes related to significant decline in ED visits during pandemics.

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Impact of Coronavirus Disease 2019 Pandemic on Crowding: A Call to Action for Effective Solutions to "Access Block"

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Introduction: Healthcare patterns change during disease outbreaks and pandemics. Identification of modified patterns is important for future preparedness and response. Emergency department (ED) crowding can occur because of the volume of patients waiting to be seen, which results in delays in patient assessment or treatment and impediments to leaving the ED once treatment is complete. Therefore, ED crowding has become a growing problem worldwide and represents a serious barrier to healthcare operations.

Methods: This observational study was based on a retrospective review of the epidemiologic and clinical records of patients who presented to the Foundation IRCCS Policlinic San Matteo in Pavia, Italy, during the coronavirus disease 2019 (COVID-19) outbreak (February 21–May 1, 2020, pandemic group). The methods involved an estimation of the changes in epidemiologic and clinical data from the annual baseline data after the start of the COVID-19 pandemic.

Results: We identified reduced ED visits (180 per day in the control period vs 96 per day in the pandemic period; $P < 0.001$) during the COVID-19 pandemic, irrespective of age and gender, especially for low-acuity conditions. However, patients who did present to the ED were more likely to be hemodynamically unstable, exhibit abnormal vital signs, and more frequently required high-intensity care and hospitalization. During the pandemic, ED crowding dramatically increased primarily because of an increased number of visits by patients with high-acuity conditions, changes in patient management that prolonged length of stay, and increased rates of boarding, which led to the inability of patients to gain access to appropriate hospital beds within a reasonable amount of time. During the pandemic, all crowding output indices increased, especially the rates of boarding (36% vs 57%; $P < 0.001$), "access block" (24% vs 47%; $P < 0.001$), mean boarding time (640 vs 1,150 minutes [min]; P 0.001), mean "access block" time (718 vs 1,223 min; $P < 0.001$), and "access block" total time (650,379 vs 1,359,172 min; $P < 0.001$).

Conclusion: Crowding in the ED during the COVID-19 pandemic was due to the inability to access hospital beds. Therefore, solutions to this lack of access are required to prevent a recurrence of crowding due to a new viral wave or epidemic. [West J Emerg Med. 2021;22(4)860–870.]

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an acute respiratory infectious disease caused by the novel coronavirus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). SARS-CoV-2 is dissimilar to other coronaviruses that usually spread in humans: it is particularly pathogenic in humans and is associated with high mortality rates.[1] Viruses that cause respiratory tract infections can exacerbate chronic lung disease, requiring visits to the emergency department (ED) and hospitalization.[2-8] Therefore, identifying viruses and monitoring the severity of their effects will remain major scientific and clinical endeavors.

Healthcare utilization changes during infectious disease outbreaks. Identifying the patterns of change is important for future preparedness and response. The effects of infectious disease epidemics on healthcare utilization depend on the characteristics of the infection.[9-13] Thus, epidemics have major effects on the healthcare system, including crowding. Crowding in the ED can occur because of the volume of patients waiting to be seen (input), delays in patient assessment or treatment (throughput), or impediments to leaving the ED once treatment has been completed (output).[14] Emergency department crowding has become a growing problem globally that represents a serious impediment to healthcare utilization. Crowding is the product of several internal and external factors, including insufficient access to hospital beds and shortages of hospital staff. Studies reported that crowding can result in a higher number of adverse events, increased morbidity and mortality, prolonged length of stay (LOS), and reduced healthcare quality. [15]

Currently, the most frequent cause of ED crowding is access block. The Australasian College for Emergency Medicine (ACEM) defines access block as "the situation where patients are unable to gain access to appropriate hospital beds within a reasonable amount of time, no greater than 8 hours"; it further defines crowding as "the situation where ED function is impeded by the number of patients waiting to be seen, undergoing assessment and treatment, or waiting for departure, exceeding the physical or staffing capacity of the department."[16] The effects of the COVID-19 pandemic on the availability of emergency services and ED crowding have not been evaluated. We conducted a large, retrospective observational study to compare the demographic and clinical data of patients after the start of the pandemic with data for patients who visited the ED in the corresponding period in the prior two years, as well as the period preceding the outbreak. We found that crowding increased as measured using throughput and output indices. The specific hypotheses were as follows:

1. the number of patients who presented to the ED decreased after the COVID-19 outbreak regardless of age and gender;
2. the modes of ED access (eg, ambulance, spontaneous), the codes for priority for medical examination, and the exit codes[17-21] (severity codes for discharge determined through clinical criteria assigned to patients by the attending emergency physicians who maintained the same classification as in triage) for severity changes after the outbreak reflect more serious illness and patients requiring high-intensity care;
3. the marked reduction in some access types (such as access for minor trauma and minor signs and symptoms) was accompanied by a homogeneous reduction in other access types;
4. throughput (such as ED LOS) and output crowding indices (such as rate of access block, total access block time, and percentage of patients who left without being seen) have been made worse by the COVID-19 outbreak;
5. clinical outcomes, such as admission and mortality rates, were worsened by the outbreak; and
6. visits attributable to the COVID-19 outbreak accounted for the majority of ED visits. The final objectives of this study were to estimate the rate of ED visits attributable to the outbreak and guide the planning of strategies for managing ED access after the outbreak of transmittable respiratory diseases.

Population Health Research Capsule

What do we already know about this issue?
Epidemics change the way patients use health services, leading to crowding that in turn leads to worse outcomes including increased adverse events and mortality.

What was the research question?
How did the COVID 19 pandemic change the use of healthcare and emergency departments (ED) and what were the consequences?

What was the major finding of the study?
We found a decrease in ED access, while crowding increased due to throughput and output factors, mainly due to exit block such as prolonged boarding.

How does this improve population health?
The problem of crowding, and in particular the exit block, must be solved at its root to improve patient care.

METHODS

Study Design

This observational study was based on a retrospective review of the epidemiologic and clinical records of patients

visiting Foundation IRCCS Policlinic San Matteo in Pavia, Italy, during the COVID-19 outbreak (February 21–May 1, 2020, pandemic group). We set as control periods, in which data on ED accesses were collected, the entire January–May periods in 2018 and 2019 (years before the pandemic) and the time span between January 1–February 20, 2020, because no emergency was declared before February 21, 2020. We extracted data using PiEsse software (PiEsse SRL, Latina, Italy). The methods included estimating the changes in epidemiologic and clinical data from the annual baseline data after the start of the COVID-19 pandemic. At the time of ED admission, patients provided informed consent for the processing of their data for medical and research purposes.

Endpoints

We aimed to assess the changes in the use of emergency resources after the COVID-19 outbreak in terms of ED visits. The key secondary aim was to define the characteristics of the population that visited our ED during the pandemic, including gender, age, and method of ED access. Other examined outcomes included the causes of ED visits during the pandemic; crowding indices such as ED LOS, total access block time, and rate of access block; clinical outcomes such as admission and mortality rates; and the proportion of ED visits attributable to COVID-19.

Inclusion and Exclusion Criteria

All non-pediatric patients (>14 years old) who visited the ED during the study periods were eligible for inclusion. Children under the age of 14 were not included as our ED is for adults. We treat children only if the reason for access is trauma; children who present for other medical reasons are referred to another ED. The same admission criteria apply to gynecological and ophthalmic emergencies: these patients are referred to specialized EDs separate from ours.

Study Population

For each patient, we collected demographic data (gender and age); vital parameters (blood, heart rate, oxygen saturation, Glasgow Coma Scale, respiratory rate); signs and symptoms; waiting time; LOS in the ED; mode of presentation to the ED; priority codes for medical examination; exit codes for severity; total access block time; and rate of access block. All medical records were accurately viewed and evaluated, and all computed tomography data were thoroughly reviewed. In this study, the pandemic group consisted of 6728 consecutive patients who presented to the ED between February 20–May 1, 2020. The time periods span from January 1–May 1, 2018, and January 1–May 1, 2019. We used January 1–February 20, 2020, as reference intervals.

Measurement of Crowding

Several indices to measure crowding have been proposed.[11] The most commonly used indices can be grouped as follows:

- Input crowding indices: waiting times, number of patients visiting the ED, and disease severity and complexity (eg, number of patients at each acuity level), and the number of patients who left without being attended to;
- Throughput crowding indices: LOS;
- Output crowding indices: mean number or percentage of admissions, patients in the ED (number or percentage), access block and boarding (mean number or percentage of patients who experienced these), and access block or boarding times (such as the total access block time).

"Waiting time" is defined as the total time from initial registration/triage to first being seen by a doctor. The overall LOS in the ED is the time from arrival at triage or registration until discharge or transfer to a ward. This variable reflects the total patient experience, including care and waiting. Access block is defined as a greater than eight hours duration in the ED from presentation to admission.[22-23] Total access block time thus represents the aggregate duration of access block for all patients studied.[24] Boarding is defined as a greater than six hours duration in the ED from medical examination to admission.[25] Thus, the total boarding time represents the aggregate duration of boarding for all patients studied.[22-25]

Statistical Analysis

We performed statistical analyses using the appropriate logistic multivariate regression models to test the association between the risk of overtime for selected time variables, to account for crowding, and the pandemic period. Continuous variables were expressed as the mean and the standard error of the mean, whereas qualitative variables were expressed as the number of observations and appropriate proportions. We made comparisons between two groups of continuous variables using Student's t-tests, whereas associations between qualitative variables were compared using the χ^2 test. Moreover, the test of proportions was used to assess the differences in ED mortality between periods. All tests were two-tailed, and the significance level was set at an alpha of 0.05 (statistical significance at $P < 0.05$). The analyses were performed using STATA software: release 14 (StataCorp, LLC, College Station, TX).

RESULTS

Use of Emergency Resources

Total and daily access between February 20–May 1, 2020 (96 patients per day) was approximately 50% lower than the control period (180 attenders per day); ED visits related to seasonal flu increased (five per day in control period vs 17 per day in the pandemic period; $P < 0.001$). Regardless of gender, the number of ED visits was lower during the pandemic period than during the other periods (6,729 vs 8,714–12,543). During the pandemic, a slight but statistically significant male predominance was observed among patients who visited the ED (3,660 vs 3,069, $P < 0.001$. We divided the population into age groups as follows: <20; 20–29; 30–39; 40–49; 50–59; 60–69; 70–79; and

≥80 years. During the pandemic we observed reductions in the number of ED visits among all age groups, particularly among patients younger than 30 ($P < 0.001$; Table 1).

Characteristics of Patients Who Visited Our ED During the Pandemic

The mode of arrival to the ED markedly changed during the pandemic. Whereas 60-70% of patients typically arrived to the ED using their own transportation prior to the pandemic, only 40% of patients arrived via autonomous means during the pandemic ($P < 0.001$). During the pandemic, a greater need for medical care and higher intensity of care were observed. Conversely, fewer patients required low-intensity care (31.2% vs 25.2%; $P < 0.001$). During the pandemic, the vital signs of the patients had deteriorated. Compared with the control groups, patients visiting during the pandemic displayed reduced oxygen saturation, higher rates of tachycardia, and lower systolic blood pressure values (see Table 2). We then compared

Table 1. Principal personal and emergency department presentation features of patients included in the study, by period of observation.

		Period*				
		Control	Pandemic	Difference	P[a]	Total
Total patients		51,439	6,729			58,168
Daily visits		180	96			276
Gender						
Male	n (%)	26,395 (51.34)	3,660 (54.39)	-22,735		30,055 (51.70)
Female	n (%)	25,014 (48.66)	3,069 (45.61)	-21,945	<0.001	28,083 (48.30)
Age group						
<20	n (%)	5,878 (11.43)	310 (4.61)	-5,568		6,188 (10.64)
20-29	n (%)	5,561 (10.82)	507 (7.53)	-5,054		6,068 (10.44)
30-39	n (%)	5,181 (10.08)	636 (9.45)	-4,545		5,817(10.01)
40-49	n (%)	6,676 (12.99)	874 (12.99)	-5,802		7,550 (12.99)
50-59	n (%)	6,754 (13.14)	1,019 (15.14)	-5,735		7,773 (13.37)
60-69	n (%)	5,703 (11.09)	936 (13.91)	-4,767		6,639 (11.42)
70-79	n (%)	6,946 (13.51)	1,100 (16.35)	-5,846		8,046 (13.84)
80+	n (%)	8,710 (16.94)	1,347 (20.02)	-7,363	<0.001	10,057 (17.30)
Transport						
Personal	n(%)	33,870 (65.88)	2,859 (42.49)	-31,011		36,729 (63.18)
Ambulance with volunteer personnel (paramedic)	n(%)	7,757 (15.09)	1,719 (25.55)	-6,038		9,476 (16.30)
Ambulance with specialized nurse	n (%)	8,483 (16.50)	1,986 (29.51)	-6,497		10,469 (18.01)
Ambulance with doctor	n (%)	1,022 (1.99)	143 (2.13)	-879		1,165 (2.00)
Other	n(%)	277 (0.54)	22 (0.33)	-255	<0.001	299 (0.51)
Triage priority						
5 code	n (%)	3,631 (7.05)	294 (4.36)	-3,337		3,924 (6.74)
4 code	n (%)	31,712 (61.71)	3,947 (58.68)	-27,765		35,659 (61.36)
3 code	n (%)	3,119 (6.06)	393 (5.83)	-2,726		3,511 (6.03)
2 code	n (%)	12,137 (23.61)	1,933 (28.73)	-10,204		14,068 (24.20)
1 code	n (%)	814 (1.57)	163 (2.41)	-651	<0.001	976 (1.67)
Outcome						
Discharge	n (%)	41,580 (80.88)	4,249 (63.14)	-37,331		45,829 (78.83)
Hospitalization	n (%)	8,393 (16.33)	2,277 (33.84)	-6,116		10,670 (18.35)
Transfer	n (%)	839 (1.63)	133 (1.98)	-706		972 (1.67)
Other	n (%)	597 (1.16)	70 (1.04)	-527	<0.001	667 (1.15)

*The considered pandemic period was February 21–May 1, 2020. The control period was the sum of the timespans January 1–May 1, 2018; January 1–May 1, 2019; and January 1–February 20, 2020.
[a]χ^2 test.

Table 2. Principal heart function parameters at presentation for patients included in the study, by period of observation.

	Period*			
	Control	Pandemic	P	Total
Heart rate				
Observations	32,228	5,278		37,506
Mean (bpm)	83.94	86.26		84.26
SE	0.10	0.25	<0.001[a]	0.09
Heart rate >110 bpm				
No (%)	30,219 (93.8)	4,854 (92)	<0.001[b]	35,073 (93.5)
Yes (%)	2,009 (6.2)	424 (8.0)		2,433 (6.5)
O_2 saturation				
Observations	32,113	5,273		37,386
Mean (%)	97.2	96		97. 0
SE	0.02	0.06	<0.001[a]	0.02
O_2 saturation <95%				
No (%)	28,022 (87.3)	4.103 (77.8)		32,125 (85.9)
Yes (%)	4,091 (12.7)	1,170 (22.2)	<0.001[b]	5,261 (14.17)
Systolic blood pressure				
Observations	32,497	5,312		37,809
Mean (mm Hg)	138.5	137.5		138.4
SE	0.13	0.32	0.004[a]	0.12
Systolic blood pressure < 90 mm Hg				
No (%)	32,168 (98.99)	5,242 (98.68)		37,410 (98.94)
Yes (%)	329 (1.01)	70 (1.32)	0.043[b]	399 (1.06)

*The considered pandemic period was February 21 to May 1, 2020. The control period was the sum of the timespans January 1 to May 1, 2018; January 1 to May 1, 2019; and January 1 to February 20, 2020.
[a]t-test.
[b]X^2 test.
bpm, beats per minute; *SE,* standard error; *O_2,* oxygen; *mm Hg,* millimeters of mercury.

the periods according to the percentage of patients with initial hemodynamic impairment and defined these patients as the those with impaired oxygen saturation (<95%), tachycardia (heart rate > 110 beats per minute), or arterial hypotension (systolic blood pressure < 90 millimeters mercurymmHg); we found that during the pandemic, patients were more likely to present with an initial hemodynamic impairment.

Various Causes of ED Visits

During the pandemic, fewer patients visited the ED for minor medical issues (eg, dermatological conditions, otolaryngological diseases) and minor trauma (respectively: 29 access per day vs 10; 50 access per day vs 11; P <0.001 (Table 3). Visits because of work accidents also declined regardless of gender or age (7 vs 2 access per day; P <0.001), as did the proportion of patients with major trauma (1 vs 0 access per day; P <0.001), which was dramatically reduced. Access for other causes had an homogeneous reduction: this applies, for example, to patients with access for neurological symptoms (13 vs 7 access per day, P <0.001), and for chest pain (13 vs 7 access per day). Conversely the percentage of patients who reported fever symptoms at home was much higher (7 vs 16 access per day; P <0.001), whereas the proportion of patients who had fever at triage was unchanged.

Crowding Indices

Input Indices

During the pandemic, a reduction in waiting time (from arrival at the ED until seen by a doctor) was observed for triage codes 5 (the lowest acuity code), 4, and 3, whereas for code 2, this reduction was not statistically significant, and for code 1 (the highest acuity code), only a small significant increase in waiting time was observed (66 vs 83 min; P < 0.001 (Tables 4 and S1).

Throughput Indices

During the pandemic the time spent in the ED increased, especially LOS (625 vs 314 min; P < 0.001. The

Table 3. Selected reasons for access to emergency department for patients included in the study, by period of observation.

	Period*			
	Control	Pandemic	P[a]	Total
Minor medical issues				
No (%)	44,629 (86.8)	6,057 (90.0)		50,686 (87.2)
Yes (%)	6,780 (13.2)	672 (10)	<0.001	7,452 (12.8)
Minor trauma				
No (%)	39,692 (77.2)	5,954 (88.5)		45,646 (78.5)
Yes (%)	11,717 (22.8)	775 (11.5)	<0.001	12,492 (21.5)
Major trauma				
No (%)	51,182 (99.6)	6,725 (99.9)		57,907 (99.6)
Yes (%)	227 (0.4)	4 (0.1)	<0.001	231 (0.4)
Occupational accident				
No (%)	49,710 (96.7)	6,569 (97.6)		56,279 (96.8)
Yes (%)	1,699 (3.3)	160 (2.4)	<0.001	1,859 (3.2)
Disease with fever				
No (%)	49,790 (96.8)	5,572 (82.8)		55,362 (95.2)
Yes (%)	1,619 (3.1)	1,157 (17.2)	<0.001	2,776 (4.8)
Respiratory symptoms				
No (%)	48,085 (93.5)	5,836 (86.8)		53,921 (92.8)
Yes (%)	3,324 (6.5)	893 (13.3)	<0.001	4,217 (7.3)
Thoracic pain				
No (%)	47,227 (91.9)	6,136 (91.2)		53,363 (91.8)
Yes (%)	4,182 (8.1)	593 (8.8)	0.057	4,775 (8.2)
Neurologic disease				
No (%)	48,364 (94.1)	6,222 (92.5)		54,586 (93.9)
Yes (%)	3,045 (5.9)	507 (7.5)	<0.001	3,552 (6.1)

*The considered pandemic period was February 21–May 1, 2020. The control period was the sum of the timespans January 1–May 1, 2018; January 1–May 1, 2019; and January 1–February 20, 2020.
[a]χ^2 test.

prolongation of LOS in the pandemic period compared with that in the control periods remained statistically significant after adjustment for age, gender, priority code, and the need for moderate-to-high–intensity care (625 vs 314 min, P < 0.001 (Table 5).

Output Indices

During the pandemic, all crowding output indices increased, especially the rates of boarding (36% vs 57%; $P < 0.001$), access block (24% vs 47%; $P < 0.001$), mean boarding time (640 vs 1150 min; $P < 0.001$), mean access block time (718 vs. 1223 min; $P < 0.001$), and access block total time (650,379 vs. 1,359,172 min; $P < 0.001$. The increased frequencies of boarding (percentage and total time) and access block (percentage and total time) in the pandemic period compared with that in the control periods remained statistically significant after adjustment for age, gender, priority code, and the need for moderate-to-high–intensity care ($P < 0.001$).

Clinical Outcomes

During the pandemic, patients had worse exit codes (severity codes for discharge through clinical criteria assigned by the attending emergency physicians who maintained the same classification as in triage) and hospitalization rates ($P < 0.001$). The need for hospitalization increased from approximately 16% to 34% ($P < 0.001$). Importantly, although the total number of ED visits decreased, the number of deaths increased. In fact, we observed 115 deaths between February 21–May 1, 2020 (pandemic), while the number of deaths during the control period was 75. Considering the difference in patient numbers (6,729 during the pandemic period and 51,439 in the control period), we found mortality rates in the ED of 1.71 per 100 patients during the pandemic and 0.15 per 100 patients ($P < 0.001$) in the previous corresponding periods.

Proportion of Visits Attributed to COVID-19

To assess the proportion of ED visits attributable to the pandemic, we analyzed patients with signs or symptoms that

Table 4. Selected time variables accounting for crowding, by period.

	Period*	Observations	Mean	Standard error	**Sum**	P[a]
Wait time (min)						
	Control period	51,405	83	0.36	-	
	Pandemic	6,729	66	0.98	-	<0.001
LOS (min)						
	Control period	51,405	314	1.84	-	
	Pandemic	6,729	625	11.36	-	<0.001
Process time (min)						
	Control period	51,405	231	1.81	-	
	Pandemic	6,729	560	11.30	-	<0.001
Access block time per patient[b] (min)						
	Control period	3,183	718	11.81	-	
	Pandemic	1,260	1,223	40.29	-	<0.001
Access block total time aggregate[c] (hours)						
	Control period	**3,183**	**-**	**-**	**5,420[c]**	
	Pandemic	**1,260**	**-**	**-**	**22,653[c]**	**-**
Boarding time per patient[b] (min)						
	Control period	**3,183**	**640**	**13.42**	**-**	
	Pandemic	**1,260**	**1150**	**45.35**	**-**	**<0.001**
Boarding total time aggregate[c] (hours)						
	Control period	**3,183**	**-**	**-**	**6,970[c]**	
	Pandemic	**1,260**	**-**	**-**	**25,954[c]**	

*The considered pandemic period was February 21–May 1, 2020. The control period was the sum of the timespans January 1–May 1, 2018; January 1–May 1, 2019; and January 1–February 20, 2020.
[a]t-test.
[b]Mean calculated only for hospitalized patients.
[c]Access block total time and boarding total time calculated only for hospitalized patients; by definition, it is not an average but the sum of each patient's access block times. Access block total time and boarding total time ware calculated from February 21–May 1, 2020 for the pandemic period and as the mean of the periods February 21–May 1, 2019, and February 21–May 1, 2018 for the control period.
Min, minute; *LOS,* length of stay.

required a differential diagnosis for SARS-CoV-2 infection. The percentage of patients who visited the ED for relevant symptoms (fever or respiratory problems) was 30.47% during the pandemic period vs 9.62% during the control period ($P < 0.001$).

DISCUSSION

Use of Emergency Resources and Characteristics of Patients Who Visited Our ED During the Pandemic

The high number of deaths associated with the COVID-19 pandemic spurred civil authorities to implement measures to contain the virus. "Red zones" were created, including restrictions on citizens' movements, business closures, and advisements to work from home when possible. Newscasts that constantly updated the spread and mortality of COVID-19 likely resulted in increased apprehension among the population.

As observed in previous studies examining changes in healthcare utilization according to disease severity,[26-27] the results of this situation showed that the reduction in emergency care utilization was most prominent for low-acuity conditions (non-urgent; minor emergency; emergency requiring low-intensity care).[26] The reduction in visits for high-acuity conditions (emergency requiring moderate-to-high–intensity care) was relatively small, despite the possibility of more serious consequences (late or missed diagnoses of some conditions, even serious ones, and time-dependent conditions such as heart attacks and strokes). The increased use of the ED by sicker patients was also evidenced by the higher prevalence of hemodynamically compromised patients. Examining the scale of ED visits for low-acuity conditions with little benefit from service use is

Table 5. Risk of overtime for selected time variables accounting for crowding, by period.

	Period*	OR[a]	95% Confidence interval	P
LOS				
	Control period	1.00 (Ref.)	-	
	Pandemic	2.58	2.40-2.78	<0.001
Boarding				
	Control period	1.00 (Ref.)	-	
	Pandemic	2.67	2.46-2.89	<0.001
Access block				
	Control period	1.00 (Ref.)	-	
	Pandemic	2.52	2.33-2.72	<0.001

*The considered pandemic period was February 21–May 1, 2020. The control period was the sum of the timespans January 1–May 1, 2018; January 1–May 1, 2019; and January 1–February 20, 2020.
[a]ORs estimated by multiple regression analysis adjusted by age, gender, priority code at triage, presence of fever or respiratory symptoms. and need for moderate to high-intensity care.
LOS, length of stay; *OR,* odds ratio.

important for both ensuring appropriate emergency surge capacity and providing evidence to redesign emergency services to decrease healthcare-related infections after disease outbreak.

Various Causes of ED Visits

During the pandemic there was a net reduction in some reasons for ED visits such as minor trauma or minor medical issues, confirming the reduction of low-acuity visits. Although the percentage of patients who had febrile symptoms at home was much higher during the pandemic, the proportion of patients who had fever at triage was not increased. This is also likely attributable to the fact that body temperature has been measured in a greater number of patients during the pandemic (53.2% vs 12.7% before the pandemic).

Patients decide to use medical care after considering the risks and benefits. When patients have concerns about nosocomial infections, those with low-acuity diseases are less likely to visit the ED.[26-27] Visits by patients with low-acuity conditions most strongly decrease when the risk of infection overwhelms the benefits of emergency service use. The rate of visits for serious conditions did not decline in the same manner. Even the inputs for high-acuity diseases, albeit stable in percentage terms, were reduced, although to a smaller degree. This is the case, for example, with presentations for chest pain and neurological disorders. This has been highlighted by some studies which reported an increase in late diagnoses.[47-50] When fears of an epidemic spread and ED visits decrease, preparations for serious conditions must be focused, and patients with severe diseases should not face barriers to emergency care. This situation also underlines the need to consider "clean" or low-risk infectious pathways for the most serious reasons for ED visits.

Crowding Indices

Causes of Crowding

Crowding of EDs has been reported for several decades. Our study found that input factors played a modest/ambivalent role in crowding in this pandemic. ED crowding had two main causes: the worsening of output and throughput factors. With regard to output factors, crowding was caused by the access block phenomenon and in particular by an unprecedented need for care in medium- and high-intensity care units.[1] In a study conducted prior to this pandemic, through tabletop simulations of a potential maxi-emergency, our research group had anticipated that such a scenario was possible. In particular, we had shown how wards with high- and medium-intensity care could most easily determine boarding time and access block.[17]

We believe this increment of access block is attributable to the discrepancy between the immediate and sudden need for intensive care (ICU) beds and the number of ICU beds available on the basis of national and local historical needs. However, it is important to emphasize that all patients, even those in need of low-intensity care, have struggled against access block. Therefore, the lack of beds seems to be the main cause of access block. Our opinion is that EDs are crowded when hospitals are crowded. The waiting time for hospitalization was also prolonged because it was necessary to screen all patients before assigning them to a "clean" vs COVID-unit bed to ensure that infected (and perhaps asymptomatic) patients were not admitted to "clean" wards or wards in which the risk of infection had to remain low.

With regard to throughput factors, crowding has resulted from changes in the role of emergency physicians and EDs. Emergency departments are no longer merely where patients are sorted into specialist departments; patients are now treated and stabilized, and differential diagnostic tests

are performed in the ED. This change in the level of care has been exacerbated in the pandemic because of the high number of critically ill patients who require stabilization before transfer to the hospital wards, and the change in patient management caused by the pandemic. In particular, the need for frequent checks, ventilatory therapies, nasal swabs and wait time for the result, the time taken for dressing and undressing by the medical and nursing staff, and the high burden of caring for patients who need ventilatory therapy mean that patients often cannot be autonomous, and because of the disease, relatives and other caregivers cannot stay to help them. As a result, the care burden on health workers has also increased.

In our opinion, the necessary doubling of patient flows (COVID-free flow and COVID flow) has also contributed to increases in work and crowding, which have doubled the work of the ED staff with the same amount of resources. In fact, nasal swabs (for serological tests), bedside chest radiographs, and bedside lung ultrasounds were obtained from all patients who awaited the results in a specific location separate from other inpatients in the ward. These necessary safety measures prolonged the processing time and LOS, together with frequent sanitation and the use of personal protective equipment by healthcare professionals. Thus, increased rates of boarding and access block during the pandemic affected all patients, including those who did not have COVID-19, despite the strong effort during the emergency peak to add approximately 300 beds for COVID-19 patients, 65 of which were dedicated to the ICU.

During the pandemic, the treatment of COVID-19 has progressively changed, particularly the indications for intubation. Early on, patients were intubated early; now alternative modes of support (eg, high-flow nasal cannula, non-invasive positive-pressure ventilation, awake proning) are recommended before intubation. Nevertheless, the need for medium- or high-intensity care persists, and COVID-19 wards are the departments that probably prolong boarding.

Possible Crowding Responses

Many researchers and societies have developed measures to prevent ED crowding and provide proper care for patients receiving emergency care. Interventions are categorized into input, throughput, and output controls.[29-33] However, measures to alleviate crowding and reduce access block are needed to prepare adequate responses for future pandemics.

Emergency preparedness for outbreaks of transmittable respiratory illness has scarcely focused on preventing crowding and protecting staff and patients. Rather, the focus has been on preparing emergency quarantine areas and isolating admission rooms. Crowding provides favorable conditions for transmission among patients in the ED through respiratory droplets, and prior research has recommended infection control measures such as case management, isolation, and planning for complex emergencies.[34-46]

To improve the practice of boarding patients, the American College of Emergency Physicians (ACEP) established a task force to develop a list of low-cost, high-impact solutions.[42-43] One of the key solutions proposed by ACEP is the use of a full-capacity protocol.[41] Although this was an effective response, the need for effective solutions for reducing access block must be reiterated. Given the emergence of pandemics and other emergencies, we must emphasize that "access Block and ED overcrowding have created a dynamic tension and the future of emergency medicine will be determined by the resolution of this conflict."[46]

Clinical Outcomes, Like Admission and Mortality Rates, Were Made Worse by the Outbreak

The rates of more serious exit codes and the need for hospitalization were approximately twofold higher than those in the control periods. This illustrates the major impact of this pandemic on the healthcare system[1–7] and simultaneously highlights the high rates of access block and boarding that occurred. A greater need for hospitalization, in this case nearly twofold higher than the historical requirement, resulted in a more rapid saturation of hospital beds. In addition, patients with greater disease severity require longer hospital stays.

Visits Attributable to the COVID-19 Outbreak Accounted for the Majority of ED Visits

To assess the rate of ED visits attributable to the COVID-19 outbreak, we analyzed ED visits associated with symptoms compatible with SARS-CoV-2 infection because the clinical suspicion and symptoms cited by the patient determines access to the ED as opposed to the final diagnosis. Specifically, patients with respiratory symptoms and fever are sent to the ED for suspected COVID-19. Excluding such a diagnosis does not reduce the use of EDs.

This study confirmed that a higher number of patients visited the ED with febrile or respiratory symptoms during the pandemic, comprising approximately one-third of all ED visits. Of course, only a portion of these patients received a diagnosis of COVID-19 or required hospitalization. This indicates that following an outbreak, more patients with symptoms of milder respiratory illness use emergency resources, and more patients seek emergency care at an early stage. These findings should be considered when creating effective responses to epidemics or pandemics involving respiratory symptoms.

CONCLUSION

This study identified a reduction in ED visits during the COVID-19 pandemic irrespective of age and gender, especially for low-acuity conditions. However, patients who visited the ED more frequently were hemodynamically unstable, more commonly exhibited abnormal vital signs, and more frequently required high-intensity care and hospitalization. During the pandemic, ED crowding

dramatically increased, primarily because of increased visits by patients with high-acuity conditions, changes in patient management that prolonged lengths of stay, and increased rates of boarding and access block.

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Impact of a Novel Emergency Department Forward Treatment Area During the New York City COVID-19 Surge

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Introduction: Coronavirus disease 2019 (COVID-19) caused a disproportionate number of patients to seek emergency care at hospitals in New York City (NYC) during the initial crisis. Our urban emergency department (ED), a member of the NYC public hospital system had to process the increased volume while also differentiating our patients' critical needs. We established a forward treatment area (FTA) directly in front of the ED to accomplish these goals from March 23–April 16, 2020.

Methods: A clinical greeter evaluated patients 18 years and older who presented to the walk-in entrance of the ED where they were screened for COVID-19-like complaints. If they did not appear critically ill and could ambulate they were directed into the FTA. Clinical and non-clinical staff worked in concert to register, evaluate, and process patients with either a disposition of directly home or into the ED for further care.

Results: A total of 634 patients were seen in the FTA from March 23–April 16, 2020. Of the 634 patients evaluated, 135 (21%) were referred into the ED for further evaluation, of whom 81 (12.7% of the total) were admitted. These patients were disproportionately male (91 into the ED and 63 admitted) and tended to have a higher heart rate (105.4 vs 93.7), a higher respiratory rate (21.5 vs 18.1), and lower oxygen saturation (93.9% vs 97.8%).

Conclusion: A forward treatment area is an effective method to rapidly screen and process an increased volume of COVID-19 patients when resources are limited. This treatment area helped decompress the ED by being rapidly deployable and effectively screening patients for safe discharge home. [West J Emerg Med. 2021;22(4)871–877.]

INTRODUCTION

New York City (NYC) experienced a dramatic coronavirus disease 2019 (COVID-19) surge in March–April 2020. The Bronx, where our institution is located, was particularly overwhelmed, experiencing the highest hospitalization and mortality rates of the city's five boroughs.[1] This occurred despite the fact that the Bronx has the highest per capita number of hospital beds and the smallest number of elderly adults in NYC.[1]

Given the high demand for emergency care during the COVID-19 pandemic, many NYC emergency departments (ED) needed non-traditional methods to care for the influx of patients.

In prior disasters in the United States, such as Hurricane Katrina in 2005, the 2009 H1N1 influenza pandemic, and Hurricane Sandy in New York in 2012, alternative ED treatment areas had to be set up to handle patient surges. During the H1N1 pandemic, EDs used many options to

meet the increased demand of patients. For example, in the state of Georgia, EDs created alternative treatment sites for high volumes of low-acuity patients in schools, community centers, mobile trailers, and outpatient clinics.[2] Pediatric EDs in Texas used similar alternate treatment sites.[3,4] After Hurricane Katrina and the closure of New Orleans' Charity Hospital, a temporary ED was set up in a convention center and then in an abandoned department store; mobile clinics were also employed.[5,6]

Despite the many novel descriptions of alternative ED treatment areas, few, if any, reports describe the creation of an ad-hoc external ED treatment area to rapidly evaluate patients and preserve the functions of the existing ED. The literature focuses mainly on non-emergency sites distant from existing EDs (ambulatory care clinics, field hospitals, etc) or complementary treatment areas of the main ED offering a suite of services. Furthermore, there are limited descriptions of an ED forward treatment area (FTA) designed specifically to rapidly assess patients during an infectious disease outbreak.

During the COVID-19 surge, the volume of incoming patients with COVID-19-like symptoms rapidly overwhelmed the physical plant and resources of our ED. Daily ED volume increased by 20% with one third to one half of all patients presenting with COVID-19-like complaints. Although volume was only up 20%, the ED became rapidly overwhelmed because suspected COVID-19 patients required individual treatment rooms to avoid exposure to staff and other patients. Hallway stretchers and chairs, a commonality in NYC EDs during normal operations, had to be avoided. Rooms required more thorough cleaning between patients, and the ED needed to avoid crowding of patients in the waiting room. Patients with COVID-19-like complaints had remarkable variability in their illness severity, which necessitated rapid identification of patients requiring interventions from those who only needed education and reassurance.

With limited treatment options in the early stages of the pandemic and hospital space severely constrained, a new evaluation paradigm was required. Described herein are the characteristics of suspected COVID-19 patients cared for in an ED FTA, as well as factors associated with the need for further treatment in the main ED and/or admission to the hospital from March 23–April 16, 2020. Our primary objective in this study was to characterize the creation and methodology of an FTA as a means to decrease the throughput of the main ED. The secondary objective was to characterize the patients who passed through the FTA as well as their disposition.

Population Health Research Capsule

What do we already know about this issue?
Little was known about ad-hoc processes to manage a sudden and sustained influx of infectious disease patients during a pandemic-level event.

What was the research question?
How can an emergency department (ED) use available resources to safely manage an infectious disease that is rapidly overwhelming resources?

What was the major finding of the study?
By establishing a forward treatment area (FTA) we were able to safely discharge 80% of patients without using main ED resources.

How does this improve population health?
The FTA saved scarce resources for patients who most needed them, allowing staff to concentrate on critically ill patients without significant adverse events.

METHODS

This was a retrospective cohort study of all patients seen and evaluated in an ED FTA during the initial NYC COVID-19 surge from March 23–April 16, 2020. The primary outcome was the ability of the FTA to successfully and rapidly screen and discharge low-risk COVID-19 persons under investigation (PUI). The secondary outcome was to run an additional analysis on the clinical characteristics of screened patients with consideration for disposition outcomes (home vs requiring further evaluation in the main ED). The study was approved by the Albert Einstein College of Medicine Institutional Review Board.

Setting

Safety net urban hospital emergency department in the Bronx, NY, receiving >100,000 annual visits with a large emergency medicine residency program. The hospital is a Level I trauma center serving a limited- resource population; it is part of the nation's largest public health hospital system.

Description of Emergency Department Forward Treatment Area

The ED FTA was comprised of two tents provided and set up by the NYC Office of Emergency Management (OEM) (Figure 1). The tents were placed directly outside (within 15 feet) of the main ambulatory ED entrance (waiting room) and labeled "COVID screening area" (Figure 2). The tents were equipped as delivered and installed by OEM with full power for lighting, computers, and heating, ventilation and air conditioning. The ED provided and installed seating and screens (to keep patients physically distanced >6 feet apart); Wi-Fi access points; workstations on wheels (WOW) with full electronic health record access and integration in each tent;

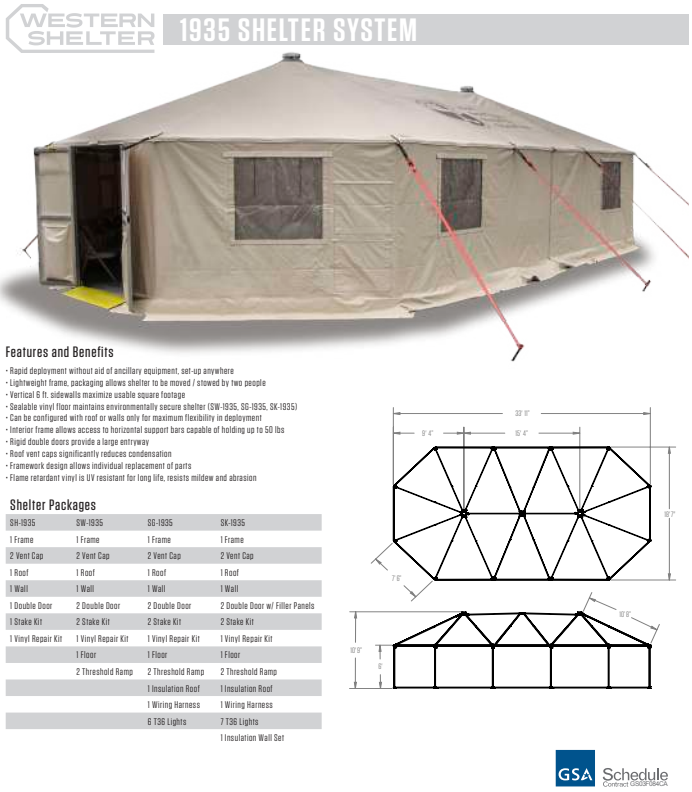

Figure 1. Tent structure schematics for emergency department forward treatment area.

printers; vital sign units for recording full sets of vital signs; and hand hygiene stations (Figure 3).

Forward Treatment Area Workflow and Protocols

Outside the main ED entrance, a "greeter" (Registered Nurse (RN) or Physician Assistant (PA)) met every patient at the walk-in entrance and visually assessed them (Figure 4). The visual assessment focused on the greeter's subjective assessment of respiratory distress (obvious distress/ability to speak in full sentences). If they appeared unstable, they were immediately brought inside the main ED for standard ED triage. If the patients appeared stable, they were assessed for reason of visit, and if related to COVID-19 subjectively (broad capture of symptoms such as fever, shortness of breath, cough, nausea / vomiting / diarrhea), they proceeded through the FTA. As the environment outside was winter in the Northeast the greeter's assessment was entirely visual and brief although the predominance of patients presenting at the time were of a COVID like nature. Patients were excluded from the area and seen directly in the ED if they were less than 18 years of age or were unable to ambulate independently or were presenting to the ED for primarily non-COVID-19 related complaints (eg, suture removal).

No testing for COVID-19 was done in the FTA, in compliance with the recommendations of the NYC DOH, because testing samples were in extremely short supply at that time.

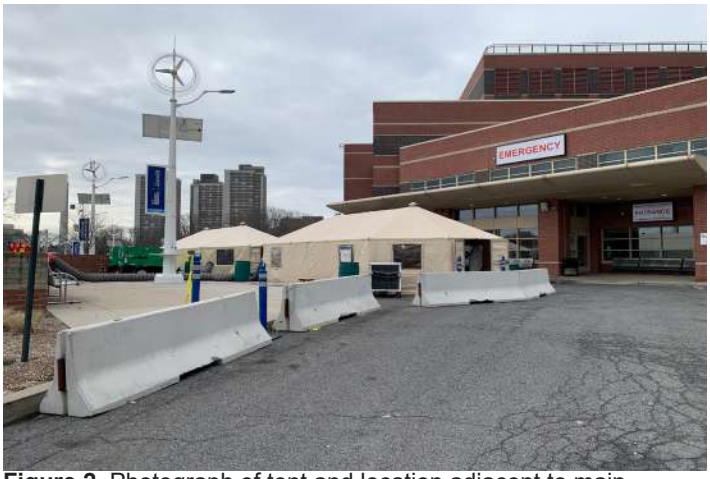

Figure 2. Photograph of tent and location adjacent to main emergency department.

Patients flowed unidirectionally through the FTA as follows:

1. Clerical staff registered the patient;
2. A patient care associate (PCA) obtained vital signs;
3. An RN performed rapid assessment and completed abridged triage;
4. A resident physician, PA, or nurse practitioner (NP) completed rapid evaluation and presented to the ED attending;
5. The attending emergency physician oversaw evaluation and disposition decision.

All members of the FTA with the exception of the clerical staff and the ED Attending did not necessarily have emergency medicine experience. These team members came from other departments within our hospital as well as volunteers and locums (RN, PA, MD) brought in by the health care system. The team members from other hospital departments included RN administrators, NPs, and residents (dental, pediatrics, etc.). The team members received Just-In-Time (JIT) Training (designed ad-hoc) at minimum of two times: on appointment to the team which included a broad overview prior to the initiation of the FTA and every morning when reporting for duty during an 0800 hour ED-wide huddle including a separate more focused second huddle prior to entering the FTA (see Appendix 1). The greeters had no specific additional training or experience. The final disposition diagnosis and decision was made by the ED Attending physician present in the FTA utilizing clinical judgement as no scoring systems existed at the time and the disease was relatively unknown.

The RNs performing the rapid assessment, the intermediary assessment by the resident/PA/NP, and the attending emergency physician were all within close proximity to one another allowing sharing of information and co-assessments adjusting for volume. Up to three lanes of RN and intermediary assessment could be performed at one

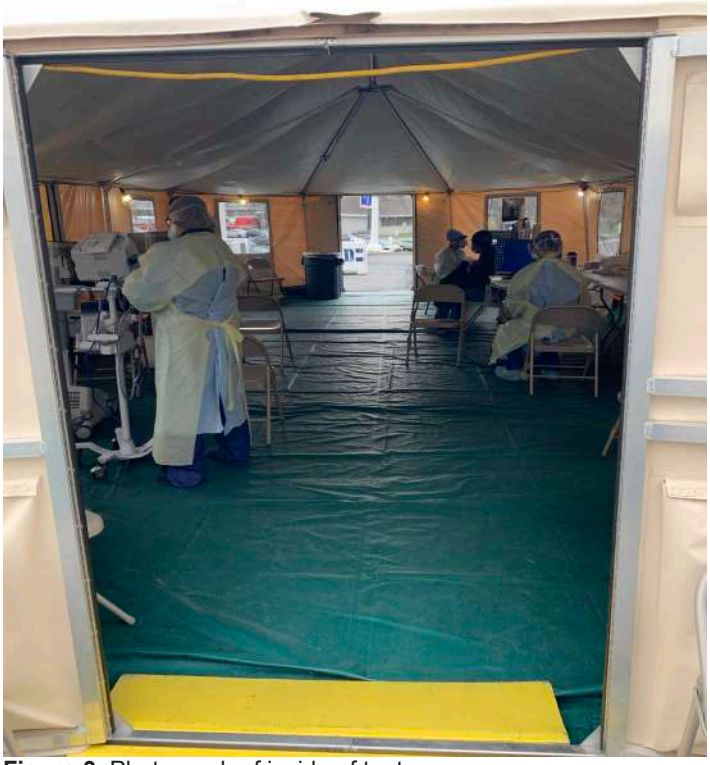

Figure 3. Photograph of inside of tent.

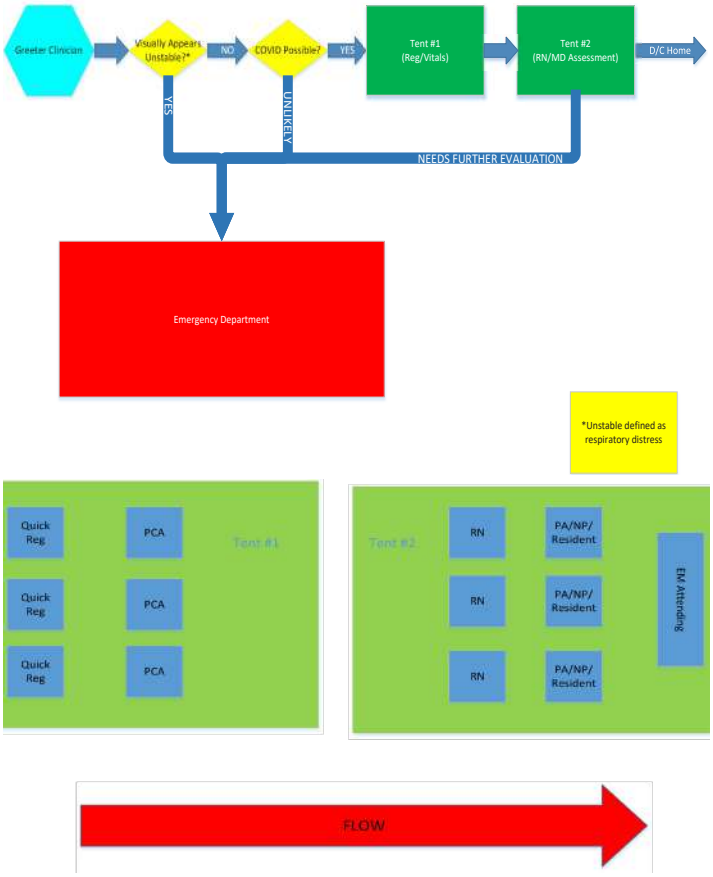

Figure 4. Forward treatment area pathway.

time depending on patient volumes with the EM attending overseeing the processes.

The FTA operated approximately 11 hours daily (9am to 8pm). This was set to start the shift with the 0800 hours ED huddle and coincide with previously established twelve-hour shift rotations.

COVID-19 Electronic Health Record SmartSet

To expedite throughput, team members used a COVID-specific SmartSet that included a prepopulated note template, diagnosis and prepopulated discharge instructions.in the EHR (Epic Systems Corporation, Verona, WI). A medical screening evaluation, fully compliant with the Emergency Medical Treatment and Labor Act, could be completed in fewer than three minutes with personalized printed discharge instructions. This Epic SmartSet was designed by our centralized hospital system. When triaged in the FTA the patient was also flagged as a "mass influx" patient within Epic and roomed in the "disaster" treatment area.

Personal Protective Equipment

Staff were required to wear full, "level 1" personal protective equipment (PPE) described by the New York City Health and Hospitals Corporation (NYCHHC) at that time as follows: N95 mask covered by a surgical mask; goggles; hair cover; double gloves; and surgical gown. Between patients, all staff changed outer gloves and sanitized their hands with an alcohol-based solution. Power air-purifying respirators were not available. During this initial surge PPE supplies were not abundant.

Data Collection

Demographics, initial vital signs, and clinical dispositions were collected for all patients presenting to the FTA area between March 23–April 16, 2020. To capture any return ED visits after evaluation in the FTA, outcomes were collected for an additional two weeks after study conclusion.

Data Analysis

We report descriptive statistics for continuous variables as means with interquartile ranges (IQR). Categorical variables are reported as counts and percentages. We divided patients into three categories: discharged from the FTA (n = 499); further assessed in the ED (n = 135); and admitted (n = 81). We used multivariable logistic regression to model the associations between needing additional evaluation in the ED or being admitted, with age, gender, initial vitals (pulse, respiratory rate, and oxygen saturation) as payer categories. To assess the quality of the model for goodness of fit we used Hosmer-Lemeshow statistics in Stata v13.0 (StataCorp, College Station, TX). We further assessed for a safety endpoint of a potential incorrect disposition, which we defined a priori as a discharge followed by a mortality in the following seven days.

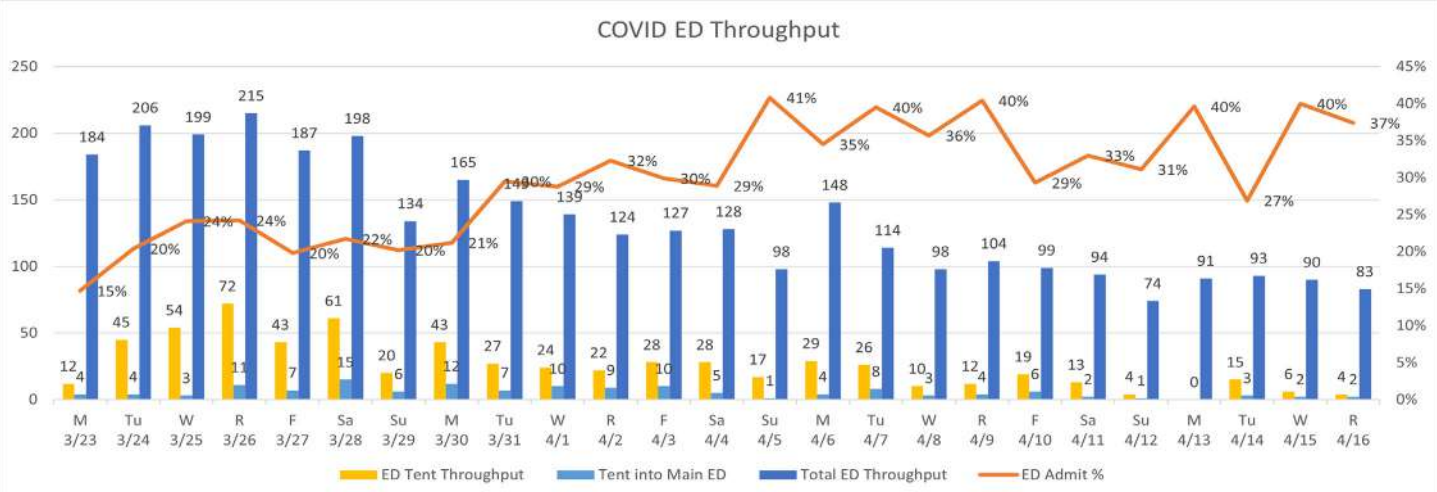

Figure 5. Patient throughput data.

RESULTS

The FTA processed 634 patients between March 23 and April 16, 2020 with a mean of 26.4 patients per day (SD 18.2, range 4-72) comprising 15-25% of overall adult ED volume during the study period. Of the 634 patients evaluated, 499 (79%) were discharged and 135 (21%) were transferred into the ED for further evaluation. Of the 135 brought into the ED, 81 (12.7% of the total) were admitted (Figure 5). Patients needing further evaluation were predominantly male: 67.4% (91/135) of the transfers into the ED and 77.8% (63/81) of the admissions. Patients transferred into the ED tended to have a higher pulse rate (105.4 vs 93.7 beats per minute) and respiratory rates (21.5 vs 18.1 breaths per minute), and lower oxygen saturation (93.9% vs 97.8%) (Table 1 and 2).

Of the 634 initially screened patients, 58 (9.1%) returned to the ED for re-evaluation. The average return after discharge was six days. Of the 58 patients who returned, 17 (29%) were admitted with their average time to return 3.5 days and an admission lasting on average 5.4 days. Of those admitted, two patients had notable outcomes:

1. Initial visit (temperature [T] 99.3ºF; heart rate [HR] 94; respiratory rate [RR] not recorded; blood pressure [BP] 153/80 millimeters mercury (mm Hg); oxygen levels] SpO_2] 97%) 41-year-old male with a past medical history of hypertension and hyperlipidemia, returned the following day (T 97.8ºF; HR 90; RR 28; BP 164/98 mm Hg; SpO_2 86%) complaining of shortness of breath, found to have acute renal injury and admitted. On hospital day two he was intubated for worsening hypoxia and on hospital day five experienced cardiac arrest without return of spontaneous circulation.
2. Initial visit (T 101.3 ºF; HR 110; RR 16; BP 121/86 mm Hg; SpO2 96%) 40-year-old male with no medical history returned three days later (T 102.9 ºF, HR 131; RR 20; BP 136/87 mm Hg; SpO_2 90%) and admitted for increased work of breathing. He was hospitalized for 14 days requiring supplemental O_2 via non-rebreather mask and discharged home with no invasive intervention.

Tables 1 and 2 describe the association between age and initial vital signs (pulse, respiratory rate, oxygen saturation) with undergoing additional evaluation in the ED or being admitted. Age >= 70 years old (Odds Ratio (OR) [6.52], 95% Confidence Interval (CI), (1.40-30.38) p-value= 0.02), increased pulse (OR [1.03] (CI, 1.01-1.05) p-value=0.003), respiratory rate (OR [1.19] (CI, 1.08-1.30) p-value <0.001), and oxygen saturation (OR [0.60] (CI, 0.52-0.70) p-value <0.001) appear most correlated with the outcome of transfer into the main ED for evaluation. Of note, although gender appeared important in the descriptive data, the effect of gender was no longer significant in the final model when initial vital signs were included. The Hosmer-Lemeshow goodness of fit for the into-the-ED model was 0.61. With the larger the value, the better the model observed events align with the expected events. The model fit of 0.61 is a good fit for the data. For association with being admitted to the hospital, age >=70 years of age (OR [6.48] (CI, 0.99-42.48) p-value 0.05), respiratory rate (OR [1.23] (CI, 1.11-1.35) p-value <0.001) and oxygen saturation (OR [0.52] (CI, 0.44-0.62) p value <0.001). The Hosmer-Lemeshow goodness of fit for the admission to hospital model was 0.90.

Patient throughput averaged about thirty minutes and never more than one hour. The FTA closed early on 4/12/20 due to physician illness and closed completely on 4/13/20 due to dangerously high winds. The FTA operations ceased on 4/16/20 due to volume of throughput not substantiating the number of staff necessitated to keep the facility open.

DISCUSSION

The use of this external, COVID-19-specific FTA allowed our ED to screen an average of 25 COVID-19 PUIs per day (up to >70/day at peak COVID-19 surge volume) with the ability

Table 1. Characteristics of forward treatment area patients discharged vs referred to the emergency department vs admitted.

	Discharged (n = 499)	Into ED (n = 135)	Admitted (n = 81)
Age category			
18-29 years old	88	9	4
30-39 years old	120	23	11
40-49 years old	134	35	19
50-59 years old	94	38	25
60-69 years old	48	22	17
≥70 years old	15	8	5
Gender			
Female	278	44	18
Male	271	91	63
Initial vital signs (mean [SD]; median [IQR])			
Pulse (n = 499)	94 (15.6); 94 (83-104)	105 (20.1); 105 (92-119)	107(16.1); 108 (92-119)
Respiratory rate (n = 304)	18 (2.2); 18 (16-20)	22 (5.6); 20 (18-24)	23 (6.2); 22 (18-25)
Temperature (ºF) (n = 499)	99.0 (0.88); 98.8 (98.5-99.3)	99.1 (4.6); 99.1 (98.5-100.1)	99.1 (5.8); 99.3 (98.7-100.5)
Oxygen saturation (%) (n =497)	98 (1.5); 98 (97-99)	94 (4.8); 95 (92-97)	92.1 (5.2); 94 (90-96)
Systolic BP (mm Hg) (n = 498)	137 (19.0); 135 (124-149)	137 (20.8); 134 (122-151)	136 (21.5); 134 (120-151)
Diastolic BP (mm Hg) (n = 498)	84 (11.3); 83 (77-90)	82 (12.8); 81 (75-89)	82 (12.5); 81 (75-86)

ED, emergency department; *SD,* standard deviation; *IQR,* interquartile range; *F,* Fahrenheit; *BP,* blood pressure; *mm HG,* millimeters mercury,

to safely discharge 79% of those patients. This comprised 15-25% of overall adult ED volume during the time frame. The external structure screened patients rapidly and determined whether further medical evaluation in the main ED was needed and expedited rapid discharge with return precautions without needing to enter the main ED in most cases. The establishment of a FTA decreased the workload of the main ED staff and their interactions with infectious patients, during a time when available isolation and resuscitation rooms were already beyond capacity.

In contrast, during pre-COVID-19 ED workflow, patients had contact with at minimum the following staff: greeter RN, greeter clerk, triage RN, PCA, ED RN, MD/PA/residents. The sequestering of a large cohort of well appearing, COVID-19 PUIs also allowed our fast-track area to be more available, and safer for patients with non-COVID complaints. Environmental cleaning services were delayed leading to excessive room closures.

By using this external structure, infectious pathogens were kept outside. Within this clear hot zone, staff members donned

Table 2. Logistic regression models for association characteristics with patients going into the emergency department) and being admitted.

	Into ED (OR (CI))	P-value	Admitted (OR (CI))	P-value
Age category				
18-29 years old (SD)	Reference		Reference	
30-39 years old (SD)	1.72 (0.59-5.03)	0.32	2.04 (0.47-8.94)	0.34
40-49 years old (SD)	2.28 (0.83-6.30)	0.11	1.97 (0.47-8.20)	0.35
50-59 years old (SD)	2.42 (0.86-6.76)	0.09	2.90 (0.71-12.00)	0.14
60-69 years old (SD)	1.35 (0.39-4.65)	0.87	2.23 (0.47-10.46)	0.31
>=70 years old (SD)	6.52 (1.40-30.38)	0.02	6.48 (0.99-42.48)	0.05
Initial Vital Signs				
Pulse	1.03 (1.01-1.05)	0.003	1.01 (0.98-1.03)	0.63
Respiratory rate	1.19 (1.08-1.30)	<0.001	1.23 (1.11-1.35)	<0.001
Oxygen saturation (%)	0.60 (0.52-0.70)	<0.001	0.52 (0.44-0.62)	<0.001
	Hosmer-Lemeshow chi^2 = 0.61		Hosmer-Lemeshow chi^2 = 0.90	

ED, emergency department; *OR,* odds ratio; *CI,* confidence interval; *SD,* standard deviation.

full PPE and were more compliant with appropriate precautions. The walkway up to the entrance area was at a slight incline, which may have allowed for a mild stress test before vitals were assessed – an unintentional design that identified patients for further evaluation who might otherwise have been overlooked.

The area had several lanes of workflow that functioned in concert allowing flexing up as volume increased with three simultaneous lanes working at the zenith of disease. Lanes were staffed by a variety of non-EM staff (floor nurse managers, dental residents, pediatric residents, oncology NPs, etc), which prevented diversion of ED resources already in short supply. The flow rate was further maximized by not performing COVID-19 testing as per NYC DOH policy.

The ED FTA appeared to be a highly functional model to effectively assess surges of ambulatory, COVID-19 PUI patients while keeping other ED patients and healthcare staff separate. With a discharge rate of 80%, only one significant adverse outcome resulted in death (0.16%), we believe this FTA was successful in its role and operations.

Certain variables (elevated pulse rate, elevated respiratory rate, decreased oxygen saturation) appeared to be associated with higher likelihood of needing further assessment in the ED. If these results are similar to those noted in other communities, these variables could be incorporated into screening pathways to triage patients to the main ED for further evaluation. Additional future screening pathways could predefine which patients would benefit from a telehealth follow-up visit.

LIMITATIONS

The majority of the staff with the exception of the ED attending did not necessarily have emergency medicine experience. Limitations of this study included the individual bias of the greeter as no strict screening algorithms were used other than clinical impression. Due to the novel nature of COVID-19, during the study period there were no well validated clinical pathways for managing ambulatory COVID-19 patients, potentially resulting in some variability of practice patterns among providers and no ability to compare our efforts with any kind of standard practice or "gold standard." While we attempted to follow up our patients and did have a 9.1% return rate, the current scope of this study did not allow us to assess how many patients had a negative outcome at home or sought care at another institution, although it should be noted that patients we did discharge from the forward screening area generally had minor symptoms and normal vital signs during a time when hospital and citywide systems were operating in a state of emergency, overwhelmed by the COVID-19 pandemic surge. As this was a single-center study, the concept may not be fully generalizable. Given the process was meant to be streamlined and minimalistic in scope, a treatment area like this could be implemented at other EDs. Further prospective evaluation would assess how an ED FTA can be optimized during similar surges.

Further research pertaining to the associated variables can be used in other field models and would be helpful. Aggregated prediction models are needed to identify which COVID-19 patients will have worse prognoses so that accurate clinical decision rules can be derived and validated. Our study was not designed to perform this work.

CONCLUSION

Our ED forward treatment area was an effective method to rapidly screen the increased volume of patients with a novel infectious pathogen in an urban environment with limited resources. This treatment area decreased the burden on the ED structure, was rapidly deployed, and effectively screened patients for safe discharge home.

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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.

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Are Smaller Emergency Departments More Prone to Volume Variability?

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Introduction: Daily patient volume in emergency departments (ED) varies considerably between days and sites. Although studies have attempted to define "high-volume" days, no standard definition exists. Furthermore, it is not clear whether the frequency of high-volume days, by any definition, is related to the size of an ED. We aimed to determine the correlation between ED size and the frequency of high-volume days for various volume thresholds, and to develop a measure to identify high-volume days.

Methods: We queried retrospective patient arrival data including 1,682,374 patient visits from 32 EDs in 12 states between July 1, 2018–June 30, 2019 and developed linear regression models to determine the correlation between ED size and volume variability. In addition, we performed a regression analysis and applied the Pearson correlation test to investigate the significance of median daily volumes with respect to the percent of days that crossed four volume thresholds ranging from 5–20% (in 5% increments) greater than each site's median daily volume.

Results: We found a strong negative correlation between ED median daily volume and volume variability (R^2 = 81.0%; $P < 0.0001$). In addition, the four regression models for the percent of days exceeding specified thresholds greater than their daily median volumes had R^2 values of 49.4%, 61.2%, 70.0%, and 71.8%, respectively, all with $P < 0.0001$.

Conclusion: We sought to determine whether smaller EDs experience high-volume days more frequently than larger EDs. We found that high-volume days, when defined as days with a count of arrivals at or above certain median-based thresholds, are significantly more likely to occur in lower-volume EDs than in higher-volume EDs. To the extent that EDs allocate resources and plan to staff based on median volumes, these results suggest that smaller EDs are more likely to experience unpredictable, volume-based staffing challenges and operational costs. Given the lack of a standard measure to define a high-volume day in an ED, we recommend 10% above the median daily volume as a metric, for its relevance, generalizability across a broad range of EDs, and computational simplicity. [West J Emerg Med. 2021;22(4)878–881.]

INTRODUCTION

Background

Emergency department (ED) visits in the United States increased from 119.2 million in 2006 to 145.6 million in 2016.[1] The increase in visits contributes to crowding, boarding, and overtaxing of clinical staff capabilities.[2,3] Several studies highlight the negative effects of crowding on patient satisfaction, care, health outcomes, and staff safety.[2,4,5] Volume predictions

and management strategies have been developed to improve operations and mitigate the impact of increased volume.[6,7] Staffing all days to the level of high-volume days would reduce crowding, however, it would be costly and inefficient on lower-volume days. Staffing to the average demand is a common approach to balance these tradeoffs.

Importance

A significant limitation of staffing to the average demand is that the method does not consider the day-to-day natural variability of demand, which is inherent to the system and cannot be eliminated. Although research exists on resource mobilization in a mass casualty or surge events (eg, the COVID-19 pandemic), few studies investigate the variability in patient volume on a day-to-day basis in the ED.[8–10] A study demonstrating that lower-volume EDs are more prone to variability is of great value for effective and efficient management of ED operations and staffing. Furthermore, developing a measure for identifying high-volume days in EDs encourages robust staffing approaches, which could balance quality and efficiency while accounting for day-to-day volume variability.

Goals

We compared the variability of patient volume relative to ED size by assessing volume-based thresholds (5%, 10%, 15%, and 20% greater than the daily median volume of the ED). We intentionally avoided standard deviations and percentiles, which naturally scale with ED volume. Using median-based thresholds as the standard measures, we studied whether smaller EDs experience a greater frequency of high-volume days as opposed to those of larger, more resource-heavy EDs.

METHODS

Data

This was a retrospective, observational study of aggregated third-party ED data. The dataset included 1,682,374 unique visits from 32 EDs in 12 states from July 1, 2018–June 30, 2019. The hospitals consisted of 28 urban and 4 rural hospitals. Collectively 5 out of 32 EDs were in academic hospitals, while the remaining 27 EDs were in community hospitals. We queried historical de-identified and anonymized data from a database of patient billing records provided by a national coding, billing, and analytics company (LogixHealth, Inc., Bedford, MA). The timestamps of patient arrivals were recorded and saved to a hospital database at the time of registration.

Setting

We excluded from the analysis pediatric-only and freestanding EDs, as well as EDs lacking data for all 365 days. Median daily arrivals in the remaining EDs ranged from 79 to 214 resulting in the annual visits ranging from about 29,000 to about 78,000. It is worth noting that although this range is relatively broad, it may not be completely inclusive of extreme ED sizes.

Analysis

To examine the correlation between ED median daily volume and volume variability, we developed a linear regression model with the following hypothesis:

H_0: ED median daily volume and the variability of volume are not correlated.
H_1: ED median daily volume and the variability of volume are linearly correlated.

Next, for all EDs we calculated the percent of days above 5%, 10%, 15%, and 20% of the median daily volume. We propose that smaller EDs will more frequently experience days with volume above a given threshold, defined as a percentage above their median daily volume. The structured hypothesis is as follows:

H_0: The frequency of days that ED volume equals or exceeds 5%, 10%, 15%, and 20% of the median daily volume has no relation to the median daily volume of the ED.
H_1: The frequency of days that ED volume equals or exceeds 5%, 10%, 15%, and 20% of the median daily volume is higher in EDs with a smaller median daily volume than those with a larger median daily volume.

We normalized the data to remove the day-of-week (DOW) effect. For each site, the ratio of the mean volume to the mean volume by DOW was multiplied by the true volume to generate adjusted daily volumes.

RESULTS

To examine the correlation between volume variability (the dependent variable) and ED median daily volume (the independent variable), we calculated the coefficient of variation (COV) for each site. The COV is used to adjust variability for ED size. We then conducted a regression analysis to investigate the correlation between ED size and volume variability. The linear regression model follows the form of $Y = mX+b$, and here, X is a vector of the median daily volume for each of the EDs (the independent variable), while Y is a vector of the COV for each of the EDs (the dependent variable). The results displayed in Figure 1 indicate a strong negative correlation with R^2 of 81.0% and $P < 0.0001$. These results demonstrate that smaller EDs generally have a higher COV and hence experience more daily volume variability than larger EDs.

We then developed a series of linear regression models and Pearson correlation tests (Figure 2) to test the primary study hypothesis. For these models, X is a vector of the median daily volumes for each of the EDs (the independent variable), while Y is a vector of the frequency of days equaling or exceeding a given threshold for each of the EDs (the dependent variable).

The results of the regression analysis indicate a statistically significant negative correlation between the independent and dependent variables, which led us to reject the null hypothesis

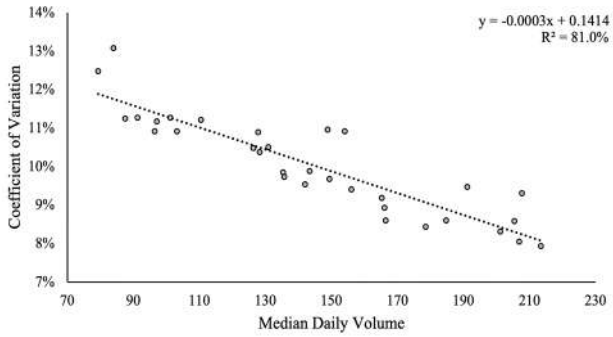

Figure 1. Regression analysis for coefficient of variation and median daily volume by emergency department: The coefficient of variation, which is equal to the standard deviation divided by the mean, is the dependent variable, while median daily volume for EDs is the independent variable. The results indicate a strong negative linear correlation with R^2 of 81.0%.

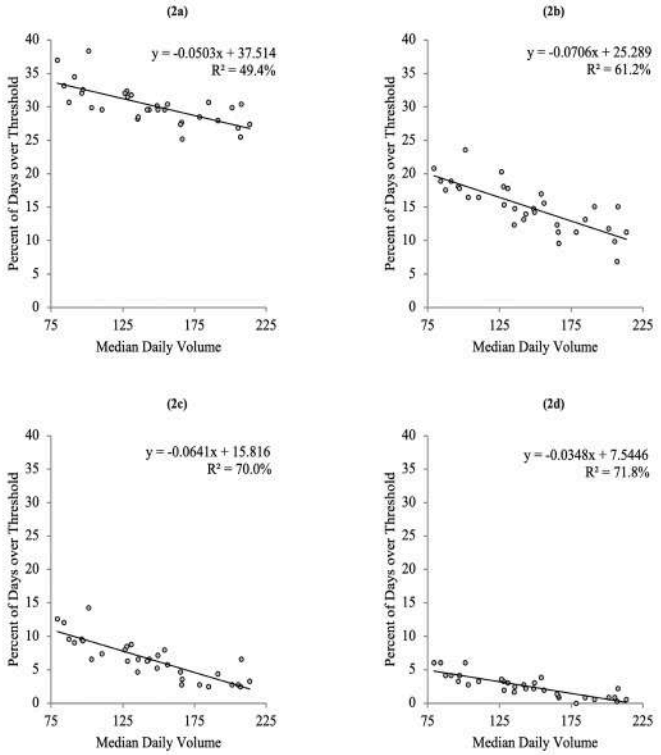

Figure 2. Regression analysis results: The percent of days exceeding specified thresholds vs daily median volume (2a: 5% above median volume, 2b: 10% above median volume, 2c: 15% above median volume, 2d: 20% above median volume). The data in all four charts indicate a negative slope, demonstrating that smaller emergency departments (ED) tend to cross percent-of-median volume thresholds more frequently than larger EDs. In these models, multiplying EDs median daily volume by the slope and adding the intercept produces an estimate of the percent of days that exceed the respective threshold.

for all four cases. This demonstrates that lower-volume EDs tend to experience high-volume days more frequently than higher-volume EDs. For instance, as shown in Figure 2c, the smaller EDs have days with 15% more volume than their median volume roughly four times as often as the larger EDs.

With the aim of formulating a measure to classify high-volume days that balances generalizability to various ED sizes, relevance, and derivation simplicity, we further analyzed the linear regression model results. To be able to generalize the high-volume metric to a broad range of EDs, we assessed the correlation determinations (R^2) for which Figures 2b-d demonstrate sufficient quality.

Regarding the relevance of the metric, Figure 1a demonstrates that high-volume days with the threshold set to 5% above the median would occur about 25%-35% of the time, which is too common to be relevant for operational purposes. Figure 2b demonstrates that smaller EDs cross the 10% threshold on roughly 20% of days, whereas larger EDs cross the threshold on roughly 10% of days. Figures 2c and 2d illustrate that larger EDs almost never cross the 15% and 20% thresholds, which would prevent measures with these thresholds to be generalizable to a variety of EDs.

Given the overall regression quality, applicability to both large and small EDs, and simplicity of derivation, we recommend 10% above median daily volume to represent a reasonable threshold for identifying high-volume days in EDs. This proposed measure is the first step in developing comprehensive measures beyond the "average" or "median" daily volume to identify "busy" days in an ED and better capture a comprehensive view of daily volume variability.

DISCUSSION

Although EDs vary with respect to the particulars of staffing, volume, acuity, boarding, and admission rate, they all are likely to operate differently on a low-volume day compared to a high-volume day. Unlike low-volume days, where different systems that are critical to efficient ED operation and flow are less likely to be stressed, higher volume days often lead to boarding and potential concerns for quality and safety because they strain medical resources and hinder the timeliness of emergency care. However, it is worth noting that low-volume days could also be problematic and impose financial challenges on ED operations as overstaffed days could lead to waste of resources and excess capacity. Hence, smaller EDs must develop strategies to identify, assess, and accommodate the effect and frequency of daily volume variability.

While the identified root causes of ED crowding and long wait times are predominantly linked to the inherent variability of demand, many of the existing solutions are focused on streamlining patient flow.[10] Therefore, static solutions are being applied to a dynamic and unpredictable problem. Bridging this gap warrants the development and implementation of novel ED staffing approaches that adaptively align ED resources

with demand. With the ability to classify high-volume days, ED leaders will be better equipped to proactively manage this variability and use appropriate staffing strategies that prevent prolonged wait times while balancing quality, provider satisfaction, operational complexity, and cost.

LIMITATIONS

A limitation of this study is that some EDs naturally have more day-to-day variability than others. For instance, an ED in a seasonal vacation town may experience significantly higher volume in certain months. Future work could explore the benefit of including additional explanatory variables, such as specific ED location, to correct for this effect. Furthermore, we obtained the data in this study for EDs in only 12 states. Although these states were distributed across broad regions of the United States, further research is recommended to support generalizing the findings.

CONCLUSION

Smaller EDs, in addition to having fewer resources to buffer increased demand, have more frequent high-volume days than larger EDs. Given the lack of a standard measure to define a high-volume day in EDs, we propose 10% above the median daily volume. Our recommended metric is directly related to daily ED volume and could be a starting point in identifying, understanding, and managing high-volume days in EDs. This work is a call to action for further studies in constructing a roadmap to develop robust measures that would help acknowledge, assess, and effectively plan for the daily volume variability in EDs.

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The Effects of Implementing a "Waterfall" Emergency Physician Attending Schedule

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Introduction: Increases in emergency department (ED) crowding and boarding are a nationwide issue resulting in worsening patient care and throughput. To compensate, ED administrators often look to modifying staffing models to improve efficiencies.

Methods: This study evaluates the impact of implementing the waterfall model of physician staffing on door-to-doctor time (DDOC), door-to-disposition time (DDIS), left without being seen (LWBS) rate, elopement rate, and the number of patient sign-outs. We examined 9,082 pre-intervention ED visits and 8,983 post-intervention ED visits.

Results: The change in DDOC, LWBS rate, and elopement rate demonstrated statistically significant improvement from a mean of 65.1 to 35 minutes (P <0.001), 1.12% to 0.92% (P = 0.004), and 3.96% to 1.95% (P <0.001), respectively. The change in DDIS from 312 to 324.7 minutes was not statistically significant (P = 0.310). The number of patient sign-outs increased after the implementation of a waterfall schedule (P <0.001).

Conclusion: Implementing a waterfall schedule improved DDOC time while decreasing the percentage of patients who LWBS and eloped. The DDIS and number of patient sign-outs appears to have increased post implementation, although this may have been confounded by the increase in patient volumes and ED boarding from the pre- to post-intervention period. [West J Emerg Med. 20XX;22(4)882-889.]

INTRODUCTION

Emergency department (ED) crowding and boarding have increased in recent years, a concern that has gained the attention of the media, physicians, and patients. It has been deemed a serious health issue[1] because patients depend on the ED for access to care for urgent or emergent issues especially when other healthcare options are unavailable.[2] Additionally, boarding and crowding have significantly strained physicians, healthcare staff, and ED beds, leading to worsened patient outcomes attributed to increased wait times, elopement, and leaving against medical advice.[3] An issue closely tied to ED crowding is the increase in patient hand-off events that occur when patients remain in the ED for a prolonged period of time (ie, longer than any individual physician's shift duration). This is problematic as transfers of care have been shown to be the highest risk event for errors in patient care.[4,5]

Despite these factors, EDs are continuously attempting to improve performance as measured by metrics such as door-to-

doctor time (DDOC) and doctor-to-disposition time (DDIS), as they are correlated with patient satisfaction and clinical quality outcomes.[6] It has been found that as DDOC increases, there is an increase in the number of patients who leave without being seen (LWBS).[6] Furthermore, LWBS patients are more likely to present later with a more severe stage of illness and with a higher chance for admission, further straining hospital systems' limited resources.[6]

One approach to mitigate the negative effects of boarding, potentially decrease patient handoffs, and improve efficiency is to implement a so-called "waterfall" schedule. A waterfall schedule is one where there are overlapping physician shifts. In addition, the model often has physicians changing locations partway through their shifts to be primarily responsible for evaluating different types of patients at different times.[5] A previous study found that implementing a waterfall schedule demonstrated a "25% reduction in proportion of encounters with patients handoffs…and a survey of physicians and charge nurses demonstrated improved perception of patient safety, ED flow and job satisfaction."[5] To determine whether a waterfall schedule could improve flow we instituted a waterfall attending schedule at our ED in February 2018. In this study we evaluate whether implementation of this scheduling model improved ED operational metrics such as DDOC, DDIS, the number of patients who LWBS or eloped, and the number of physician handoffs.

Population Health Research Capsule

What do we already know about this issue?
Previous research has evaluated the effects of advanced practice providers, fast tracks, and adjustments to physician scheduling to improve emergency department throughput.

What was the research question?
We evaluated the effect of a waterfall schedule on door-to-doctor and door-to-disposition times, left without being seen and elopement rates, and number of patient sign-outs.

What was the major finding of the study?
The waterfall schedule improved door-to-doctor time, left without being seen rates, and elopement rates.

How does this improve population health?
Physician scheduling can expedite patient care and decrease elopement and left without being seen rates.

MATERIALS AND METHODS

This study was performed at a medium-sized, urban, academic ED with a three-year emergency medicine (EM) residency program composed of 24 residents, 20 full-time educational faculty attendings, and 5-8 per diem attending physicians. The hospital is a Level I trauma center, a designated stroke center, and a STEMI, burn, and psych receiving center. The ED has 36 beds, six trauma/resuscitations bays, and up to 20 hallway/chair spaces, and has approximately 54,000 patient visits per year.

Schedule Format

The pre-waterfall attending physician schedule consisted of two morning shifts (6 AM-4 PM and 9 AM-7 PM), two afternoon shifts (3 PM -12 AM and 6 PM-3 AM) and one single-coverage overnight shift (11 PM-7 AM) for a total of 46 hours of attending coverage. Additionally, there were two physician-in-triage (PIT) shifts (10 AM-6 PM and 5 PM-1 AM) whose role was to screen patients as they arrived to the ED and expedite the ordering of labs and imaging while patients waited for examination and treatment spaces to become available. Including the PIT shifts, there was a total of 62 hours of attending coverage.

In February 2018 an attending "waterfall" schedule was implemented based on the model described by Yoshida et al.[5] Shifts were scheduled from 6 AM-3 PM, 9 AM-6 PM, 11 AM-9 PM, 2 PM-12 AM, 5 PM-1 AM, 8 PM-4 AM, and 11 PM-7 AM. The waterfall schedule has 62 hours of attending coverage. There were no entire PIT shifts. All emergency physicians (EP) began their shifts by seeing all new patients arriving to the ED until the next attending arrived to relieve them. With the new schedule, the attending was stationed in triage for the first 2-3 hours of his or her shift with the goal of evaluating every walk-in patient. On initial evaluation the EP could start a note. If time permitted, they could perform an entire history and physical (H&P). If it was particularly busy, they could perform an abbreviated H&P with the plan to re-evaluate the patient again later. Patients were evaluated on an exam table that could be flattened to enable a complete exam.

Once relieved, the EP would sign out to another physician. Afterward they would transition to become the "back doctor" and would see ambulance runs while dispositioning the patients who had been initially triaged. Specifically, the 6 AM-3 PM EP signs out to the 11 AM-9 PM EP, the 9 AM-6 PM EP signs out to the 2 PM-12 AM doctor, the 11a-9p doctor signs out to the 5 PM-1 AM EP, and the 2 PM-12 AM doctor signs out to the 8 PM-4 AM EP. Both the the 5 PM-1 AM and 8 PM-4 AM EPs sign out to the 11 PM overnight physician at 12 AM and 3 AM, respectively (Figure 1).

Advanced practice providers (APP) continued to manage fast-track patients with low Emergency Severity Index levels

Figure 1. Waterfall schedule for emergency physician attendings.

between 10 AM -7 PM, as they had prior to the implementation of the attending waterfall schedule. The calculations for DDOC time and DDIS time included fast-track patients for pre and post implementation.

Data Collection

Aggregated de-identified data was extracted from the electronic health record (Epic Systems Corporation, Verona, WI) for the periods before implementation (December 1, 2017- January 31, 2018) and after implementation (December 1, 2018-January 31, 2019) of the waterfall schedule. The institutional review board deemed the study to be exempt from review. We excluded February 1–November 30, 2018 to account for inconsistencies and confounders associated with the transition. We evaluated DDOC times, DDIS times, number of attending sign-outs, number of patients who eloped, and number of patients who LWBS.

Statistical Analysis

We excluded the highest 1% DDOC times and DDIS times, in order to remove extreme outlier values. The one-sample Kolmogorov-Smirnov test was used to examine the distribution of DDOC and DDIS. None of them followed normal distribution; therefore, we used non-parametric Mann-Whitney U tests to compare DDOC and DDIS before and after the intervention. A P-value <0.05 was considered statistically significant. We used SPSS Statistics version 26 for Windows (IBM Corporation, Armonk, NY) for data analysis.

RESULTS

The study included 9083 charts before and 8983 charts after the intervention. There were 49.9% females in the pre-implementation group and 50.1% in the post-implementation group. The average age was 48.7 in the pre-implementation group and 48.6 in the post-implementation group. The overall department demographics and make-up did not change between pre and post implementation. Refer to Table 1 for demographics.

Table 1 shows the distribution of DDOC and DDIS before and after the intervention, excluding the top 1% extreme values. The change in DDOC was statistically significant from a mean of 65.1 to 35 minutes (P <0.001). However, the change in DDIS from 312 to 324.7 minutes seemed to reflect a slight increase although not statistically significant (P = 0.310). Excluding the top 1% did not change the statistical significance of DDOC. Excluding the top 1% did make the DDIS lose statistical significance. We excluded the top 1% regardless of its effect on the results because these 1% are outliers that do not represent the bulk of patients (Table 2).

There were 102 LWBS in the pre group (total N: 9083) and 64 LWBS in the post group (total N = 8983) implementation. The prevalence of LWBS was 1.12% in the pre-implementation group and 0.92% in the post-implementation group (P = 0.004). A total of 360 patients eloped in the pre and 175 eloped in the post group. The prevalence of elopement was 3.96% in the pre- and 1.95% in the post-implementation group (P < 0.001).

Table 1. Demographic statistics for pre- and post-implementation

	Study phase			
	Pre		Post	
	Count	%	Count	%
Gender				
Female	4,531	49.9%	4,499	50.1%
Male	4,551	50.1%	4,484	49.9%
Age group				
≤ 10	20	0.2%	12	0.1%
11 - 20	351	4.3%	409	5.0%
21 - 30	1,451	17.7%	1,457	17.8%
31 - 40	1,424	17.4%	1,316	16.0%
41 - 50	1,263	15.4%	1,202	14.7%
51 - 60	1,361	16.6%	1,443	17.6%
61 - 70	1,096	13.4%	1,158	14.1%
71 - 80	641	7.8%	675	8.2%
81 - 90	423	5.2%	384	4.7%
91 - 100	172	2.1%	143	1.7%
101+	5	0.1%	3	0.0%
Race				
White	6,314	69.5%	6,209	69.1%
Asian	1, 11	12.2%	1,121	12.5%
Black or African American	357	3.9%	360	4.0%
Native Hawaiian or Other Pacific Islander	50	0.6%	55	0.6%
Other/unknown	1,250	13.8%	1,238	13.8%
Ethnicity				
Non-Hispanic [8]	4,986	54.9%	4,995	55.6%
Hispanic [9]	4,006	44.1%	3,904	43.5%
Other/unknown	90	1.0%	84	0.9%

Figure 2 shows the number of sign-outs pre and post implementation. The number of sign-outs skewed toward a higher number in the post group as compared to pre (P <0.001) The average number of sign- outs was 0.1 in the pre-implementation group and 0.4 in the post group.

We conducted a post-implementation survey of the attending physicians and received eight responses. Of those eight responses, seven were faculty before and after implementation. Of the eight attendings, three were formerly residents. The survey inquired about the attending's opinion of the waterfall schedule's effect on faculty workflow, resident workflow, number of handoffs, faculty teaching, on-shift education, on-shift documentation, ability to leave shift on time, burnout, patient rapport, quality of patient care, patient satisfaction, patient throughput, and overall opinion. These results are summarized in Figure 3.

DISCUSSION

Given the recent emphasis on increased ED efficiency and throughput, studies have begun to evaluate how different physician staffing and patient distribution models are improving these metrics. It appears that using PIT doctors, fast track and APPs is an improvement, yet there may be ways to improve throughput even further. In one study an ED changed its attending staffing model from non-overlapping shifts to overlapping shift times and noted that door-to-full-exam time decreased from 84 minutes to 52 minutes without increasing staff hours.[7] Another study compared using a PIT doctor to moving that physician to the main ED without changing physician staffing hours and found improvement in DDOC time, DDIS time, and decreased LWBS.[8] An important study that inspired ours was performed by Yoshida et al. They implemented a waterfall schedule where a new attending arrives every 3-5 hours. When the new

Table 2. Distribution of door-to-doctor times (DDOC) and door-to-disposition (DDIS) times in minutes (both excluding top 1%) before and after intervention.

	Before	After
DDOC excluding top 1%		
N	8,482	8,682
Minimum	0	0
Maximum	345	307
Mean	65.1	35
Median	35	24
SD	72.85	33.7
DDIS excluding top 1%		
N	8,588	8,723
Minimum	0	1
Maximum	3,891	4,353
Mean	312	324.7
Median	209	211
SD	352.12	445.65

SD, standard deviation.

attending arrives, he or she sees new, high- acuity patients until the next attending arrives and he or she transition to a secondary role where they disposition their patients and see lower acuity patients. Yoshida and colleagues found a 25% reduction in patient handoffs but no improvement in median length of stay.[5] The waterfall schedule we implemented was slightly different than Yoshida's. Ours has EPs seeing a high volume of lower acuity patients during their triage time, and then transitioning to the higher acuity ambulance runs at the end of the shift. The patients who are "triaged" during the beginning of the shift remain the attendings' patients

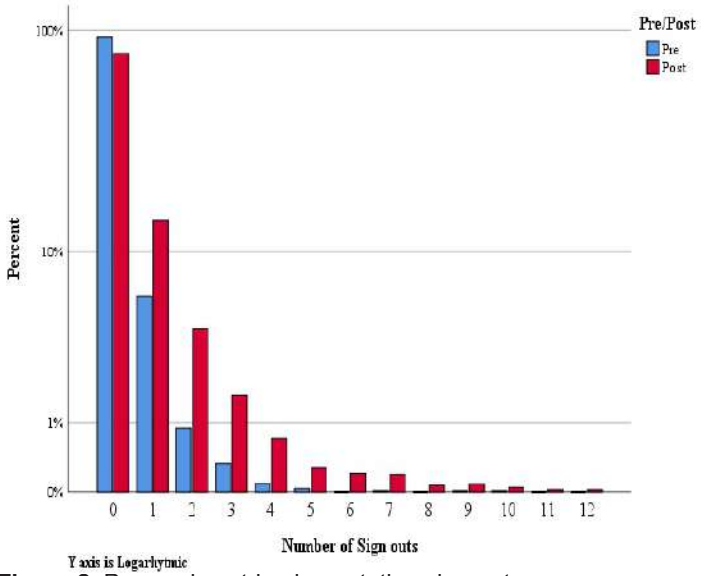

Figure 2. Pre- and post-implementation sign-outs.

throughout the entirety of their shift, as opposed to other triage models in which another physician would primarily manage and follow up on results.

At our institution we already had a PIT doctor and a fast track staffed by APPs. Yet due to the significant patient volumes and ED boarding, our ED staff suffered from significant delays in patient throughput. By the afternoon all ED beds were full, and patients were getting the majority of their treatment in the waiting room. The PIT doctor was therefore responsible for the patients who had been triaged until they were placed in a main ED bed, which was often many hours later. Attendings function at different speeds, and there was significant variation in patient volumes seen depending on which attending was assigned to triage. Benefits of the PIT model were extremely variable. Some PITs would screen 40+ patients and discharge 10+ while others would screen under 20 and discharge none, resulting in significant, variable downstream impacts including leaving the ED attendings with 20-30+ pending patients. Some attendings were proactive about discharging patients who had complete workups while they were still in the waiting room while others did not. Furthermore, the addition of another physician to the traditional academic center model of the resident-attending physician team led to patient confusion over who his or her doctor was. Furthermore, orders placed in triage were often not consistent with what the attending EP wanted and would result in the overutilization of resources, a known issue with PIT systems.[9,10]

Our goals in implementing the waterfall schedule were to standardize the process and minimize variability in patient volumes. The idea of having a PIT doctor is sound, yet new information shows that having one provider be primarily responsible for a patient could be more efficient.[9] This waterfall schedule could potentially represent the best of both worlds – an attending designated to triage for quick evaluation and maintain the patient's continuity of care team throughout the ED stay.

Our study found a statistically significant improvement in DDOC while a non-statistically significant increase in DDIS. In addition, we found a statistically significant improvement in rates of both patients who LWBS and elopements. The improvement in DDOC, LWBS rates, and decreased number of elopements is consistent with previous studies.[2,13] It is possible that the decreased LWBS in the post group could have increased the DDIS time, as previously these patients were not waiting for care. Furthermore, seven of the eight attendings we surveyed reported that the waterfall schedule positively or strongly positively improved faculty workflow and efficiency. Furthermore, six of the eight felt that this new schedule positively or strongly positively improved patient throughput. We suspect the lack of significant change in DDIS was likely related to the overall hospital model. Since our institution is a medium-sized teaching hospital, residents in the ED as well as on consulting services play a significant role in

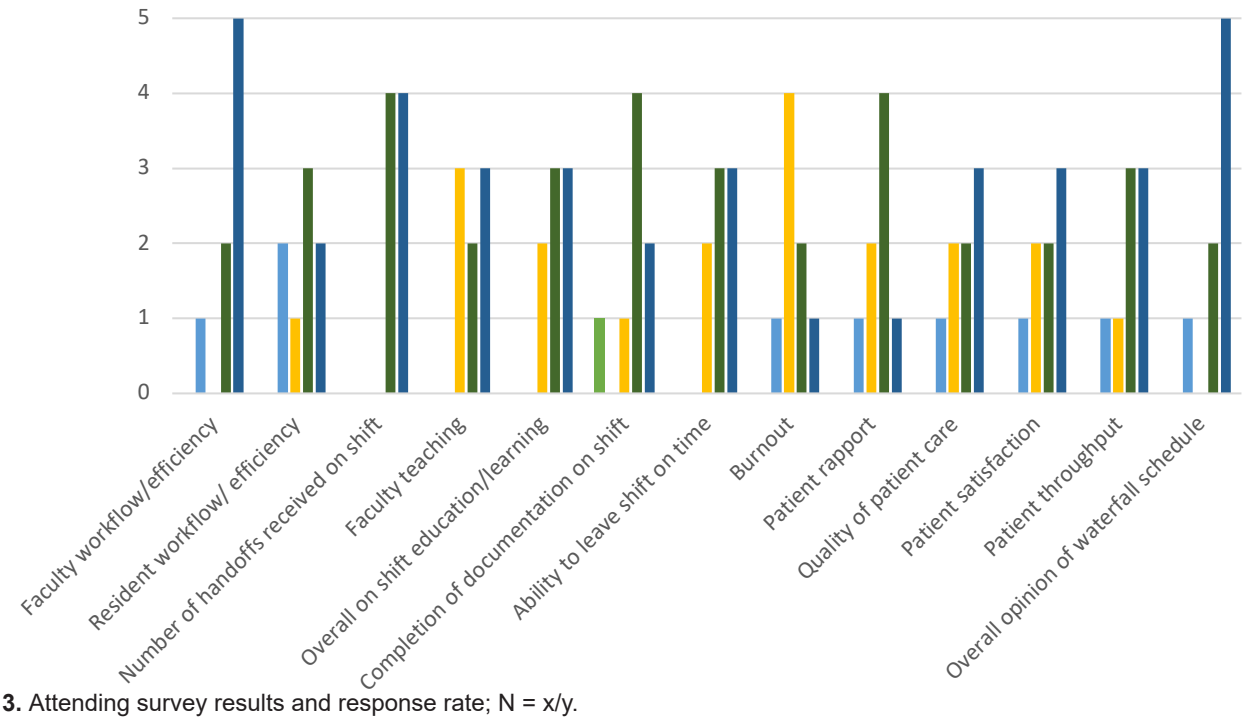

Figure 3. Attending survey results and response rate; N = x/y.

the disposition of patients. Changes to an attending schedule, therefore, might not have as notable an effect on ED metrics as they would at non-teaching hospitals. Significant increases in delays are often related to our consultant responses.

In discussion with physicians and other ED staff we found that morale and patient care improved after implementation of this new model. Three of eight faculty responded that the waterfall schedule either positively or strongly positively impacted their burnout. In addition, five of eight faculty believed the new schedule either positively or strongly positively improved patient satisfaction as well as the overall quality of the patient's care. The attendings considered prior ED PIT shifts to be extremely stressful and overwhelming. In the survey one attending wrote, "the triage shifts were horrible!" Additionally, the triage shifts did not significantly decrease patients per hour for the other EPs who ultimately still evaluated the patients once beds were open. One attending commented in the survey that a main benefit of the schedule change was that, "two attendings didn't need to talk to the patient…that patients are seen and followed by the same attending." When asked what was the worst part of the new waterfall schedule their answers were that "the shifts are very front loaded…seeing the majority of your patients in the first 2-3 hours can be tough and you have to move quickly." Despite comments about the shift being frontloaded, the overall sense is that the scheduling changes improve burnout and physician satisfaction as the triage shifts are stressful and challenging. The current model is much improved because the designated triage time is limited to three hours as opposed to an entire shift.

Additionally, attendings take full responsibility for all patients seen during their shifts, allowing the patients to be spread out among seven attendings per day instead of five, with two attendings only providing initial evaluation and orders. Furthermore, by placing the triage time at the beginning of the shift, physicians are able to disposition their patients more, and hand-offs subjectively seem to be better. Our results interestingly skewed toward having more sign-outs post implementation. Yet, all eight survey results stated that the number of hand-offs received on shift after implementation of the waterfall schedule was either positive or strongly positive with several comments about being able to disposition patients by the end of shift and having fewer hand-offs. There were no responses indicating that sign-outs were worse after implementation.

We believe the disparity in the numerical data and the survey data is related to the increased boarding and increased psychiatric population. These patients who are admitted or waiting for psychiatric placement often remain in the ED for up to 20, or even 60, hours and are signed out by too many EPs. So, while active sign-outs decreased, overall sign-outs of admitted patients increased, thereby affecting the numeric results. In addition, as compared to the Yoshida model, our waterfall schedule requires EP attendings to see emergency medical services runs at the end of their shifts. These patients tend to be more complicated and therefore often have longer lengths of stay. This could also partially explain the increased number of sign-outs.

This study is significant because it is the first to evaluate this kind of attending staffing model at a teaching hospital

with EM residents. The previously implemented PIT model did not allow for residents to initially evaluate patients and obtain the "first touch." In the prior model residents would wait to see patients who would be placed in main ED beds, which often occurred after their labs and imaging had resulted. Studies have evaluated how a PIT doctor affects resident education. One study evaluating the impact of a PIT doctor via a questionnaire found there was a negative impact on development of a differential diagnosis and an emphasis on disposition as compared to an emphasis on initial evaluation.[11] The waterfall model helps negate this issue. As the PIT will be the physician of record, residents come to triage and perform the initial assessment with the attending.

When the waterfall attending schedule was initiated, the resident schedule remained unchanged. Residents either had a morning shift, a swing shift, or a night shift. Times varied slightly by postgraduate year (PGY) level. At any given time, there was one resident from each PGY level in the ED. The residents were not assigned to a particular attending. They were instructed to evaluate ambulance runs primarily and when time permitted to evaluate triage patients with the triage attending. Residents were in triage initially evaluating patients around 70% of the time. They could then formulate a plan and coordinate with the attending as they would both continue the patients' care even when they moved to the back. Although the post-implementation physician survey had a low response rate, the feedback we did get was generally positive. Five of eight faculty believed the waterfall schedule positively or strongly positively impacted the ability for faculty to teach. Six of eight felt that the change positively or strongly positively improved overall shift education and resident learning.

Future studies could further evaluate the waterfall schedule. First, it would be important to see the impact on a community ED that is attending run to further evaluate the change in disposition time. In addition, looking at the number of sign-outs while controlling for psychiatric patients or admitted ED boarding patients and focusing on only active patients would be an important next step. In addition, evaluating a waterfall schedule for residents in coordination with a waterfall schedule for attendings and the effect on resident learning and efficiency would be another valuable avenue of research.

LIMITATIONS

One limitation of this study was that it was performed at a single, medium-sized teaching hospital, which makes the findings less generalizable to larger academic centers or community sites. In addition, our institution transitioned to Epic EHR on November 4, 2017, which could have confounded our findings. Another limitation is the lack of specific data in pre- and post-cohorts on admission rates and the number of psychiatric patients. Further, we excluded the top and bottom 1%, which affected our statistical significance and could be considered a limitation. Yet we believe the 1% were outliers and did not represent the majority of our patient population and would therefore not accurately affect our conclusions if those outliers had been left in the sample.

A final limitation is our poor survey response rate and the concern for response bias. As the majority of our responses were positive, it is possible that only those physicians with a particularly positive experience would have taken the time to complete the survey.

CONCLUSION

Patient volumes and boarding in the ED continue to increase, and staff are attempting to find solutions to improve throughput. Models including PIT doctors, fast track and utilization of APPs show promise; yet implementing specific attending schedules should be considered as well. Our study evaluated the implementation of a waterfall attending schedule at an urban, academic emergency department and showed significant improved in door to doctor time, and the rates of elopement and patients who left without being seen, while there was no significant change in doctor to disposition time.

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An Assessment of the Social Determinants of Health in an Urban Emergency Department

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Introduction: Social determinants of health (SDOH) have significant impacts on patients who seek care in the emergency department (ED). We administered a social needs screening tool and needs assessment survey to assess SDOH and evaluate for trends in the population of patients visiting our ED.

Methods: A survey was distributed via convenience sampling to adult ED patients to capture self-reported demographic information and data about social needs. We categorized the questions related to SDOH based on the International Classification of Diseases, Tenth Revision, Clinical Modification coding format and created a composite variable called "SDOH Strata" based on the SDOH Index scores (0-5-low, 6-10-middle, or ≥11-high). We conducted bivariate analyses using the sociodemographic characteristics of the patients and their SDOH Strata using Fisher's exact test. We then conducted multinomial logistic regression to examine the association between the patients' sociodemographic characteristics and the SDOH Strata.

Results: A total of 269 surveys were collected. We observed that Hispanic/Latino patients were more than two times as likely (odds ratio: 2.04, 95% confidence interval [CI], 1.12,-6.51) to be in the higher impact stratum than in the lower impact stratum. Those who were undocumented had 3.43 times increased adjusted odds (95% CI, 1.98, 9.53) of being in the higher than the lower impact stratum compared to US citizens. Additionally, people speaking Spanish as their primary language were 5.16 times as likely to be in the higher impact stratum compared to the reference (English-speaking and lower impact stratum).

Conclusion: In our patient population, patients noted to have the highest impact burden of the SDOH were those who identified as Hispanic/Latino, Spanish-speaking, and undocumented immigrant status. [West J Emerg Med. 2021;22(4)890–897.]

INTRODUCTION

The Emergency Medical Treatment and Labor Act (EMTALA) enacted by the US Congress in 1986 mandates that anyone coming to an emergency department (ED) has the right to be stabilized and treated, regardless of ability to pay or insurance status.[1] Many EDs serve as a safety net for those who have unmet social needs and these EDs are often located where vulnerable patient populations seek care, including those who are uninsured and undomiciled. As the gateway to the healthcare system, the ED is in a prime position to assess patients' social needs and help formulate plans to address them. Previously, ED interventions aimed at addressing patients' social needs such as healthcare access, insurance enrollment, and patient follow-up adherence have been found

to be successful. Interventions have included the use of social workers, community health workers, and student volunteers to provide linkages to local resources.[2-6] While it may seem counterproductive to address non-emergent issues in the ED setting, the EDs relevance in addressing these issues is clear. Thus, a new area of focus, "social emergency medicine," has been established to incorporate social context into the structure and practice of emergency care.[7,8]

Social determinants of health (SDOH) are defined as "the conditions in which people are born, live, learn, work, play, and age."[9] They are divided into five determinant areas: 1) economic stability; 2) education; 3) social and community context; 4) health and healthcare; and 5) neighborhood and built environment.[10] Unmet social needs, such as food, housing, transportation, and other societal factors including substance use disorder, domestic violence, mental illness, and limited English proficiency, are known to have a significant impact on healthcare outcomes. Understanding an individual's disease or diagnosis alone may not be sufficient to positively impact their health. For clinicians and interdisciplinary healthcare teams, addressing social needs is necessary to have a positive effect on health and help eliminate health inequities.

The SDOH have significant impacts on patients who seek care in the ED. Economic stability affects employment, housing status, and food security, and can have significant downstream effects on overall health. Studies have shown that there is a higher prevalence of poor health and mortality in the unemployed.[11-13] In homeless individuals, lack of resources makes it difficult to maintain health and navigate the health system, and makes them more likely to use the ED than the general population.[14-17] Food insecurity, lower education levels, and limited access to primary care have all been found to increase ED utilization as well.[18-23] In one study, Spanish-speaking patients with limited English proficiency (LEP) were found to have increased unplanned ED revisits within 72 hours.[24] Poor health literacy has also been associated with medication nonadherence, overall poorer health, increased ED utilization, and increased hospitalization.[25-27]

When negatively impactful SDOH are prevalent, they present challenges to the health of a significant portion of the population. Patients are often left to seek solutions in the ED setting. Many EDs that function as safety-net hospitals regularly care for the underserved and vulnerable populations. These patients may comprise the entire spectrum of the socioeconomically disadvantaged, which may include the homeless, the uninsured, and the unemployed. We administered a social needs screening tool and needs assessment survey to evaluate trends in our patient population to gain a broader understanding of the community needs and impacts of the SDOH.

Population Health Research Capsule

What do we already know about this issue?
Social determinants of health (SDOH) have significant impacts on patients seeking care in the ED. Social needs screening can help formulate targeted interventions.

What was the research question?
We sought to assess the SDOH in ED patients in a safety-net hospital and identify patients with the highest impact burden of SDOH.

What was the major finding of the study?
The highest burden of SDOH was in patients who identified as Hispanic/Latino, Spanish-speaking, and undocumented immigrants.

How does this improve population health?
Our study points to the need to assess the SDOH in ED patients using multidisciplinary teams to identify social needs and help design strategies to address them.

METHODS AND ANALYSIS

We developed a survey to capture self-reported sociodemographic data along with information on SDOH in ED patients. Sociodemographic questions included age, gender, race/ethnicity, citizenship status, and sexual identity, among others. We incorporated questions from the previously validated Centers for Medicare & Medicaid Services' Accountable Health Communities Health-Related Social Needs Screening Tool to obtain information on numerous SDOH such as housing, social support, and substance use.[28] We added questions regarding ED utilization, including the participants' reasoning for selecting the ED for care and barriers to accessing healthcare. The survey tool was piloted on a sample of 15 patients by our research staff to ensure the questions were easy to understand. Minor suggestions on wording for two questions were made and they were revised. The pilot data was not included as part of the survey analysis.

Patients recruited for the survey were registered in the ED of a large, urban safety-net hospital located in Houston, Texas. Participants were recruited voluntarily using a convenience sample in the ED, including the waiting room and various lower acuity care areas shortly after a medical screening examination or being bedded to a room, during February to early March 2020. Recruitment was done between the hours of 9 AM and 11 PM Monday through Sunday, depending on the availability of research staff. Excluded patients were those under the age of 18, with 1:1 sitters, and incarcerated individuals. Pregnant patients > 20 weeks were also not included as they go directly to the obstetrics intake unit.

Surveys were administered verbally by trained research staff in a private screening room in the waiting area or individual patient rooms in a care area. Individual responses were entered into a secure database via smartphone or tablet. The survey was translated into Spanish, and phone interpreters were available for patients who did not speak English.

We performed descriptive statistics on the sociodemographic information of the survey respondents, and present the results with frequency tabulations and percentages. We categorized the questions related to SDOH based on the *International Classification of Diseases, Tenth Revision, Clinical Modification* coding format, whenever possible, or grouped them into more meaningful categories. We also performed descriptive statistics on the questions related to the SDOH. Next, we dichotomized the responses to all SDOH questions into the following groups: 1) 0 – does not contribute to poor SDOH; and 2) 1 – contributes to poor SDOH. We created a SDOH index by summing the scores of all the SDOH questions for each of the respondents. The lower the SDOH index score, the lesser the individual was impacted by poor SDOH. We created a composite variable called "SDOH Strata" based on the SDOH index scores. A modified Delphi process was used with experts in emergency medicine, health disparities, and epidemiology to discuss how to stratify the SDOH index score to create the strata. We categorized the SDOH index scores as follows: 0-5 "lower impact stratum;" 6-10 "moderate impact stratum;" and scores ≥11 were categorized into the "higher impact stratum." For example, if a person belonged to the higher impact stratum, they would be considered to have a higher SDOH burden as compared to those in the moderate or lower impact strata.

We conducted bivariate analyses using the sociodemographic characteristics of the patients and their SDOH strata using Fisher's exact test, as some of the frequency values were very small (ie, less than five). Due to the small percentage of missing information (only six records), no imputation techniques were applied, and we removed the missing records prior to running multivariate analyses. Lastly, we conducted multinomial logistic regression to examine the association between the patients' sociodemographic characteristics and the SDOH strata. The lower stratum was considered the referent category. All tests of hypothesis were two-tailed with the type-1 error rate set at 5%. The institutional review board deemed this survey a quality assurance activity as the project's focus was to identify the social needs of patients using our ED for program planning and implementation, and no identifying information was collected.

RESULTS

A total of 269 patients agreed to participate in the survey, and 263 completed it in its entirety. Patients who declined participation were excluded from the analysis. For reference, our total ED volume for 2019 was just under 82,000 visits.

Table 1 summarizes the self-reported sociodemographic characteristics of the 269 patients. The age distribution was generally young, with 86.2% of our sample under the age of 60. In 2019, 43.3% of our ED population was between 18-39, which is comparable to our study population of 43.9%. Additionally, 39.8% of our ED population was between 40-59, which is comparable to our study population of 40.1%. Hispanic/Latinos (46.1%) and Blacks (34.9%) comprised

Table 1. Sociodemographic characteristics of patients surveyed.

Sociodemographics	N	%
Age		
18-39 years	118	43.9%
40-59 years	108	40.1%
60-79 years	37	13.8%
80+ years	2	0.7%
Missing	4	1.5%
Gender		
Female	146	54.3%
Male	118	43.9%
Other/Missing	5	1.9%
Identify as LGBTQ+		
No	242	90.0%
Yes	15	5.6%
Other/prefer not to answer	12	4.5%
Race/Ethnicity		
White	32	11.9%
Black	94	34.9%
Hispanic	124	46.1%
Others	14	5.2%
Missing	5	1.9%
Citizenship status		
US citizen	167	62.1%
Lawfully present	36	13.4%
Undocumented	44	16.4%
Non-immigrant	7	2.6%
Prefer not to answer/missing	15	5.6%
Type of Insurance		
Medicare	16	5.9%
Medicaid	8	3.0%
CHIP	4	1.5%
Private	14	5.2%
Financial Assistance Program	107	39.8%
Others	11	4.1%
Uninsured	109	40.5%

LGBTQ+, lesbian, gay, bisexual, transgender, queer, and other; *US,* United States; *CHIP,* Children's Health Insurance Program.

our representative sample. For comparison, our overall ED population for 2019 was 56% Hispanic/Latino and 33% Black. The numbers of English and Spanish speakers were nearly equivalent at 128 and 122, respectively.

The supplemental table shows the relative distribution of SDOH affecting this population, which we classified as problems related to education and literacy, housing and economic circumstances, psychological trauma, employment, social environment, substance abuse, mental health, or access to healthcare. The majority of our patients (43.9%) had earned a high school diploma or equivalent, whereas 22.3% had less than a high school-level education. While 75.1% reported having a stable place to live, 74.7% also reported living in poor conditions. In terms of access to food, 51.7% of respondents reported food insecurity or shortage. Financial insecurity was reported by 69.9% of participants. Regarding employment, 17.1% of those surveyed were unwillingly out of work, and another 13.8% were unable to work due to a disability, contributing to less favorable SDOH.

Substance abuse was not uncommon in our patient population, particularly the use of alcohol (five or more drinks in a day in males or four or more drinks in a day in females) and tobacco (any use). Rates of tobacco use and alcohol binge drinking were comparable, with 32.3% and 32.7% of patients admitting to each activity in the past year, respectively. Mental health challenges were also prevalent, as 46.5% of patients experienced feeling down, depressed, or hopeless at least several days in the prior two weeks. This population experienced significant barriers in accessing healthcare, with 67.7% experiencing a barrier of at least one kind, most commonly lack of insurance. There was also a significant proportion of patients who came to the ED for reasons that reflected poor SDOH: concern about the cost of other facilities (11.5%); lack of awareness of alternative options (4.1%); or "other" (ie, no access to reliable transportation to a more appropriate facility, unavailability of a timely outpatient appointment, new to the area, and lacking a primary care doctor) (24.9%). Table 2 displays the sociodemographic characteristics of patients in relation to their SDOH stratum, with lower impact stratum meaning more optimal SDOH and higher impact stratum meaning less optimal SDOH. The lower, middle, and higher impact strata represented 47 (17%), 118 (44%), and 104 (39%) patients, respectively. Thus, the majority of patients had to deal with multiple sub-optimal conditions that contributed to poor SDOH and, therefore, a higher impact score. Notably, the middle and higher strata contained a similar proportion of males and females, while the lower impact stratum had a predominance of females (63.8%). Race/ethnicity of patients also varied markedly between strata. Being White was disproportionately weighted toward lower and middle impact strata (81.3%). By contrast, Hispanic/Latinos and Blacks were more likely to fall within the higher impact strata (46.0% and 33%, respectively). This trend held for immigrants, especially those who were undocumented. US citizens, conversely, were more evenly dispersed across strata and comprised the bulk of the lower impact stratum (89.4%). The primary language spoken also appeared to be a predictor of stratum, with Spanish speakers expressing more SDOH burden than their English-speaking counterparts. The higher impact stratum was 56.7% Spanish speakers, which was in stark contrast to the lower impact stratum, where English speakers held a 74.5% majority.

Table 3 shows the results of multinomial logistic regression between the various sociodemographic characteristics of patients and their likelihood of being in the middle or higher impact stratum as compared to the referent category of those in the lower impact stratum. We observed that when compared to White patients, Black patients were 1.22 times as likely (odds ratio [OR]: 1.22, 95% confidence interval [CI], 1.08-1.76), and Hispanic/Latino patients were two times as likely (OR: 2.04, 95% CI, 1.12, 6.51) to be in the higher impact stratum. Those who were undocumented had 3.43 times increased adjusted OR (aOR) (95% CI, 1.98, 9.53) of being in the higher rather than the lower impact stratum compared to US citizens; whereas being lawfully present or a non-immigrant (student visa, temporary employee, visitor) had an 82% reduced aOR: 0.18 (95% CI, 0.05, 0.63) of being in the higher impact stratum compared to the referent groups. Additionally, people having Spanish as their primary language were 3.12 times as likely to be in the middle impact stratum but 5.16 times as likely to be in the higher impact stratum compared to the reference (English speaking and lower impact stratum).

DISCUSSION

In this study population, the sociodemographic factors with the most significant association to a high burden from social needs included being Hispanic/Latino, primarily Spanish-speaking, and undocumented immigrant status. Numerous factors have been postulated as a link between undocumented status and increased social needs impact, including discrimination, immigration policy, and a lack of understanding of the US healthcare system by immigrant populations.[29] A paper by Gurrola and Ayon in 2018 eloquently outlines the far-reaching consequences of anti-immigration policy and structural discrimination against undocumented immigrants regarding each of the five SDOH domains. A common theme affecting each domain was lack of integration, preventing equal educational opportunities, economic stability, and access to basic healthcare services.

Similarly, there have been several studies seeking to identify barriers faced by patients with a primary language other than English or LEP persons. A study by Sentell suggested that LEP individuals may be less likely to receive or be recommended for critical resources.[30] This study focused on access to mental health services among Latinos and Asian/Pacific Islanders. Stark disparities existed when controlling for ethnicity in each group identifying LEP as the primary risk factor in lack of mental health referral.

Table 2. Sociodemographic characteristics of patients visiting the emergency department based on their social determinants of health (SDOH) stratum (based on SDOH index score: lower impact stratum – index score 0-5; middle impact stratum – index score 6-10; and higher impact stratum – Index score 11-16).

	Lower impact stratum		Middle impact stratum		Higher impact stratum	
	N	Prevalence	N	Prevalence	N	Prevalence
Total	47		118		104	
Age						
18-39 years	17	14.4%	53	44.9%	48	40.7%
40-59 years	26	24.1%	45	41.7%	37	34.3%
60+ years	4	10.3%	19	48.7%	16	41.0%
Missing	0	0.0%	1	25.0%	3	75.0%
Gender						
Female	30	20.5%	65	44.5%	51	34.9%
Male	16	13.6%	52	44.1%	50	42.4%
Other/missing	1	20.0%	1	20.0%	3	60.0%
Identify as LGBTQ+						
No	39	16.1%	107	44.2%	96	39.7%
Yes	6	40.0%	5	33.3%	4	26.7%
Other/prefer not to answer	2	16.7%	6	50.0%	4	33.3%
Race/Ethnicity						
White	12	37.5%	14	43.8%	6	18.8%
Black	20	21.3%	43	45.7%	31	33.0%
Hispanic/Latino	14	11.3%	53	42.7%	57	46.0%
Others	1	7.1%	7	50.0%	6	42.9%
Missing	0	0.0%	1	20.0%	4	80.0%
Citizenship status						
US citizen	42	25.1%	71	42.5%	54	32.3%
Lawfully present/non-immigrant	3	7.0%	18	41.9%	22	51.2%
Undocumented	2	4.5%	22	50.0%	20	45.5%
Prefer not to answer/missing	0	0.0%	7	46.7%	8	53.3%
Primary language						
English	35	27.3%	56	43.8%	37	28.9%
Spanish	11	9.0%	52	42.6%	59	48.4%
Other	1	5.3%	10	52.6%	8	42.1%

LGBTQ+, lesbian, gay, bisexual, transgender, queer, and others; *US,* United States.

Numerous studies have highlighted the risks of social and health inequity faced by minority populations in the US. However, as suggested by Lillie-Blanton and LaVeist, the relationship between minority status and socioeconomic status is so complex that controlling for social factors and attributing risk purely to race or ethnicity alone may completely miss the point.[31] This survey has helped to identify vulnerable groups within our specific patient population and opens the door to future-focused projects. Moving forward requires an action plan such as that suggested by Wong et al: "[T]o design services that promote health equity, there must be a clear focus on specific communities at risk, a commitment to listen and collect meaningful data to understand local needs and priorities, a conviction to make progress, and ongoing assessment of health outcomes."[32]

While screening is often the initial step in understanding the impact of SDOH within a population, what is known regarding the state of SDOH screening in the US? With widespread knowledge of the impact of SDOH and commitment to improving health outcomes, there has been an increase in screening programs that vary in terms of care setting, topics addressed, and linkage to resources.[33] There is currently a lack of consensus guidelines on a particular screening tool with numerous in use.[34] A portion of the

Table 3. Multinomial logistic regression between sociodemographic characteristics of patients visiting the emergency department and their social determinants of health stratum (lower impact stratum is the referent group).

Sociodemographics	Middle Impact Stratum [OR] (95% CI)	Higher Impact stratum [OR] (95% CI)
Age		
18-39 years	Reference	
40-59 years	1.12 (0.68, 2.01)	2.32 (0.92, 4.02)
60+ years	1.08 (0.50, 2.33)	0.71 (0.21, 2.41)
Gender		
Female	Reference	
Male	0.42 (0.1, 2.31)	1.33 (0.79, 3.62)
Identify as LGBTQ+		
No	Reference	
Yes	0.83 (0.13, 5.17)	3.00 (0.36, 12.92)
Race/Ethnicity		
White	Reference	
Black	0.52 (0.21, 1.72)	1.22 (1.08, 1.76)*
Hispanic/Latino	1.40 (0.14, 3.11)	2.04 (1.12, 6.51)*
Others	0.53 (0.14, 2.43)	2.03 (1.31, 10.23)*
Citizenship status		
US citizen	Reference	
Lawfully present/ non-immigrant	0.62 (0.30, 1.27)	0.18 (0.05, 0.63)*
Undocumented	0.82 (0.23, 1.51)	3.43 (1.98, 9.53)*
Primary language		
English	Reference	
Spanish	3.12 (1.31, 6.40)*	5.16 (1.85, 9.10)*

*Represents statistically significant values based on Type 1 error rate set at 5%, ie, P-values less than 0.05.
OR, odds ratio; *CI,* confidence interval; *LGBTQ+,* lesbian gay, bisexual, transgender, queer and other; *US,* United States.

screening tool used by this group was the Accountable Health Communities Health-Related Social Needs Screening Tool, as the tool has been tested in a multitude of communities to date.[28] However, it must be noted that novel questions were added to this survey, given our desire for sociodemographic data in conjunction with the domains of social determinants.

In addition to choosing a survey tool, there was discussion regarding where screening could or should take place.[34] The ED may be the only point of contact within a healthcare system for patients with the highest burden of social needs. To eliminate health disparities and achieve health equity, interdisciplinary teams that include physicians, nurses, social workers, counselors, community health workers, and volunteers, should collaborate and coordinate to address the patient's social needs. Much of this work can be done through increased community engagement and advocacy for systemic and social change when there are unmet needs in vulnerable populations.

In an article by Hsieh, the argument is made that the focus in the ED must shift to include social needs in the acute care setting to truly optimize healthcare costs and health outcomes.[35] However, a paradox exists in addressing social needs in a busy, fast-paced setting. We would like to propose a few thoughts on how SDOH screening may be implemented into the ED workflow. One initial consideration for implementation is how to create a program that will be attainable for departments with varying resources. For instance, a plan would ideally be actionable for any setting, from an academic center with 24-hour social work coverage to a community ED with minimal interdisciplinary support. As previously mentioned, it would be ideal to engage support staff and avoid developing a burdensome task for the busy emergency physician. Wallace et al published a proposed workflow for SDOH screening worth highlighting, as several crucial points were analyzed in that study.[36] One initial question was who would be responsible for administering the screening questions. Numerous individuals were considered, including ED registration and nursing, with the ultimate decision to use registration staff. The screening tool used included 10 questions targeting SDOH domains known to be actionable by available resources. Once screened, the protocol outsourced referrals to existing state 2-1-1 systems. Our study provides a carefully thought-out workflow, but it was only active at a single institution. Necessary follow-up would entail a multicenter trial of a workflow tracking short- and long-term outcomes.

LIMITATIONS

While this survey was intended to be a needs assessment, several inferences were made from the results. There are, however, flaws in making definitive conclusions from an analysis of this type of investigation. First, because it was a single-center study, it lacks external validity. There were also limitations in the method of gathering participants using a convenience sample. Convenience sampling can result in sampling bias, which would not necessarily be representative of the population being assessed and can similarly affect selection bias, which may not reflect true similarities or differences in respondent groups. Surveys were not completed 24 hours a day, which could have affected the sample of patients enrolled. As we intended to provide actionable program planning based on completed survey results, only patients who agreed to respond to the survey were included; thus, the total number of patients approached was not tracked. To be more representative of our population, we would have benefitted from a more systematic and random sampling methodology.

Our survey was administered at a safety-net hospital, which can overestimate individuals with socioeconomic constraints. Most patients who use our health system are

referred to us because they are known to be uninsured or experiencing financial hardships. This survey was important in identifying the social needs of our specific patient population, but there can also be the issue of self-reporting. None of our responses were collected from the electronic health record, which may have caused two types of self-reporting bias: social desirability bias and recall bias. Questions were not asked about marital status, household size, and childcare issues. Also, there was limited analysis of socioeconomic constraints, as the association of household income to the SDOH was not evaluated. Due to ease of recruitment, languages spoken were primarily English and Spanish, which prevented a thorough assessment of the prevalence of specific SDOH in non-English speakers.

Lastly, the COVID-19 pandemic limited the number of surveys we were able to administer due to operational changes in our ED workflow. Our care areas were geographically adjusted, and patient access was limited to essential providers, which prevented us from deploying some of our research staff. The stay-at-home orders in early March 2020 required us to terminate survey collection. The pandemic would likely have had a significant shift in the results from surveys completed before the economic shutdown and social distancing directives.

CONCLUSION

In our patient population, those who identified as Hispanic/Latino, Spanish-speaking, and undocumented immigrant status were noted to have the highest burden of social determinants of health. Our study was limited primarily by its small size at a single center and the lack of random sampling, which would have improved the generalizability of our findings. Even so, this points to the need to address the SDOH in patients who present to the ED for care, as for many, SDOH can prove burdensome and significantly affect health outcomes.

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Racial Discrimination from Patients: Institutional Strategies to Establish Respectful Emergency Department Environments

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INTRODUCTION

Social identity-based discrimination from patients against healthcare providers is a prevalent and well-documented phenomenon.[1–3] Numerous studies and essays detail clinicians' experiences of slurs, harassment, and violence from patients based on racial identity.[4–8] In this essay, we advance arguments about how emergency departments (ED) should respond to interpersonal racism from patients. We use an anthropological definition of race as a socially constructed way of categorizing humans based on perceived physical traits, such as skin and hair color.[9] However, race does not have an inherent biological or genetic basis: there is greater physical and genetic variation within racial groups than between them, and racial categories vary across societies.[9] Rather, race is assigned in ways that afford privilege, wealth, and power to some, while disadvantaging others.[9,10]

In this editorial, we focus on interpersonal racism, defined as the expression of racial discrimination between individuals, including racial jokes, harassment, and singling someone out on the basis of race.[10] We recognize that racial discrimination can manifest in more subtle ways, such as microaggressions, or commonplace verbal or behavioral exchanges that convey hostility—often unintentionally—toward marginalized groups.[11] Given significant variability in healthcare providers' recognition and acceptance of microaggressions as discriminatory,[12] our advocacy here focuses on unified institutional responses to interpersonal racism. We are interested in increased discussion about protecting the rights and wellbeing of emergency physicians at the same time that we address patients' medical needs, particularly in our climate of profound political polarization in the United States.

Strategies for Dealing with Racist Patients: the Lens from Acute Care Settings

Biomedical scholarship predominantly advances the individual physician's appeasement, negotiation, and accommodation of racist patients, with a focus on prioritizing and moving forward a patient's medical care.[13,14] For example, when a patient declines care from a physician who is a racial minority, hospital staff often seek out another physician to care for the patient.[4] When a patient yells racial slurs at physicians or tells them to "go back to their country," the physician is expected to respond to the patient courteously, if at all, in the interest of maintaining professionalism,[6] or to re-orient themselves to patient needs and "depersonalize" their experiences.[15] These strategies construe acceptance of racism from patients as necessary to maintain the therapeutic relationship and imply that the targets of such abuse should be willing to incur it as part of the inevitable costs of the job. However, as seen in the response to sexual discrimination and harassment and bullying, both in broader society and in the medical profession specifically, attitudes and behaviors that were once accepted as part of the prevailing culture are increasingly and rightfully being denounced.[16,17] Recognition of the detrimental effects of sexual discrimination and bullying, including psychological consequences, hindered career advancement, and the effects of burnout and attrition on the profession as a whole, have led organizations such as the Joint Commission on Accreditation of Healthcare Organizations and the National Academies of Sciences, Engineering and Medicine to call for institutional and systemic responses.[18,19]

Less emphasis has been placed on institutional responses to interpersonal racism in healthcare settings. Williams and Rohrbaugh suggest conceptualizing racist language as *verbal*

assault to underscore traumatic consequences and to trigger reporting of such encounters to administrators, as is done for physical assaults that occur in hospitals.[4] They also suggest team debriefing and de-escalation trainings to help cope with disruptive and discriminatory patients.[4] Others have advocated for involvement of ethics committees with disruptive and hateful patients.[13]

Unique aspects of emergency care settings affect the possibilities for individual and institutional responses to interpersonal racism. Prior evidence suggests that workplace violence is more common in EDs than in other clinical settings, yet emergency physicians may feel ill-equipped and unjustified in responding to racist abuse from patients who are experiencing an acute psychiatric crisis, delirium, intoxication, or are otherwise in distress.[20] Unlike longitudinal care settings, the ED leaves little time for clinicians to establish a therapeutic relationship with patients, which may further disincentivize confronting racist patients. Emergency physicians also face pressure to appease racist patients due to the Emergency Medical Treatment and Labor Act (EMTALA), which stipulates that all patients who seek care in the ED must receive a medical screening examination and stabilization of an emergency medical condition, regardless of their social identity, ability to pay, or behavior.[21] Additionally, time constraints, acuity, and frequent changes in team composition preclude emergency clinicians' abilities to acutely or consistently involve ethics committees, debrief in real time, or find another clinician to care for a racist patient.
Consider the following scenarios:

Scenario: A Black emergency medicine resident begins a primary survey during a trauma resuscitation. The patient, who is alert, shouts racial slurs at the resident, including "[N-word] bitch," and demands another physician. None of the team members present acknowledge the discriminatory behavior and proceed with the rest of the survey.

Scenario: A Sikh attending emergency physician evaluates a young intoxicated male patient cursing at staff from the stretcher. When the patient sees the physician, who wears a turban, he begins yelling, "I don't want to see a foreign doctor! I want to see an American doctor!"

In each case, the physician is emotionally traumatized by the hateful remarks, but may feel morally and legally compelled to evaluate the patient for an emergency medical condition warranting stabilization. If the physician determines that the patient does have an emergency medical condition requiring treatment, then we see three viable, but imperfect, options. First, the physician can continue treating the patient, assuming the patient allows, prioritizing the patient's health needs over the physician's own emotional wellbeing, and despite the likelihood of a poor therapeutic alliance. Second, if not in a single coverage ED, the physician could ask another physician, if available, to care for the patient. Third, the physician can supervise and direct the patient's care through an intermediary–a resident physician, advanced practice provider, nurse, or technician—acknowledging that this could lead to variations in care.

The identity of each physician, encompassing their personal values, experiences, and social and emotional capital, also affects their potential immediate responses. In the first scenario, the trainee, who lacks support from the team, does not have the power to excuse herself from the care of the patient. Furthermore, the trainee may fear repercussions of reporting the incident, such as being seen as too emotionally sensitive, unable to prioritize patients' needs, or stereotyped as an angry minority. In the second scenario, the attending physician may feel compelled to compartmentalize the interaction in the moment and maintain composure as the leader of the care team, particularly if concerned about an emergency medical condition.

These scenarios highlight that no singular prescriptive practice can be recommended for emergency physicians who experience interpersonal racism from patients. These physicians should not be charged with personally responding to these situations if they do not desire to do so. Rather, they would benefit from broader institutional support and anti-racist policies as below.

Suggested Institutional Actions to Establish Respectful Work Environments

We suggest three critical institutional actions that EDs should take to respond to interpersonal racism from patients and establish respectful work environments. First, EDs should establish a patient, visitor, and staff code of conduct. An ED code of conduct should clearly state that discriminatory language and behaviors are not tolerated (see Figure). The code of conduct should be displayed in view of patients and visitors and be physically and electronically accessible to staff as other policies are. If an individual displays discriminatory language or behaviors, staff should provide a verbal reminder of the code of conduct. If the individual then persists in racist language or behaviors, the care team should assess the individual's ability to be discharged. EMTALA and its mandate originated from the guiding principle to care for indigent and uninsured patients. If a racist and disruptive patient does not have a medical condition requiring emergency stabilization and could otherwise be treated as an outpatient, discharging the patient is acceptable. An individual's right to and need for healthcare must be weighed against a clinician's safety and right to work in an environment free from discrimination. While the First Amendment protects hate speech up until it incites violence,[22,23] employers are proscribed by Title VII of the Civil Rights Act (CRA) of 1964 from engaging in employment discrimination practices.[24] A code of conduct created and promulgated by a hospital is a measure that can promote an environment that is firmly anti-racist and anti-discrimination.

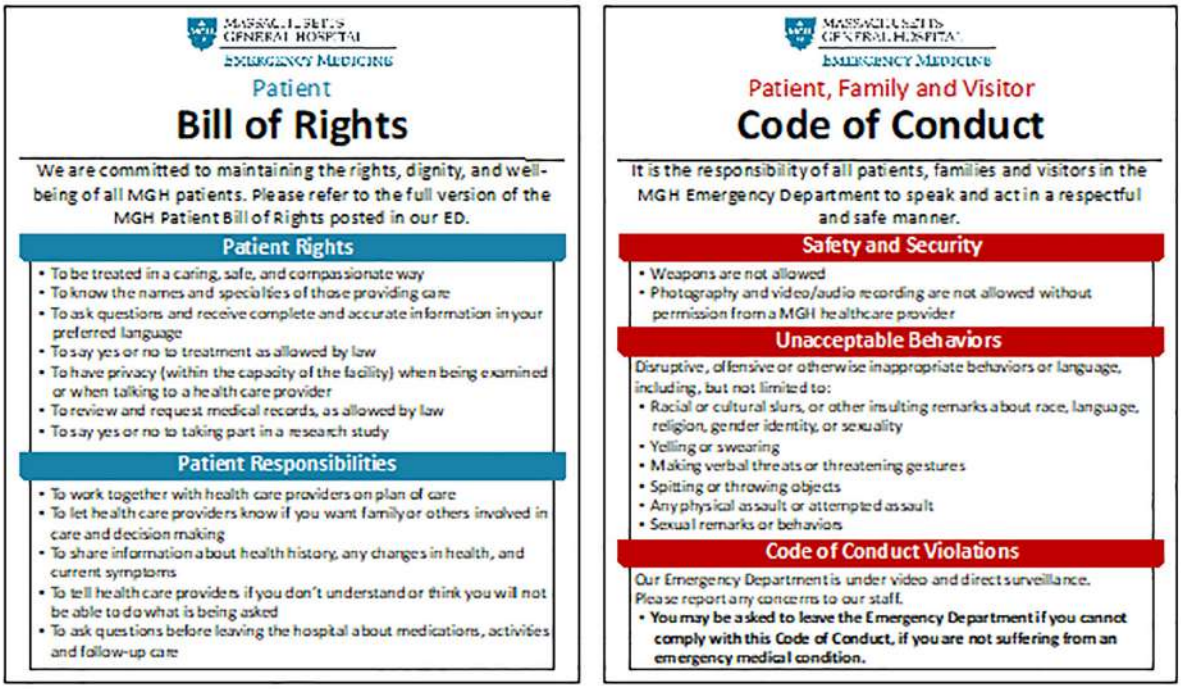

Figure. Code of Conduct, Massachusetts General Hospital Emergency Department.
Used with permission from the Department of Emergency Medicine, Massachusetts General Hospital.

Second, EDs should establish expectations that staff, as members and representatives of the institution, can and should address discrimination from patients in real time. Immediate responses to racism can be particularly meaningful and supportive if expressed by a bystander, rather than the target.[25] A bystander response should ideally both address the inappropriateness of racist behavior and lend support to the target of racism.[26] Hospital staff who witness discrimination should explicitly make a statement such as this: "Discrimination is not acceptable in the hospital environment"; or "Racist remarks are not tolerated in our emergency department" (see Table). Regardless of a patient's or visitor's mental status, staff should remind them of the code of conduct, as some individuals with mild intoxication and psychiatric illness are redirectable.

Lending support to the target of discrimination may take the form of an individual check-in with the target, such as, "I'm sorry that happened. How can I support you?" A short staff debrief establishing that interpersonal racism is not acceptable can unify the team and express alliance with the target. While immediate debriefing may not be feasible in all high-volume and high-acuity situations, making the time to do so, even if quickly, contributes to a workplace environment of solidarity. Additionally, the transition of care of a discriminatory patient, who still requires treatment, to another physician is in itself a powerful act. This is fundamentally different than acquiescing to racist patients' demands: the decision ultimately rests with the victim, and the intent is to protect them from further abuse. This can be achieved through a protocol that is disseminated and discussed among the physicians in a group and that can be referenced and activated in real time.

While we acknowledge limitations of such protocols in single-coverage EDs as well as situations where patients lack capacity or have immediately life-threatening illness, leadership should foster a culture that normalizes and promotes this form of support whenever feasible. Establishment of these expectations and guidance on how staff can respond to racism can be offered in the form of an announcement at a staff meeting, an email, or, where resources are available, through formalized bystander training.[27] Sample language is outlined in the Table.

Third, EDs should create or link to hospital-wide incident reporting mechanisms. There is a clear precedent for healthcare organizations to implement systemic interventions to prevent and report physical assaults in the workplace.[28] Incident reporting, whether to department leadership, human resources, anti-racism committees, and/or institutional centers for diversity and inclusion, could contribute to administrative knowledge about the frequency and scope of racist encounters. Additionally, as immediate staff debriefing may not occur in emergency care settings, reporting mechanisms could facilitate a third party reaching out to and supporting the targeted clinician after a racist encounter.

Patients who commit physical aggression against hospital staff receive flags in their charts, leading to warning

Table. Sample language for addressing interpersonal racism from patients.
Developed in collaboration with the Social Emergency Medicine Interest Academy of the Harvard Affiliated Emergency Medicine Residency

Situation	Sample language	Strategies employed
Bystander outlines behavioral expectations for patient or visitor	"Racist language is not acceptable in our hospital. Please be respectful."	Rely on institutional policy to strengthen position
	"I must remind you that our code of conduct outlines that discriminatory language and behavior is not tolerated."	Take firm but professional approach Remind patient/family of therapeutic intent
	"Racist remarks are not tolerated in our emergency department. Please remember that as we take great care of you."	
	"We are doing our best to take excellent care of you. Please refrain from making racist statements."	
Bystander checks in with target	"I am sorry that happened. It upset me. I wanted to check in on how you are doing."	Acknowledge situation, name own feelings without projecting them onto target, offer support
	"I am sorry that happened. Please let me know how I can support you."	
	"I am sorry that happened. I would like to report this incident to our supervisors, if that is okay with you."	
Care team member leads debrief	"Our patient's racist language and behaviors today are not acceptable. I'd like to remind everyone of our code of conduct."	Outline interpersonal racism as not tolerated Remind staff of institutional policy
Care team member assists with provider transition of care when a physician has experienced interpersonal racism	[to colleague:] "I am sorry about what happened. I am willing to assume care of this patient."	Acknowledge situation and offer alternative Affirm appropriateness of care handoff
	"This patient has been stabilized and it is appropriate for their care to be handed off."	Recognize that victims of interpersonal racism, particularly trainees, may not feel empowered to voice a preference to not participate in the care of discriminatory patients
	"We can have another provider take care of this patient primarily."	
	[to trainee:] "I'd like to have another provider take care of this patient primarily. You did nothing wrong, but I don't think it is a positive environment for you to remain in."	

notifications upon opening the electronic health record. We suggest implementing similar electronic warning systems for patients who engage in racist verbal aggression. Repeat offenders may have a contract or care plan developed, clearly outlining behavioral expectations when receiving emergency and hospital-based care.

In this essay, we focus on race, recognizing the difficulty and awkwardness of conversations about racism when compared to other forms of social identity-based discrimination. However, our recommendations can just as easily apply to creating institutional support for those marginalized on the basis of other identities, such as gender, sexual orientation, or ability status.

CONCLUSION

Institutional responses to interpersonal racism can empower emergency physicians to address discrimination from patients in real time. Rather than relying solely on targets of racial discrimination to accommodate or directly respond to patients, we advocate for institutional responses to promote respectful and supportive workplace environments.

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Perceptions of Emergency Care by Sexual and Gender Minorities in Colorado: Barriers, Quality, and Factors Affecting Identity Disclosure

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Introduction: Expanding on data concerning emergency department (ED) use and avoidance by the sexual minority (those who identify as lesbian, gay, bisexual, queer, other [LGTBQ+]) and gender minority (those who identify as transgender, gender nonconforming, other) community may inform future ED LGTBQ+ training and clinical practice. Investigation objectives included characterizing rates of emergency care avoidance, identifying barriers to emergency care, and assessing emergency care quality and cultural competency for sexual and gender minorities.

Methods: In this population-based, cross-sectional needs assessment, sexual minority, gender minority, and/or cisgender heterosexual-identified participants were selected based on participants' subscription to newsletters or social media accounts for One Colorado, an LGBTQ+ advocacy organization. Each participant completed a single digital survey that collected qualitative and quantitative data about ED perception, use, and demographics.

Results: A total of 477 LGBTQ+ or heterosexual-identified individuals (mean age = 44.3 (standard deviation [SD] = 16.7)) participated in the study. Lifetime emergency care avoidance rates for gender minorities were markedly increased (odds ratio [OR] 3.8, 95% confidence interval [CI], 2.2 – 6.6; P <.001), while avoidance rates for sexual minorities were similar to those of cisgender heterosexual respondents (17% vs 14%; P <.001). Gender minorities were more likely than sexual minorities to both avoid emergency care due to fear of discrimination (43% vs 15%; P =.002) and to have experienced discrimination during their last ED visit (OR 11, [95% CI, 5–24]; P <.001). No significant differences were observed between participants in care avoidance due to financial reasons or prior negative experiences. No cited ED factors that influenced identity disclosure decisions were distinctly predictive.

Conclusion: Gender minorities are more likely than sexual minorities and heterosexual cisgender individuals to report ED avoidance and discrimination at last ED visit. Future work characterizing deficits in LGBTQ+ ED care might reduce these avoidance and discrimination rates, enhancing the level of patient care provided to this population. [West J Emerg Med. 2021;22(4)903-910.]

INTRODUCTION

Despite significant advances in lesbian, gay, bisexual, transgender, queer, and other sexual and gender minority-identified (LGBTQ+) rights, sexual minorities (those who identify as lesbian, gay, bisexual, queer, other) and gender minorities (those who identify as transgender, gender nonconforming, other) still experience considerable socioeconomic disparities that impact health and healthcare access. Fear of discrimination often frames this population's healthcare encounters and shapes healthcare-related behaviors.[1,2]

Limited published data characterizes the LGBTQ+ population's access to emergency medical care. A focused study of sexual minorities in the Bronx found that emergency department (ED) use was higher compared to the general population, despite adequate access to primary care physicians. Nearly 78% of LGB individuals surveyed had a primary care doctor with whom they were comfortable discussing LGB issues.[3] Conversely, a Canadian study found 21% of transgender respondents reported previously avoiding emergency care due to fear that their identity would affect their care.[4] A subsequent study supported the Canadian investigation, finding gender minority-identified participants more likely to report negative effects of identity disclosure to their provider.[5] Despite these foundational investigations, no prior study has provided detailed data on care avoidance for both sexual and gender minorities, care satisfaction, and factors associated with identity disclosure in the emergency care setting.

One investigation exploring gender minority-identified individuals' ED experiences found an association between negative ED experiences and lack of provider sensitivity toward and training about this population.[6] When exploring cultural competency training in the ED, a survey of emergency medicine residency program directors found that only a third incorporated LGBTQ+ health content into the didactic curriculum.[7] An additional survey of physicians at an academic health center found that the majority of physicians would not regularly discuss sexual orientation, sexual attraction, or gender identity with patients.[8] Taken together, the paucity of culturally competent LGBTQ+ training for residents and limited incorporation of LGBTQ+-relevant discussions into patient care pose potential barriers to providing optimal care for LGBTQ+-identified individuals. The need for culturally competent ED care is critical given the significant use by minority patients and the rapidity of the work, where brief contact time and the need for efficiency can magnify small discordances in patient interactions.[9] To adequately address the needs of minority patients within the ED, we must first develop a robust understanding of those needs.

With this needs assessment, we sought to identify the following: care avoidance rates and factors associated with care avoidance; factors associated with ED selection for the LGBTQ+ community; factors associated with identity disclosure within the ED; and factors associated with perceived discrimination in the ED.

Population Health Research Capsule

What do we already know about this issue?
Members of the sexual and gender minority (SGM) community experience considerable socioeconomic disparities that impact their health and healthcare access.

What was the research question?
How do SGM community members perceive emergency department (ED) care relative to heterosexual individuals?

What was the major finding of the study?
Gender minority community members reported ED avoidance and discrimination more than other study participants.

How does this improve population health?
Efforts to reduce rates of ED avoidance and perceived discrimination among SGM community members could enhance the level of care provided to this population.

METHODS

Study Design and Population

Surveys were distributed through the email list and social media accounts of a prominent Colorado LGBTQ+ organization, One Colorado, from August–November 2015 using three separate email notifications. Anyone with a survey link was eligible to participate, although Colorado residents belonging to the LGBTQ+ community were specifically targeted through the selected distribution method. The study was determined to be exempt from review by the University of Colorado Institutional Review Board.

Survey Content and Administration

A digital survey used 36 multiple-choice questions and fill-ins to collect qualitative and quantitative data about ED perception and use, as well as demographic information. We used a validated, two-question approach to assess gender and assign participants to the gender minority group.[10] The remainder of the questions were designed by the study team, tested within the survey group, tested on two external volunteers, and revised extensively over a one-month period based on feedback about clarity of questions and concern regarding answer options.

Data Analysis

Data were housed in a Microsoft Excel document (Microsoft Corporation, Redmond, WA) and analyzed using Stata 13 (StataCorp, College Station, TX), using chi-squared and Fisher's exact tests (when n <10 in a given cell) to assess for differences in categorical data according to a predetermined statistical analysis plan. Participants were excluded if both sexual orientation and gender identity were not reported. Based on key results from this analysis, alongside pre-hoc hypotheses, we used logistic regression to determine odds ratios (OR) for care avoidance and reporting a negative last ED visit. Logistic models were built additively based on *P*-value and effect size from a model containing all factors hypothesized to generate an effect.

RESULTS

The survey was distributed to a listserv of 10,000 members of a local LGBTQ+ organization, with requests to respond about their personal experience in the emergency department. A total of 477 participants who reported gender and sexual orientation responded to the survey; however, as the total number of members who fit those criteria is not known, an actual response rate cannot be calculated. Of these participants, 450 completed meaningful portions of the survey. The final sample consisted of six heterosexual men, 36 heterosexual women, 168 sexual minority men, 150 sexual minority women, and 90 gender minorities (22 transgender men, 34 transgender women, and 34 gender nonconforming, intersex, or other respondents). Of those responding, 88% had previously visited the ED, with an average time since last ED visit of 5.3 years (standard deviation = 6.7). Further summary statistics are available in Table 1.

Gender minorities reported higher rates of ED avoidance compared to sexual minorities and heterosexual cisgender respondents. Sexual minority respondents reported similar rates of ED avoidance compared to their heterosexual peers; however, the sampling technique combined with low numbers of heterosexual respondents may limit the conclusions that can be drawn about heterosexual cisgender groups. There was no difference in avoidance rates between heterosexual and sexual minority women ($P = 0.382$). Small numbers of male heterosexual cisgender respondents limited the ability to assess for differences between heterosexual and sexual minority men.

Care avoidance was additionally associated with both annual income level ($P <0.001$) and insurance type ($P = 0.003$). No difference in avoidance rates were noted between White and non-White respondents ($P = 0.115$). Gender minorities were more likely to have a lower income than sexual minorities ($P <0.001$) and less likely to have private insurance ($P <0.001$). Using logistic regression to control for the effect of income, insurance type, and race

Table 1. Summary characteristics of the survey sample.

	Heterosexual cisgender male	Heterosexual cisgender female	Sexual minority male	Sexual minority female	Gender minority	Total
N	6	36	168	150	90	450
Age mean (SD)	69.3 (14.8)	50.7 (19.5)	46.4 (14.8)	41.1 (16.2)	41.0 (17.4)	44.3 (16.7)
Time since last visit mean (SD)	11 (19.6)	7.7 (8.0)	6.2 (6.7)	4.7 (6.1)	3.7 (5.0)	5.3 (6.7)
Any racial minority N (%)	0	5 (14%)	25 (15%)	16 (11%)	9 (10%)	55 (12%)
Income						
< $35,000	4 (67%)	13 (37%)	45 (27%)	50 (34%)	50 (56%)	162 (37%)
$35,000 - $74,999	1 (16.5%)	15 (43%)	52 (32%)	63 (42%)	29 (33%)	160 (36%)
> $75,000	1 (16.5%)	7 (20%)	68 (41%)	35 (24%)	10 (11%)	121 (27%)
Insurance type						
Private	2 (33%)	23 (64%)	129 (77%)	109 (73%)	49 (54%)	312 (69%)
Medicaid	0	3 (8%)	12 (7%)	13 (9%)	17 (19%)	45 (10%
Medicare	3 (50%)	8 (22%)	16 (9%)	15 (10%)	8 (9%)	50 (11%)
Military	1 (17%)	0	4 (2%)	2 (1%)	7 (8%)	14 (3%)
Uninsured	0	1 (3%)	4 (2%)	5 (4%)	2 (2%)	13 (3%)
Multiple	0	1 (3%)	1 (1%)	2 (1%)	4 (4%)	8 (2%)
Other	0	0	2 (1%)	2 (1%)	3 (3%)	7 (2%)

SD, standard deviation.

revealed that the odds of reporting care avoidance were 3.8 times greater among gender minorities compared to male sexual minorities (Table 2).

Half of those who previously avoided care reported doing so for financial reasons, with an equal distribution for heterosexual cisgender respondents, sexual minorities, and gender minorities (Table 3). Fear of discrimination was identified as a barrier to seeking care more frequently by gender minorities (43%, 19/25) compared to sexual minorities (15%, 8/55) ($P = 0.002$). Of those with a history of care avoidance, 45% (20/44) of gender minorities and 29% (16/55) of sexual minorities reported a prior negative ED experience as the reason for avoidance ($P = 0.241$). The rate of avoidance due to a prior negative experience outside of the ED was again similar between sexual and gender minorities ($P = 0.248$).

When choosing an ED, few respondents reported researching the ED to determine its LGBTQ+-friendliness prior to presenting (3%, 10/356). Gender minorities were more likely to research departments (7%, 6/83) than sexual minorities (1.5%, 4/273) ($P = 0.028$). Factors affecting ED choice included proximity (53%), transport by emergency medical services or another individual (20%), reputation (9%), and other reasons such as insurance limitations (15%). Only 1% of respondents chose an ED based on the knowledge of its LGBTQ+-friendliness (one gender minority, four male sexual minorities).

Of those who felt the question was applicable, 36 respondents (12%) felt their LGBTQ+ identity negatively affected their most recent visit, with 41% of these respondents believing they were treated differently than other patients and 41% reporting hearing homophobic/transphobic language in the ED. Respondents who self-identified as LGBTQ+ parents also reported difficulties presenting with a child for care, including needing to correct staff on correct pronoun usage.

"I've been expected to coach attending medical staff on pronouns and grammar while receiving emergency care and also while being interrogated (and argued with) about my biological sex (because they didn't understand being intersex nor did they understand the difference between gender and sex)."

Some cisgender sexual minority respondents noted subtle ways in which they felt marginalized by staff.

Table 2. Odds of ever avoiding care generated by logistic regression.

	N (%) Ever avoided care	Odds Ratio	95% CI	P value
Gender/Sexual orientation				
Male sexual minority	17 (10%)	1 (control)		
Female sexual minority	38 (25%)	3.3	(1.7 – 6.4)	0.001
Transgender man[1]	11 (50%)	6.1	(2.1 – 18)	0.001
Transgender woman[2]	14 (41%)	6.7	(2.6 – 17)	<0.001
Other gender minority	19 (56%)	9.2	(3.7 - 23)	<0.001
Any gender minority[3]	44 (49%)	3.8	(2.2 – 6.6)	<0.001
Income				
<$35,000	54 (37%)	1 (control)		
$35,000 - $74,999	29 (20%)	0.36	(0.19 - 0.70)	0.003
> $75,000	14 (14%)	0.29	(0.14 - 0.64)	0.002
Insurance				
Private	65(23%)	1 (control)		
Medicaid	17 (40%)	0.78	(0.33 - 1.9)	0.574
Medicare	4 (10%)	0.23	(0.070 - 0.73)	0.013
Military	5 (38%)	1.1	(0.30 - 4.4)	0.838
Uninsured	2 (17%)	0.24	(0.045 - 1.3)	0.101
Other	1 (14%)	0.21	(0.022 – 2.0)	0.171
Multiple	4 (57%)	2.0	(0.32 - 13)	0.459
Race				
White (control)	83 (23%)	1		
Other race/ethnicity	16 (31%)	1.9	(0.90 – 4.0)	0.090

$P_{model} < 0.0001$, P_{seudo} $R^2 = 0.1676$.
[1]Female to male transgender, a gender minority.
[2]Male to female transgender, a gender minority.
[3]Any gender minority combines transgender + other gender minority; values generated from a separate logistic regression.
CI, confidence interval.

Table 3. Number of patients reporting having ever avoided the emergency department by sexuality and gender identity.

	Cisgender Heterosexual N (%)*	Sexual Minority N (%)*	Gender Minority N (%)*	P-value
Ever avoided	6 (14%)	55 (17%)	44 (49%)	<0.001
Financial reasons	3 (50%)	27 (49%)	18 (43%)	0.900
Fear of discrimination	0	8 (15%)	19 (43%)	0.002
Prior negative ED experience	2 (33%)	16 (29%)	20 (45%)	0.241
Prior negative experience outside ED	0	8 (15%)	11 (25%)	0.248

*Subgroups presented as a percentage of those who ever avoided care.
ED, emergency department.

"*My husband and I went together to the ER. No one attempted to keep us apart but no one inquired as to our relationship either. In some ways this 'avoidance' of our relationship made me feel a bit awkward. When physicians and nurses spoke to me, they basically ignored my spouse. It would have been better if they asked what our relationship was and then indicated approval and spoke to both of us as a couple. It has been my impression that with straight couples they tend to speak to both husband and wife as a pair."*

"I was there of [sic] a relatively minor emergency room procedure, and had my girlfriend accompanying me while I was there. After her being repeatedly referred to as my friend, we both felt more comfortable if she wasn't sitting directly next to me when the doctor came in."

Gender minorities were 10 times more likely than sexual minorities to report their identity negatively affecting their last visit (35% vs 5%) (95% CI, 5–24, P <0.001). Reporting a negative visit was more prevalent in the lowest third of income (<$35,000, 21%) vs the middle- (6.7%) and high- (8.1%) income groups (P = 0.005). Similar income- and access-related trends in identity negatively affecting a respondent's last visit were observed in those with Medicaid (30%) compared to those with Medicare (13%) or private (8.2%) insurance (P = 0.008).

No significant differences in rates of reporting a sexual or gender identity-associated negative ED experience were noted based on race (11% of White respondents and 19% of non-White respondents, P = 0.168) or in sexual minorities based on gender (3% of men and 7% of women, P = 0.234). No significant differences in reporting a negative last ED visit were observed for those who presented for a mental health (24% vs 11%, P = 0.122) or sexual health (0 vs. 12%, P = 1) concern.

Respondents cited numerous intra-ED factors that impacted comfort with their sexual and/or gender identity disclosure. Excluding subjects who selected both positive and negative options (n = 13), the following were selected by respondents as positively or negatively impacting their decision to disclose identity in the ED: welcoming (22%) or unwelcoming (9%) nurse; welcoming (18%) or unwelcoming (7%) physician; non-inclusive intake forms (ie, binary gender options) (21%); lack of LGBTQ+ signage (20%); and lack of gender- neutral bathrooms (10%). Respondents cited non-inclusive non-discrimination statements, presence of family members to whom the patient hadn't disclosed their identity, and negative experiences with administrative staff as additional factors affecting identity disclosure.

Analyzed as three levels (factor not commented on, supportive factor noted, and detracting factor noted), the presence of a nurse or physician non-comment, supportive comment, or detracting comment was associated with increased likelihood of identity disclosure (Table 4).

While positive and negative ED factors were minimally predictive of identity disclosure, they were markedly predictive of whether or not a respondent's sexual/gender identity negatively impacted the last ED visit. Assessed independently, there were differences (P <0.001) in reporting a negative experience depending on having a welcoming/unwelcoming physician or nurse, presence of gender-neutral bathrooms, absence of an inclusive intake form, or absence of LGBTQ+ signage. Assessed together using logistic regression and controlling for whether or not the patient was a gender minority, odds of reporting a negative visit were increased by having an unwelcoming physician (OR [4.4], P = 0.035) or nurse (OR [22], P <0.001), with no effect based on the presence or absence of LGBTQ+ signage, gender-neutral bathrooms, or inclusive intake forms (Table 5). Neither income level nor insurance type contributed to this model, and so were excluded.

DISCUSSION

This needs assessment uncovered a variety of data on ED utilization by the LGBTQ+ community and revealed several important findings.

Emergency Department Avoidance

In both sexual minorities and gender minorities ED avoidance was prevalent when controlling for income, insurance, and race, gender minorities avoided more frequently, consistent with a previous investigation conducted in the United States.[6] Among those who reported a history of avoidance, a similar proportion of sexual and gender minorities avoided

Table 4. Emergency department factors noted present by the percentage of those who disclosed gender/sexual identity.

ED factor	N (%) Identity disclosed	P (level)
Nurse not commented on	67 (34%)	< 0.001
Supportive nurse	35 (61%)	
Negative nurse	14 (53%)	
Physician not commented on	75 (35%)	0.004
Supportive physician	30 (59%)	
Negative physician	11 (55%)	
Bathroom not commented on	97 (40%)	0.435
Gender-neutral bathroom	3 (33%)	
No gender-neutral bathroom	16 (52%)	
Intake form not commented on	75 (37%)	0.090
Inclusive intake form	9 (45%)	
Non-inclusive intake form	32 (52%)	
LGBTQ+ signage not commented on	86 (40%)	0.173
LGBTQ+ signage	0	
No LGBTQ+ signage	30 (46%)	

ED, emergency department; *LGBTQ+*, lesbian, gay, bisexual, transgender, queer, other.

for financial reasons or due to prior negative healthcare experiences. Gender minorities reported avoiding due to fear of discrimination more than sexual minorities. Expressed as a proportion of all gender minorities, the percentage who reported avoidance due to fear of discrimination was identical to the previously reported percentage of trans community members who avoided care in Ontario, Canada.[4] However, limited conclusions about ED avoidance can be drawn between these two studies due to differences in sampling methodology.

Our findings suggest that emergency care avoidance within the gender minority community occurs significantly more often than in the heterosexual cisgender community. Prior negative ED experiences as well as perceptions about ED care beyond personal experience appear to shape this behavior. These findings suggest a need to couple improving intra-ED care with outreach and public efforts, such as involving local LGBTQ+ organizations in physician training.

Emergency Department Choice

While few respondents researched the ED to determine its LGBTQ+-friendliness prior to presenting, gender minorities reported this behavior more frequently than sexual minorities.

Table 5. Odds of reporting last emergency department experience as negative by patient and ED factors.

	N (%) Negative last ED visit	OR	95% CI	*P* value
Unadjusted model				
Gender minority	22 (39%)	11	(5.0 -24)	< 0.001
	$P_{model} < 0.0001$, pseudo $R^2 = 0.1809$			
Adjusted model				
Gender minority		13	(4.6 – 37)	< 0.001
Nurse not commented on		1		
Supportive nurse		0.59	(0.11 – 3.2)	0.527
Negative nurse		22	(5.1 – 92)	< 0.001
Physician not commented on		1		
Supportive physician		NA		
Negative physician		4.4	(1.1 – 18)	0.035
	$P_{model} < 0.0001$, pseudo $R^2 = 0.50$.			

ED, emergency department; *OR*, odds ratio; *CI*, confidence interval.

Respondents reported having little control over ED choice, with the majority choosing based on proximity, extrinsic factors (eg, insurance coverage), or transport by emergency medical services. A portion of respondents chose based on reputation, which may have incorporated LGBTQ+-friendliness and thus diluted the response for choosing an ED specifically for this quality.

These findings suggest that services for identifying LGBTQ+-friendly providers or hospitals, while useful in primary care and for elective procedures, may be less beneficial in emergency care. If online resources for identifying LGBTQ+-friendly EDs were to be developed, our results suggest that emphasis should be placed on EDs committed to quality, gender minority care, such as those requiring cultural competency staff training.

Identity Disclosure

Respondents reported many ED factors that contributed to identity disclosure. A welcoming physician or nurse was the most common hospital factor that contributed to disclosure, while lack of LGBTQ+ signage or non-inclusive intake forms (eg, binary gender options) were detracted from identity disclosure.

When analyzed as a three-level variable (factor not commented on, positive factor noted, detracting factor noted), noting any factor was associated with identity disclosure at last visit regardless of emotional valence. This might suggest recall bias, where those with a positive or negative experience during their last ED visit were more likely to recall factors that those with a neutral experience, thus affecting our ability to measure a true relationship. This may also represent an element of reverse causation; those who disclosed their identity might have been more likely to experience negative encounters with staff. Given these analytic complications, the true impact of these factors on identity disclosure is difficult to assess.

Additional factors that were not captured by our survey likely impact identity disclosure decisions. While not predictive of identity disclosure as a binary yes/no, our data do suggest that patients analyze numerous intra-ED factors as part of the identity-disclosure process.

Emergency Department Discrimination

Gender minorities were more likely than sexual minorities to report a last visit negatively impacted by gender identity/sexual orientation. Negatively perceived interactions with physicians and/or nurses were strongly predictive of experiencing a negative encounter. Increased estimates for a negative interaction with nurses vs physicians may reflect longer interaction time with nurses, interactions with multiple nurses, or more overt differences in care quality based on discrimination. These results may also reflect chance, with similar odds of causing a negative experience when accounting for the wide confidence intervals.

Our findings suggest that interventions aiming to improve LGBTQ+ cultural competency should target both physicians and nurses. No information was gathered regarding negative encounters with other ED staff (eg, administrative staff, technicians, etc.); so data-based recommendations cannot be made for this group.

No differences were observed in the likelihood of discrimination based on race, gender among sexual minorities, or visit type, although the relatively low event rate and number of subgroups analyzed limits definitive conclusions.

Strengths

To our knowledge, our study is the first ED-focused needs assessment for the LGBTQ+ community. We received a significant number of responses from both sexual and gender minorities with notable socioeconomic diversity.

LIMITATIONS

While our sample size was robust, it lacked a sufficient number of racially diverse participants to examine the role of race/ethnicity in ED avoidance or discrimination. A limited number of heterosexual cisgender respondents limited comparison to the general population. Limited numbers of respondents reporting seeking care for sexual health (n = 6) or mental health (n = 17) concerns preclude analysis of outcome quality for patients presenting with these complaints. Our sample's composition of members of a Colorado-based LGBTQ+ organization's social network reduces applicability to states with differing political climates and LGBTQ+ acceptance pervasiveness.

Additionally, all outcomes were self-reported and retrospective. This raises the possibility of recall bias, where those reporting negative ED encounters remembered greater detail about experiences than those reporting less remarkable visits. Mean time since last visit was five years, an interval that likely reduced recall of specific factors contributing to visit quality and likelihood of identity disclosure. Finally, as our sample was taken from membership within a LGBTQ+ organization, it is very possible that responder bias may have skewed both the response from under-represented groups and the cisgender heterosexual population in our sample, and may not reflect the experiences of the cisgender heterosexual population in general. Similarly, by using our population of sexual minority males as our control group for a subset of our analysis, we may have skewed our results; however, this variation from standard is another reminder that "heterosexual" should not be the default in all circumstances. Doing so allowed us to stratify rates of avoidance among sexual and gender minorities when a convenience sample of cisgender heterosexual respondents was limited.

Future Studies

Our study revealed significant findings concerning the LGBTQ+ community that may form the basis for future investigation. Future studies administering patient surveys immediately after ED visits may reduce the effect of recall bias

and yield more robust data. Investigations seeking to further characterize perceived shortcomings of ED visits in specific areas (eg, provider communication, partner involvement, physical exam, etc) may identify additional deficits in care. Incorporating physician and nurse gender into the analysis might yield informative insight on the effect of provider gender on care. Outcomes data for ED visits including bounce-back rates, hospital admission rates, and mortality might provide further detail on the impact of ED avoidance and intra-ED discrimination. Finally, given the disproportionate burden of ED avoidance and discrimination, future work should further characterize specific deficits impacting the gender minority community. Based on our findings, interventions targeting this population's care would likely have a powerful impact.

CONCLUSION

Gender minorities are more likely than sexual minorities to report ED avoidance and discrimination at last ED visit. Future work should further characterize deficits in ED care for this population and assess the efficacy of interventions to reduce ED avoidance and perceived discrimination.

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Cross-sectional Analysis of Food Insecurity and Frequent Emergency Department Use

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Introduction: Emergency department (ED) patients have higher than average levels of food insecurity. We examined the association between multiple measures of food insecurity and frequent ED use in a random sample of ED patients.

Methods: We completed survey questionnaires with randomly sampled adult patients from an urban public hospital ED (n = 2,312). We assessed food insecurity using four questions from the United States Department of Agriculture Household Food Security Survey. The primary independent variable was any food insecurity, defined as an affirmative response to any of the four items. Frequent ED use was defined as self-report of ≥4 ED visits in the past year. We examined the relationship between patient food insecurity and frequent ED use using bivariate and multivariable analyses and examined possible mediation by anxiety/depression and overall health status.

Results: One-third (30.9%) of study participants reported frequent ED use, and half (50.8%) reported any food insecurity. Prevalence of food insecurity was higher among frequent vs. non-frequent ED users, 62.8% vs 45.4% (P <0.001). After controlling for potential confounders, food insecurity remained significantly associated with frequent ED use (adjusted odds ratio 1.48, 95% confidence interval, 1.20-1.83). This observed association was partially attenuated when anxiety/depression and overall health status were added to models.

Conclusion: The high observed prevalence of food insecurity suggests that efforts to improve care of ED patients should assess and address this need. Further research is needed to assess whether addressing food insecurity may play an important role in efforts to reduce frequent ED use for some patients. [West J Emerg Med. 2021;22(4)911–918.]

INTRODUCTION

Even before the coronavirus disease (COVID-19) pandemic, food insecurity affected over 10% of United States households, including nearly 14% of households with children.[1] By May 2020, nearly 18% of US nonelderly adults and 22% of parents with children reported food insecurity in the prior month.[2] Food insecurity is associated with a wide range of negative health outcomes and with higher healthcare costs.[3-11] Large racial and ethnic inequities exist in food insecurity, as they do for health outcomes broadly; Black and Latinx households are disproportionately affected compared to White households.[2]

A systematic review of the literature on social needs of emergency department (ED) patients found that prevalence of food insecurity is even higher among ED patients than among the general public.[12] Studies have also found associations between food insecurity and more frequent ED use among specific groups including people experiencing homelessness,[13,14] and people with diabetes,[15] and among low-income Americans more generally.[16] Food insecurity may lead to increased ED use due to its association with poor physical and mental health,[11] worse control of chronic diseases,[11,17,18] and medication non-adherence,[19] which are in turn associated with ED use.[20-22] We build on past literature by examining the association of food insecurity and frequent ED use among a large, random sample of ED patients not restricted to any particular subpopulation. We aimed to increase understanding of potential pathways between food insecurity and frequent ED use by examining whether poor physical and mental health might be mediators of this relationship.

Population Health Research Capsule

What do we already know about this issue?
Emergency department (ED) patients have a high prevalence of social needs including food insecurity. Associations of food insecurity with frequent ED use are not well documented.

What was the research question?
Is food insecurity associated with self-reported frequent ED use in a sample of public hospital ED patients?

What was the major finding of the study?
Food insecurity was prevalent among our patient sample and was significantly associated with frequent ED use.

How does this improve population health?
Future interventions targeted to frequent ED users should address the high prevalence of unmet social needs such as food insecurity in this population.

METHODS

Study Design

We describe a cross-sectional, secondary analysis of baseline survey questionnaires conducted with randomly sampled ED patients as part of a larger study described previously.[23,24] The study was approved by the NYU School of Medicine Institutional Review Board.

Setting and Participants

Data collection occurred at a large, urban, public hospital in New York City from November 2016–September 2017. Adult (≥18 years) ED patients were eligible if they were medically/psychiatrically stable, not in prison/police custody, and spoke English or Spanish. Research assistant (RA) shift schedules rotated over time to cover all hours of the day and days of the week, with the number of shifts scheduled during a given time window over the course of the study approximately mirroring ED patient arrival volumes. The RAs approached patients following a random sampling scheme; they then read questions aloud and recorded responses using REDCap (Vanderbilt University, Nashville, TN) secure electronic data capture tools.[25] Participants provided written informed consent and received $15 compensation.

Measures

Measures were self-reported. We defined frequent ED use as self-report of ≥4 ED visits in the past 12 months, to any ED, including the current visit. While there is no standard definition of "frequent ED use," ≥4 visits within one year is commonly used.[26] Past research has found patients self-report ED visits with good accuracy.[27]

Participants answered four questions about food insecurity in the past 12 months from the widely used US Department of Agriculture (USDA) Household Food Security Survey.[28] Questions were as follows: 1) I/we worried whether my/our food would run out before I/we got money to buy more; 2) The food that (I/we) bought just didn't last, and (I/we) didn't have money to get more; 3) (I/we) couldn't afford to eat balanced meals; and 4) Did you ever eat less than you felt you should because there wasn't enough money for food?

For the first three questions, participants responded "never true," "sometimes true," or "often true." For the last question—a measure that identifies *very low food security*[1] (sometimes called *food insufficiency*)—participants responded "yes" or "no," with yes being considered an affirmative response. The primary independent variable was *any food insecurity*, defined as participants giving an affirmative response (both "sometimes true" or "often true" were included as affirmative) to any of the four items. We separately examined association of frequent ED use with only

the more severe form of food insecurity, food insufficiency. In bivariate analyses we also examined each food insecurity question separately and the number (0–4) of questions answered affirmatively.

Covariates included age, gender, race and ethnicity, insurance status, difficulty meeting essential expenses (past year),[29] homelessness (living in a shelter, unsheltered, or doubled up; past year), unhealthy alcohol use,[30] and moderate or greater problems with drug use as measured by the Drug Abuse Screening Test (DAST-10). We decided a priori to examine physical health, anxiety, and depression as potential mediators based on prior literature and theory positing these factors as sensitive to food insecurity and as strong drivers of ED use.[11,22,31,32] Self-reported overall health was measured using a single item from the US Centers for Disease Control and Prevention Health-Related Quality of Life score, asking "Would you say that in general your health is"; possible answers were excellent, very good, good, fair, and poor.[33] Anxiety was measured using the GAD-2 (general anxiety disorder) and depression using the PHQ-2 (patient health questionnaire); both are previously validated two-item screeners.[34,35]

Analysis

We examined bivariate associations using chi-squared tests of independence for categorical variables. We conducted multivariable logistic regression to examine the independent association of any food insecurity and food insufficiency with frequent ED use while adjusting for potential confounders. As described above, we examined for mediation by anxiety or depression and overall self-rated health. Anxiety and depression were combined into a single binary variable due to significant collinearity; no other variables demonstrated significant collinearity (Spearman correlation coefficients < 0.4). We examined mediation by including the hypothesized mediators in adjusted regression models and determining whether effect estimates were attenuated compared to effect estimates in models including confounders but without hypothesized mediators.[36] Complete case deletion was used in regression models; the amount of missing data was small (3.7%).

RESULTS

Research assistants approached 6097 patients, of whom 2924 (48%) were eligible. The most common reasons for ineligibility were being medically unstable, intoxicated, not speaking English/Spanish, or in police/prison custody. Of eligible patients, 2396 (82%) agreed to participate. After removing duplicate records for patients who participated more than once (n = 84) there were 2312 participants. Three did not answer the question about past ED use (n = 3) and were excluded from bivariate and multivariable analyses. Participants were diverse in gender, race and ethnicity, and age (Table 1). Half (50.8%) reported any food insecurity. Many also reported difficulty meeting basic expenses and past year homelessness.

Table 1. Participant characteristics.

	n (%)[a] n=2,312
Sociodemographics	
Age	
18–30	488 (21.1)
31–50	855 (37.0)
51–65	689 (29.8)
>65	279 (12.1)
Gender	
Female	1,006 (43.8)
Male	1,293 (56.2)
Race/ethnicity	
Hispanic/Latino	1,270 (55.3)
Non-Hispanic Black	531 (23.1)
Non-Hispanic White	280 (12.2)
Other	217 (9.4)
Insurance	
Uninsured	621 (26.9)
Medicaid and/or Medicare	1,202 (52.1)
Private / Other	485 (21.0)
Unable to meet essential expenses, past 12 months	936 (40.8)
Homelessness (including living doubled up[b], past 12 months)	492 (21.4)
Health	
Number of ED visits, past 12 months (including current visit)	
1	754 (32.6)
2	466 (20.2)
3	375 (16.2)
4+	714 (30.9)
Overall self-rated health	
Excellent or very good	538 (23.4)
Good	722 (31.4)
Fair	754 (32.8)
Poor	287 (12.5)
Moderate or greater problems with drug use (by DAST-10)	276 (12.0)
Unhealthy alcohol use	747 (32.4)
Positive screen for anxiety (GAD-2) or depression (PHQ-2)	859 (37.6)

[a] Percentages shown are among those who answered a given question; denominators for some questions are <2,312 due to a small amount of missing data for some questions (never exceeding 1.6%).
[b] Living "doubled up" includes "couch surfing" or staying with friends, family members, or others due to lack of other housing options.
ED, emergency department; *DAST,* drug abuse screening test; *GAD,* generalized anxiety disorder; *PHQ*, patient health questionnaire.

Table 1. Continued.

	n (%)[a] n=2,312
Food insecurity (past 12 months)	
Worried food would run out before got money to buy more	
Often true	299 (13.1)
Sometimes true	586 (25.6)
Never true	1,403 (61.3)
Food didn't last and didn't have money to get more	
Often true	264 (11.5)
Sometimes true	558 (24.4)
Never true	1,466 (64.1)
Couldn't afford to eat balanced meals	
Often true	284 (12.4)
Sometimes true	562 (24.6)
Never true	1,437 (62.9)
Ate less than felt should because not enough money for food (yes)	632 (27.7)
Any food insecurity (any of 4 questions answered affirmatively)	1,159 (50.8)
Number of food insecurity questions answered affirmatively	
0	1,122 (49.3)
1	245 (10.8)
2	220 (9.7)
3	260 (11.4)
4	427 (18.8)

[a] Percentages shown are among those who answered a given question; denominators for some questions are <2,312 due to a small amount of missing data for some questions (never exceeding 1.6%).

Nearly one-third (30.9%) were frequent ED users.

Participants who reported frequent ED use had significantly higher prevalence of food insecurity than other ED patients (Table 2). This finding held true across each individual food insecurity question and for food insecurity overall, with 62.8% of participants with frequent ED use endorsing any food insecurity vs 45.4% of participants who did not report frequent ED use (P <0.001).

In multivariable analyses (Table 3), both any food insecurity (adjusted odds ratio [aOR] 1.48, 95% confidence interval [CI], 1.20–1.83) and food insufficiency (aOR 1.45, 95% CI, 1.16–1.83) were associated with frequent ED use. These relationships were partially attenuated in models adding depression/anxiety and overall health status, with persistently significant yet reduced aORs for the associations of food insecurity/insufficiency and frequent ED in mediation models.

DISCUSSION

We found a robust association between food insecurity and frequent ED use, including in multivariable analyses adjusting for potential confounders. This relationship was partially attenuated by controlling for anxiety/depression and overall health status, suggesting the possibility of mediation. Notably, while prevalence of food insecurity was highest among participants who reported frequent ED use, even participants without frequent ED use had a high prevalence of food insecurity.

Our findings are consistent with past research showing ED patients have a high prevalence of social needs, including food security. A systematic review[12] showed that while studies varied, food insecurity prevalence of ED patients was generally above 20%, with several studies finding prevalence of one-third or even higher.[12] A few studies examining the association of food insecurity and frequent ED use, among specific subgroups[13-15] and more generally,[16] have uniformly found a significant association. Other studies have found food-insecure ED patients are more likely to have chronic pain, mental health concerns, substance use, and homelessness, all of which are known to be associated with frequent ED use.[3,37]

Our study was unique in randomly sampling a large number of ED patients and including multiple measures of food insecurity, as well as examining the independent association of food insecurity with frequent ED use while controlling for possible confounders and exploring mediation. Although we cannot prove causality in this cross-sectional study, one potential hypothesis is that food insecurity contributes to anxiety/depression and poor overall health, which in turn contributes to frequent ED use. This hypothesis could be examined in future longitudinal research.

The strong association observed between food insecurity and frequent ED use in this study has implications for programs aiming to reduce frequent ED use. Frequent ED use has been the subject of persistent programmatic and policy attention in the US, although programs to address it have had variable success, particularly when examined using robust study designs.[38] Our study adds to evidence suggesting the importance of assessing and addressing the social and structural conditions of people's lives as an integral part of programs developed to reduce frequent ED use.

There has been increased interest nationally in screening for patient social needs in healthcare settings. For food insecurity, a two-item screening tool called the Hunger Vital Sign has been well tested and validated in healthcare settings.[39-42] The items are based on two of the USDA Food Security Survey questions used in our study, on worry about food running out and food not lasting. Research indicates patients generally feel positively about being asked such questions in healthcare settings, including EDs.[43,44] Some studies have suggested patients may prefer and more readily disclose food insecurity when electronic tablet-based screening is used,[45] although other studies have suggested no difference in social needs disclosure with tablet vs in-person interviews.[46]

Table 2. Food insecurity and other characteristics for patients by frequent emergency department (ED) use status.

	Frequent ED Use n (%) n=714[a]	No Frequent ED Use n (%) n=1595[a]	*P*-value[b]
Sociodemographics			
Age			<0.001
18–30	122 (17.1)	366 (22.9)	
31–50	246 (34.5)	609 (38.2)	
51–65	257 (36.0)	429 (26.9)	
>65	88 (12.3)	191 (12.0)	
Gender			0.02
Female	285 (40.1)	719 (45.4)	
Male	426 (59.9)	866 (54.6)	
Race/ethnicity			<0.001
Hispanic/Latino	348 (49.1)	920 (58.0)	
Non-Hispanic Black	219 (30.9)	311 (19.6)	
Non-Hispanic White	80 (11.3)	200 (12.6)	
Other	62 (8.7)	155 (9.8)	
Insurance			<0.001
Uninsured	122 (17.1)	499 (31.3)	
Medicaid and/or Medicare	454 (63.7)	746 (46.8)	
Private / Other	137 (19.2)	348 (21.8)	
Unable to meet essential expenses, past 12 months	365 (51.5)	571 (36.1)	<0.001
Homelessness (including doubled up), past 12 months	256 (36.1)	235 (14.8)	<0.001
Health			
Overall self-rated health			<0.001
Excellent or very good	112 (15.8)	426 (26.7)	
Good	182 (25.7)	540 (33.9)	
Fair	262 (37.1)	491 (30.8)	
Poor	151 (21.4)	136 (8.5)	
Moderate or greater problems with drug use	130 (18.4)	146 (9.2)	<0.001
Unhealthy alcohol use	247 (34.8)	500 (31.4)	0.11
Positive screen for anxiety or depression	362 (51.5)	496 (31.4)	<0.001
Food insecurity (past 12 months)			
Worried food would run out before got money to buy more			<0.001
Often true	141 (19.9)	157 (9.9)	
Sometimes true	205 (28.9)	381 (24.1)	
Never true	363 (51.2)	1040 (65.9)	
Food didn't last and didn't have money to get more			<0.001
Often true	140 (19.8)	124 (7.8)	
Sometimes true	201 (28.4)	356 (22.5)	
Never true	366 (51.8)	1, 100 (69.6)	

[a] Percentages shown are among those who answered a given question; denominators for some questions are lower due to a small amount of missing data for some questions (never exceeding 1.7%).
[b] P-values for bivariate associations tested using chi-squared tests of independence for categorical variables.

Table 2. Continued.

	Frequent ED Use n (%) n=714[a]	No Frequent ED Use n (%) n=1595[a]	*P*-value[b]
Couldn't afford to eat balanced meals			<0.001
Often true	149 (21.2)	135 (8.6)	
Sometimes true	196 (27.8)	365 (23.1)	
Never true	359 (60.0)	1078 (68.3)	
Ate less than should because not enough money	276 (39.1)	355 (22.5)	<0.001
Any food insecurity	444 (62.8)	714 (45.4)	<0.001
Food insecurity questions answered affirmatively			<0.001
0	263 (37.5)	859 (54.7)	
1	73 (10.4)	172 (10.9)	
2	68 (9.7)	152 (9.7)	
3	103 (14.7)	157 (10.0)	
4	195 (27.8)	231 (14.7)	

[a] Percentages shown are among those who answered a given question; denominators for some questions are lower due to a small amount of missing data for some questions (never exceeding 1.7%).
[b] P-values for bivariate associations tested using chi-squared tests of independence for categorical variables.

To date, few studies have rigorously examined how to best assist ED patients who screen positive for food insecurity. A systematic review by De Marchis et al found 23 studies—most of which were of low quality—that examined interventions addressing food insecurity in healthcare settings.[47] One study found having an electronic health record order for referral to a local food bank partner (with patient contact information sent to the food bank and the food bank proactively contacting patients) resulted in more ED patients receiving referrals, 63% of whom ultimately received assistance.[48]

LIMITATIONS

Our study results should be interpreted in light of a few limitations. First, measures were self-reported. We used validated questions when available and chose measures for which we expected self-report to be accurate. Second, this study was conducted in a single public hospital ED serving a patient population with high levels of social needs. However, multiple other studies conducted in geographically diverse EDs have found that ED patients have a high prevalence of food insecurity.[12] Even if prevalence of food insecurity and other participant characteristics in our study differed from those of patients at other EDs, we do not expect the relationship between food insecurity and frequent ED use would be unique to the ED patients we studied.

Finally, we cannot suggest causality for relationships observed in this cross-sectional study. Although we controlled for multiple potential confounders, including other measures

Table 3. Association of emergency department (ED) patient food insecurity with frequent ED use.

	Unadjusted Model OR (95% CI)	Adjusted Model[a] OR (95% CI)	Mediation Model[b] OR (95% CI)
Any food insecurity[c]	2.03 (1.69–2.44)	1.48 (1.20–1.83)	1.36 (1.09–1.70)[e]
Food insufficiency[d]	2.21 (1.82–2.67)	1.45 (1.16–1.83)	1.29 (1.02–1.64)[e]

[a] Adjusted models include: gender, race and ethnicity, age category, insurance status, homelessness in past 12 months, difficulty meeting essential expenses in past 12 months, unhealthy alcohol use, and moderate or greater drug use problems.
[b] Mediation models additionally adjust for anxiety/depression (positive GAD-2 or PHQ-2) and self-rated overall health. Independent effect estimates for the association between the mediators and outcomes in the mediation models were all positive and statistically significant (not shown).
[c] Any food insecurity defined as affirmative response (often true or sometimes true coded as affirmative) to ≥1 of the 4 US Department of Agriculture (USDA) food insecurity questions asked (over the past 12 months).
[d] Food insufficiency defined as a "yes" response to USDA question of whether participant had eaten less than they felt they should because there was not enough money for food in the past 12 months.
[e] Parameter estimates for any food insecurity and food insufficiency reduced in mediation models by 21.2% and 31.5%, respectively.
OR, odds ratio; *CI,* confidence interval.

of socioeconomic status, there is a possibility of unmeasured confounders. Additionally, although we postulate one hypothetical causal pathway in our mediation analyses, the data remain cross-sectional; we were unable to prove causal associations, and mental health and health status could potentially be confounders as well as mediators. Additional longitudinal and qualitative research could further elucidate the relationship of food insecurity and frequent ED use. We also suggest implementing and studying programs to assist ED patients with food insecurity.

CONCLUSION

We found a high prevalence of food insecurity among ED patients in our study population. Food insecurity was significantly associated with frequent ED use. Efforts to improve care of patients who frequently visit the ED should assess and address social needs including food insecurity; even apart from any potential effects on reducing future ED use, having adequate food is a critical human need that such efforts could be well-positioned to help address. More generally, EDs have long been described as "social welfare institutions,"[49] and there has been a recent resurgence of interest within emergency medicine in patient social needs.[50] This study adds to the body of evidence supporting the potentially important role of EDs in assisting patients with food insecurity.

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The Role of Gender in Nurse-Resident Interactions: A Mixed-methods Study

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Introduction: The role of gender in interprofessional interactions is poorly understood. This mixed-methods study explored perceptions of gender bias in interactions between emergency medicine (EM) residents and nurses.

Methods: We analyzed qualitative interviews and focus groups with residents and nurses from two hospitals for dominant themes. An electronic survey, developed through an inductive-deductive approach informed by qualitative data, was administered to EM residents and nurses. Quantitative analyses included descriptive statistics and between-group comparisons.

Results: Six nurses and 14 residents participated in interviews and focus groups. Key qualitative themes included gender differences in interprofessional communication, specific examples of, and responses to, gender bias. Female nurses perceived female residents as more approachable and collaborative than male residents, while female residents perceived nurses' questions as doubting their clinical judgment. A total of 134 individuals (32%) completed the survey. Females more frequently perceived interprofessional gender bias (mean 30.9; 95% confidence interval {CI}, 25.6, 36.2; vs 17.6 [95% CI, 10.3, 24.9). Residents reported witnessing interprofessional gender bias more frequently than nurses (58.7 (95% CI, 48.6, 68.7 vs 23.9 (95% CI, 19.4, 28.4). Residents reported that gender bias affected job satisfaction (P = 0.002), patient care (P = 0.001), wellness (P = 0.003), burnout (P = 0.002), and self-doubt (P = 0.017) more frequently than nurses.

Conclusion: Perceived interprofessional gender bias negatively impacts personal wellbeing and workplace satisfaction, particularly among female residents. Key institutional stakeholders including residency, nursing, and hospital leadership should invest the resources necessary to develop and integrate evidence-based strategies to improve interprofessional relationships that will ultimately enhance residency training, work climate, and patient care. [West J Emerg Med. 2021;22(4)919-930.]

BACKGROUND

The importance of teamwork and interprofessional collaborative practice in clinical care cannot be overstated. Evidence suggests that gender has effects on the culture, practice, and organization of medicine for both nurses and physicians at all levels of training; these effects intersect with

perceptions of power dynamics, professional hierarchies, and spheres of practice.[1-4] The quality of nurse-physician interactions affects provider wellness in the workplace.[5] Studies demonstrate that physicians' and nurses' perspectives differ with regard to both the quality of their interactions and the degree of interprofessional collaboration and respect.[4-8] Further-more, evidence suggests that among medical students and resident physicians the perceived importance of collaborative interprofessional care may decrease over time.[9] Interactions between female resident physicians and female nurses may be particularly challenging, as the intersection of gender and professional identities can lead to dysfunctional communication patterns.[10]

Effective communication and collaborative decision-making between nurses and physicians contributes to high-quality care, while poor team dynamics, disrespect, and miscommunication adversely affect patient safety[8,11-16] and length of stay.[17] Patient care "mishaps" may result from communication failures between nurses and residents.[18] Developing strong interprofessional relationships may be particularly challenging for students[2] and resident physicians,[10] as they are by nature of their roles only transient members of clinical teams. While a clinician's years of experience play a role in establishing positive interprofessional relationships,[12] less is known regarding the role of gender, particularly for interprofessional relationships.

Gender disparities persist within the medical field for both nurses and physicians, with studies documenting continued salary disparities for both professions.[19-21] There is also evidence of significant differences in faculty evaluation of female and male trainees with respect to milestone achievements during residency,[22,23] which may be attributable to unconscious gender bias. Similarly, female gender is associated with more negative nursing evaluations of resident physicians;[24,25] however, limited data exist to explain factors that contribute to this disparity.[26] Research on the intersection of gender on resident/nursing interactions and leadership styles during resuscitations reveals that female residents express higher stress levels and discomfort when exhibiting directive leadership styles, despite this often being perceived as the most effective style; furthermore, female residents report needing to negotiate interactions, "gain trust," or choose less assertive behaviors during interprofessional interactions than their male counterparts.[10,27-29]

However, the impact of gender bias on interprofessional relationships is not as well studied,[10,30,31] in particular the extent to which gender bias occurs in interactions between resident physicians and nurses. During residency, physicians develop behavioral practice patterns that may last throughout their careers. The aim of this study was to explore and understand perceptions and experiences of gender bias in the context of interprofessional relationships between emergency medicine (EM) residents and nurses. This study builds on emerging literature exploring the ways in which gender shapes interactions between nurses and physicians during residency training.[10] Our findings can inform strategies for improved interprofessional collaborative practice during residency training.

Population Health Research Capsule

What do we already know about this issue?
Gender disparities persist in emergency medicine (EM). Gender shapes the culture, practice, and organization of medicine for both nurses and physicians.

What was the research question?
How does gender affect interprofessional interactions between EM resident physicians and nurses?

What was the major finding of the study?
Perceived interprofessional gender bias negatively impacts personal wellbeing and workplace satisfaction, particularly among female residents.

How does this improve population health?
Understanding how gender and gender bias affect interprofessional dynamics in EM creates opportunities to improve teamwork and patient care.

Study Objective

Our goal was to explore the effects of gender on interprofessional interactions between EM resident physicians and nurses.

METHODS

This sequential mixed-methods study gathered qualitative data, which informed the development of a quantitative survey. The study was conducted at two urban, academic, Level I trauma centers with annual ED censuses of approximately 63,000 and 115,000. Spanning these two EDs is a single, four-year EM residency program that matches 15 residents per year.

Phase I: Qualitative Study

We recruited EM nurses and resident physicians to participate in qualitative interviews and focus groups. We limited recruitment of resident physicians to second-, third-, and fourth-year residents given their longitudinal experiences with nursing colleagues. Similarly, nurses recruited for

participation in the qualitative portion of this study were limited to those with more than two years of institutional experience. The research team's resident members [EC, AC] contacted eligible participants from a roster of 42 residents, while the research team's nurse members [JV, LN] contacted a convenience sample of 31 nurses from both institutions who were eligible and who had indicated in informal conversations that they would be willing to participate. After an individual expressed their willingness to participate, scheduling was taken over by the team's social scientist [NZ], who conducted interviews and focus groups.

Semi-structured interviews were piloted with three individuals (one female nurse and two residents, one male and one female) to refine interview and focus group guides. Subsequently, focus groups were conducted with residents, separated by gender. Due to scheduling challenges, five nurses from two different institutions opted to participate in individual interviews rather than as part of a focus group. Between June–October 2019 interviews and focus groups were conducted by a trained interviewer [NZ] with no professional role in the residency or either ED. Questions focused on providers' perceptions and experiences of how gender affects interprofessional interactions (Appendix 1). Interviews ranged from 20-40 minutes; focus groups lasted 90 minutes. Interviews and focus groups were recorded with consent of participants and transcribed verbatim using a transcription service (TranscribeMe, Inc., Oakland, CA).

We analyzed using inductive and thematic content analysis,[32] allowing dominant themes to emerge. Free-text responses from the electronic survey (see below) were also coded and included in qualitative analysis. The research team developed a codebook from successive rounds of reviewing transcripts. Each transcript was coded for themes independently by two of four authors [EC, LN, JV, NZ] using a web-based, qualitative data analysis tool (Saturate, Jonathan Sillito, Brigham Young University, Provo, UT). An experienced qualitative researcher [AC] led resolution of coding discrepancies with research team input.

Reflexivity

Reflexivity in qualitative research refers to researchers' consideration of how their sociocultural values and experiences influence study design and analysis. Qualitative data was collected by a social scientist [NZ] who does not have clinical EM experience. Analysts were all female, and included senior EM nurses [LN, JV], emergency physicians [AC, EC; both senior residents], and social scientists [AC, NZ]. Coding pairs were intentionally grouped across professions (nurse/MD, MD/social scientist or nurse/social scientist). Results were additionally presented to healthcare providers at three local and national conferences for feedback on interpretation of the major themes identified. To protect participant identity, transcripts are not publicly available. The study codebook is available in Appendix 2.

Phase II: Quantitative Study

An anonymous electronic survey, developed through an inductive-deductive approach informed by the interviews and focus groups, was administered via Research Electronic Data Capture (REDCap, Vanderbilt University, Nashville, TN) and distributed via institutional email to all EM residents (60 individuals) and EM nurses at both hospitals (159 at one facility and 203 at the other), regardless of experience level. Up to two reminders of the invitation to participate were sent over the course of one week. Respondents were asked about the perceived frequency with which gender affects both their personal and witnessed interactions with colleagues across professions. Participants were also asked about how interprofessional gender bias affects the workplace with regard to job satisfaction, patient care, personal wellness, burnout, self-doubt, and patient safety. We collected basic demographic and professional experience data. Complete survey questions are available (Appendix 3).

For the purpose of exploring the impact of seniority on perceptions of gender bias, postgraduate year (PGY)-1 and -2 residents are considered "junior," while PGY-3 and -4 residents are considered "senior." Nurses with >4 years of experience were considered "senior," while those with fewer years of experience were considered "junior." We analyzed data in Stata 15.0 (StataCorp, LLC, College Station, TX), and included descriptive statistics and between-group comparisons using Student's t-tests for continuous data and two-sample Wilcoxon rank-sum test for ordinal data.

Ethics

This study was reviewed by the local institutional review board and determined to be exempt from further review (Protocol #2019P000147). Funding to support this research was provided by the Massachusetts chapter of the American College of Emergency Physicians 2018 Resident Research Grant. We report qualitative findings following the Standards for Reporting Qualitative Research guidelines.[33]

RESULTS

This study included 20 participants in the first, qualitative phase, and 134 respondents to the quantitative survey. The findings from each phase are described below, and in Tables 1-5.

Qualitative Data

A total of 20 individuals participated in the qualitative portions of this study (see Table 1). Individual interviews were conducted with eight participants: six nurses (three female and three male, two from one institution and four from the other), and two residents (one female and one male). Focus groups were gender-specific with seven male residents in one group and five female residents in the other. Four themes emerged from qualitative data: communication in interprofessional relationships; specific examples of

Table 1. Demographics of participants by profession.

	Total	Nurses	Residents
Qualitative study			
Total participants	20	6	14
Interviews	8	6 (3F, 3M)	2 (1 M, 1 F)
Focus groups	12	0	12 (5F, 7M)
Survey respondents			
	N (%)	N (%)	N (%)
Complete responses	134 (32.0)	104 (28.7)	30 (52.6)
Gender			
Female	99 (73.9)	88 (84.6)[+]	11 (36.7)[++]
Male	31 (23.1)	12 (11.5)	19 (63.3)
Prefer not to say	4 (3)	4 (3.85)	0 (0)
	Mean (SD)	Mean (SD)	Mean (SD)
Age	36.7 (±10.15)	38.8 (±10.6)	29.4 (±2.2)
Tenure	N (%)	N (%)	N (%)
PGY1/<1 year	11 (8.2)	2 (1.9)	9 (30)
PGY2/1-2 years	23 (17.2)	13 (12.5)	10 (33.3)
PGY3/2-3 years	22 (16.4)	15 (14.4)	7 (23.3)
PGY4/3-4 years	10 (7.5)	6 (5.8)	4 (13.3)
>4 years	68 (50.8)	68 (65.4)	n/a
Race			
White	108 (80.6)	88 (84.6)	20 (66.7)
Black	7 (5.2)	6 (5.8)	1 (3.3)
Asian	6 (4.5)	0	6 (20.0)
American Indian	2 (1.5)	0	2 (6.7)
Other/prefer no reply	11 (8.2)	10 (9.6)	1 (3.3)
Hispanic	4 (3)	1 (1.0)	3 (10)

[+]Approximately 80% of emergency medicine (EM) nurses in the study population identify as female; exact numbers were not available as this was beyond the scope of IRB-approved data collection.
[++]At the time of this study, 23 of 60 EM residents identified as female (gathered through personal correspondence with ECM and AC), yielding a 47.8% response rate among female EM residents.
M, male; *F*, female; % respondents indicates response rate within professional group; *SD*, standard deviation; *PGY*, post-graduate year.

gender bias toward nurses; specific examples of gender bias toward residents; and responses to interprofessional gender bias. Representative quotes from each of these themes are listed in Table 2.

I. Communication

The theme of how gender shapes communication in interprofessional relationships emerged from data collected from both residents and nurses, particularly among females of each group. Examples of how gender shapes interprofessional communication significantly differed between nurses and residents. Female residents perceived questions from nurses about patient care as a threat to their decision-making and expertise. Female nurses identified feeling that female residents are more approachable about patient care questions and are more collaborative in their language and behavior than male residents.

II. Examples of Gender Bias toward Nurses

Nurses offered two major examples of witnessed or experienced interprofessional gender bias. They described male residents dismissing female nurses' perspectives about patient care and emphasized that this occurs much more frequently than with female residents. Dismissive behaviors included residents not being willing to engage in conversation about nurses' concerns about orders, lab values, or plans of care. The second example centered on the perception that male nurses receive more respect than female nurses. Both female and male nurses perceived that resident physicians,

Table 2. Representative quotes.

Theme	Quote
I. Gendered communication in interprofessional relationships	
Differential communication strategies enacted by female residents	"I think the one thing that I have become particularly cognizant of is that the female residents almost always, when they place orders, will then go and talk to the nurse and tell them what orders they've placed, which I assume is a strategy they've developed to just actually enact the plans they want to happen." - Male resident [Interview 1]
	And I went into the room, I saw that the patient was unstable, and I said-- or could be unstable. And I said, "Hey, do you think we should--" and it's never a, "Do this," it's always like, "We should--" or "Can we--" The way we phrase things is also very different. I imagine it probably varies between men and women. But I think, again, going back to that-- you have to kind of do a shared decision making. I'm never commanding anybody to do anything, so it's like, "Do you think we should get more IV access on this patient?" and she was just like, "No. This patient is totally stable, doesn't need it. I'm not doing it." - Female resident [Focus Group 1, speaker 4]
Female and male nurse interactions with female residents vs male residents	"Well, when I'll question a dosing of a medication and asking for an explanation and if feels like-- I don't want to put words in someone else's mouth but I think sometimes the male doctor has maybe kind of sometimes brushed me off and sometimes explained but maybe not in a thorough way that I would like. Whereas I feel like some of the female residents have been more open to explaining the situation and their rationale and they go into more in depth and stuff than maybe some of the male doctors have and stuff. Where they have been more dismissive at times and stuff about why they're doing things and stuff." - Male nurse [Interview 4]
	"And for the most part, there's always going to be somebody -- there's always new and up-and-coming residents that will turn to the nurse and say, "What do you think?" And there have been. And in that case, I will say I've had more female residents ask me that than the male docs. I mean, there's one here and there. Don't get me wrong. But more of the female residents will say, "What do you think?" - Female nurse [Interview 5]
II. Examples of gender bias toward nurses	
Dismissal of female nurse's concerns about patient care	"I've been called sweetie, hon, etc., more times than I can count. Been referred to as 'just a nurse,' and my input regarding patient care, decision-making or patient's condition has been dismissed." -Female nurse [Survey, open response, respondent 70]
	"I think sometimes the male doctor has maybe kind of brushed me off, and sometimes explained but maybe not in a thorough way that I would like. Whereas I feel like some of the female residents have been more open to explaining the situation and their rationale, and they go into more in depth and stuff than maybe some of the male doctors have." -Male nurse [Interview 4]
	"So let's say they put in an order and you disagree with it…Guy doctor will get all offended, not change it. You have to go above him usually and go to an attending in order to advocate for your patient, while a female resident will be like, 'You know what? Thank you. I'm new to this. Let me look into what it was. I'll double-check with my attending to make sure,' and all that, instead of immediately being, 'No. I'm right.'" -Male nurse [Interview 6]
	"As a female RN, I sometimes feel like some male physicians will not make eye contact with me when I am asking for a med request or patient questions, rather than females, who usually do look me in the eye. I do understand that we are all busy and focused on documenting and charting, but I feel disrespected when that eye contact is inconsistent." -Female nurse [Survey, open response, respondent 145]
Preferential treatment for male nurses	"I would say that [male nurses] get taken more seriously [than female nurses] and that they're not questioned as much about things that they say or feel." -Female nurse [Interview 3]
	"As a male nurse, I feel that I am more frequently listened to by male physicians." -Male nurse [Survey, open response, respondent 106]

Table 2. Continued.

Theme	Quote
III. Examples of gender bias toward residents	
Disproportionate pushback against female residents	"I think their orders are frequently questioned and their care plans are frequently questioned in a way that male residents are not." -Male resident [Interview 1]
	"I think the interactions between the female and male residents and the nurses is different in the sense that you [as a female resident] get, I think, more pushback from nurses with orders, more questioning your judgment, more hesitancy in carrying out orders and doing tasks." -Female resident [Focus Group 1, speaker 2]
	"I think I've probably seen more of the female nurses being more aggressive towards some of the female residents than male residents, I think in general. I think I've seen them be more critical of their same gender, so." Male nurse [Interview 4]
	"I think that I commonly get more preferential treatment from nurses because I'm male. I think that especially within—a great example is when nurses will say that they have more confidence in your decision-making than they do in one of your female colleague's decision-making." -Male resident [Focus Group 2, speaker 2]
Building relationships with female nurses	"I can think of one specific example where the [male resident] got a little love note from a nurse basically saying, 'Oh thank you for saving this patient's life,' with a little heart on the bottom…I just can't imagine that happening with one of the women residents." -Male resident, [Focus Group 2, speaker 4]
	"I certainly feel like male colleagues get a differential relationship and experience with the nurses—on attention to orders, attention to personal relationships, in a lot of ways, of trying to be much friendlier or more than friendly with male residents in a way that they're less open to with female residents. And I don't think that that's always true across the board, but I see it more than I do with female residents." -Female resident [Focus Group 1, speaker 5]
	"…[Male residents] can be friends [with nurses], but in moments of leadership, they can still be looked at as leaders. Whereas, I think a lot of times, the nurses don't necessarily see the women as leaders; they'll see them as peers." -Female resident [Focus Group 1, speaker 4]
IV. Responses to gender bias	
Speaking with administration on issues of gender bias	"I've also brought this issue up to one of our administrative people, who's higher up, here at the Brigham, and he was aware of the issue. And one of the feedback that I got was that I should be delegating more tasks to the nurses because he saw me bringing a CD to radiology and instead of doing that, I should be giving it to the nurse so that I can be at the bedside taking care of the patient. And when I try to explain, "As a female, it's really hard to do," and I don't know if our male colleagues feel the same way, but-- actually, it's funny." - Female resident [Focus Group 1, speaker 3]
Perceptions of the effectiveness of safety reports	"I don't know, although I don't know what happens to any of the safety reports that we do on anything. I think that, from my perspective as a resident, they seem fairly ineffectual. And I'm sure that's not actually true. I'm sure there is some work that gets done on them. But I feel like for all the safety reports that people have been involved in, I've never actually noticed anything change in any way." - Male resident [Interview 1]
Female nurse experiences with having gender bias addressed	"I think that if I said that I felt like he wasn't taking me seriously because I was a girl, it probably would have been pushed under the rug, and that it would be taken more seriously if it was more advocating on the behalf of a patient. S1: 13:42 Do you know why that's the case? S2: 13:43 I just don't think they take it serious. I don't think that it's management's prerogative to take that seriously." - Female nurse [Interview 3]
Male nurses experiences of speaking about gender bias with female colleagues	"I've chatted with a few of them [female nurse colleagues], just about how disappointed they are, and not only just the few numbers of females nurses of color on our department, but just how little sway they have in the department in general." - Male nurse [Interview 6]

irrespective of the physician's gender, take male nurses' input about patient care more seriously.

III. Examples of Gender Bias toward Residents

When residents were asked for specific examples of witnessed or experienced gender bias toward residents, two major examples were described. First, female and male residents alike perceived that female residents receive more "pushback" from nurses of both genders. This included nurses questioning residents about orders and plans, disregarding residents' plans, or not supporting residents in performing procedures. While residents held these perceptions regarding patient care in general, some reported the dynamics as more obvious and upsetting to female residents when they occurred during trauma and critical care resuscitations. Secondly, both female and male residents perceived that male residents have greater ease establishing friendly and collegial relationships with female nurses. With the exception of a few female nurses with whom male residents had difficult interactions, male and female residents perceived female nurses to be more friendly with male residents and interested in socializing with them outside the hospital. Female residents felt that they had to work harder and be more deferential toward female nurses to build relationships with them over time.

Participants from both professions recognized that gender alone did not account for their or others' experiences of being dismissed or questioned. Rather, residents reported that gender had a lesser impact on interprofessional interactions as they progressed through training and gained more institutional experience.

IV. Responses to Gender Bias

Several suggestions emerged within the theme of responses to interprofessional gender bias. Both residents and nurses identified filing "safety reports," the institutional standard for addressing quality concerns, as a potential course of action. However, residents identified their lack of anonymity as a major deterrent to pursuing this option. Nurses identified filing a complaint with the human resources department as an alternative. However, no respondents reported having taken these steps. Both nurses and residents gave examples of discussing biased interactions with their same-profession colleagues, including the emotional impact of these problematic experiences.

Quantitative Survey

In total, 134 individuals (32% response rate) completed the survey, including 104 nurses (28.7% response rate) and 30 residents (52.6% response rate) (Table 1). Participating nurses were 84.6% female, while 36.7% of resident respondents were female. The gender balance of respondents roughly reflected that of each of these groups (approximately 80% female nurses at each institution; 38.5% of residents identified as female, yielding a 47.8% response rate among female EM residents). None of the respondents identified as non-binary. Among nurses, four individuals preferred not to indicate their gender, and their data were omitted from between-gender comparisons. The mean age of nurse respondents was significantly older than residents (36.7 vs 29.4 years, P <0.001). Most (80.6%) respondents self-identified as White, although the resident cohort had greater racial diversity (Table 1).

Perceptions of Gender Bias in Interprofessional Interactions

Perceptions of the frequency with which respondents both *experienced* and *witnessed* interprofessional gender bias were evaluated on a 100-point scale, labeled from "never" (0) to "always" (100) (Table 3). Among all respondents, females more frequently reported *experiencing* interprofessional gender bias than males (mean frequency 30.9, 95% confidence

Table 3. Perceptions of gender bias in interprofessional interactions.

	All	Nurses	Residents
	Mean* (95% CI)	Mean (95% CI)	Mean (95% CI)
Frequency of experiencing interprofessional gender bias			
All	29.6 (25.4, 33.8)	24.8 (20.3, 29.4)	38.8 (27.4, 50.1)
Female	30.9 (25.6, 36.2)	26.4 (21.3, 31.4)	66.9 (53.8, 80.0)
Male	17.6 (10.3, 24.9)	9.9 (2.5, 17.3)	22.5 (11.6, 33.4)
Frequency of witnessing interprofessional gender bias			
All	31.7 (26.9, 36.5)	23.9 (19.4, 28.4)	58.7 (48.6, 68.7)
Female	29 (23.5, 34.5)	23.4 (18.6, 28.3)	73.5 (57.3, 89.8)
Male	37.5 (27.1, 48.0)	17.8 (3.6, 31.9)	50.1 (38.0, 62.1)

*Values are a numeric representation of frequency on a 100-point scale, with 0 reflecting never and 100 reflecting always.
CI, confidence interval.

interval [CI], 25.6, 36.2 vs 17.6, 95% CI, 10.3, 24.9). This difference was noted both among female nurses (mean frequency 26.4, 95% CI 21.3, 31.4) vs 9.9 (95% CI, 2.5, 17.3] among male nurses, as well as among female residents (mean frequency 66.9 (95% CI 53.8, 80.0]) vs 22.5 (95% CI, 11.6, 33.4) for male residents. Female residents more frequently experienced interprofessional gender bias than their female nursing colleagues (mean frequency 66.9 [95% CI 53.8, 80.0] for female residents vs 26.4 [95% CI, 21.3, 31.4] for female nurses), but no significant difference was noted between male nurses and male residents.

Overall, significant between-profession differences emerged in the reported frequency of *witnessing* interprofessional gender bias. Resident physicians reported witnessing this bias more frequently than nurses [mean 58.7 (95% CI, 48.6, 68.7) among residents vs 23.9 (95% CI, 19.4, 28.4) among nurses [see Table 3]). This held true across both genders, such that female residents reported witnessing interprofessional gender bias more frequently than female nurses (mean 73.5 [95% CI, 57.3, 89.8] vs 23.4 [95% CI, 18.6, 28.3]), and male residents more frequently reported this than male nurses (50.1 [95% CI, 38.0, 62.1] vs 17.8 [95% CI, 3.6, 31.9]).

Perceived Manifestations of Interprofessional Gender Bias

Several questions explored the perceived manifestations of interprofessional gender bias that emerged from qualitative data, including the following: having a concern raised about oneself to a superior; having an order ignored; being given less trust; having one's role confused by a cross-professional colleague; and being called a term of endearment by a cross-professional colleague. With the exception of having orders ignored, resident physicians reported experiencing each of these manifestations of gender bias significantly more frequently than their nursing colleagues (Table 4). No significant differences were identified between female and male nurses; however, female residents experienced each of these significantly more frequently than their male resident colleagues.

Impact of Gender Bias in Interprofessional Interactions

Respondents were asked about the frequency with which interprofessional gender bias affected several aspects of their work experience and patient care. Residents, when compared with nurses, more frequently felt gender bias negatively affected job satisfaction ($P = 0.002$), patient care ($P = 0.001$), personal wellness ($P = 0.003$), burnout ($P = 0.002$), and self-doubt ($P = 0.017$). Female residents felt gender bias affected these areas more frequently than their male colleagues, and more frequently than female nurses (Table 5). No significant between-gender differences were found among nurses on these factors, nor between male nurses and male residents.

Seniority did not modify any of the aforementioned relationships. The perceived negative impact of gender bias on job satisfaction increased with seniority among female residents ($P = 0.01$), but seniority was not otherwise associated with significant differences in the perceived impact of interprofessional gender bias.

DISCUSSION

Gender shapes the professional experiences of healthcare providers, including medical students,[2] resident physicians,[10,28] and nurses.[20,21] The extent to which gender bias shapes interprofessional interactions between residents and nurses remains incompletely described, although existing literature suggests that female gender identity may complicate interprofessional interactions.[10] Power and privilege are created and justified through multiple social identities: Gender operates not alone but in conjunction with sexuality, race, ability, and other social identities to advantage some and disempower others.[34] By design, this study focused specifically on the ways in which gender affects interprofessional interactions between resident physicians and nurses in the emergency department (ED).

Our study is situated in an understanding of gender through gender socialization theory,[35] which posits that humans learn femininity and masculinity through social interactions, primarily with their families, peers, and groups.

Table 4. Perceived manifestations of gender bias in interprofessional interactions.

	Between-profession comparison						Between-gender comparison			
	Nurses vs residents		Female nurse vs female resident		Male nurse vs male resident		Female vs male nurses		Female vs male residents	
	Z*	P	Z*	P	Z*	P	Z*	P	Z*	P
Called term of endearment	-5.84	<0.01	-5.08	<0.01	-2.765	0.01	-0.144	0.88	2.054	0.04
Role confused	-3.15	<0.01	-3.74	<0.01	-0.888	0.38	-0.281	0.78	2.304	0.02
Given less trust	-2.988	<0.01	-5.172	<0.01	-0.544	0.59	0.442	0.66	4.279	<0.01
Order ignored	0.21	0.83	-2.219	0.03	0.968	0.33	0.494	0.62	2.902	<0.01
Concern raised to attending	-6.887	<0.01	-6.163	<0.01	-2.6	0.01	-0.948	0.34	2.517	0.01

*Two-sample Wilcoxon rank-sum tests for between-group comparisons

Table 5. Perceived impact of gender bias in interprofessional interactions.

	Between-profession comparison						Between-gender comparison			
	Nurses vs residents		Female nurse vs female resident		Male nurse vs male resident		Female vs male nurses		Female vs male residents	
	Z*	P	Z*	P	Z*	P	Z*	P	Z*	P
Job satisfaction	-3.04	0.002	-4.39	<0.001	-1.15	0.250	0.85	0.400	3.50	<0.001
Patient care	-3.26	0.001	-3.98	<0.001	-1.83	0.068	1.39	0.166	2.40	0.016
Wellness	-2.96	0.003	-4.24	<0.001	-1.25	0.210	1.21	0.225	3.31	0.001
Burnout	-3.07	0.002	-4.41	<0.001	-1.08	0.280	0.71	0.478	3.17	0.002
Self-doubt	-2.39	0.017	-3.93	<0.001	-1.60	0.111	1.84	0.065	3.21	0.001
Patient safety	0.78	0.437	-0.95	0.344	-0.35	0.730	0.08	0.940	0.52	0.601

*Two-sample Wilcoxon rank-sum tests for between-group comparisons, all P-values two-tailed.

We become socialized into traditionally binary gender roles and identities, which create differential societal expectations for males' and females' behaviors. These expectations of gender roles permeate all environments, from the household to the workplace. In medicine, for example, women are expected to display caregiving and communicative capacities, while men are expected to display leadership and decision-making capacities, stemming from traditional gender roles within the household and society at large. Particularly early in residency, informal learning occurs in interprofessional relationships.[3] This learning may shape long-standing behaviors and can affect professional identity development. As women now make up almost half of resident physicians across specialties,[36] it is more important than ever to understand the ways that gender and gender bias affect interprofessional relationships.

This study reveals that both nurses and residents view gender as an important factor influencing interprofessional interactions; however, the perceived manifestations and impact of gender differed sharply between the two professional groups. This was most notable in qualitative data revealing how gender shapes communications between EM nurses and residents. While EM nurses expressed frustration with male residents, who were viewed as more dismissive and less collaborative when approached with a patient care question, female residents felt that frequent questioning of their clinical plans by nursing colleagues, and particularly from female nurses, reflected a lack of trust of female physicians. These starkly different perceptions of the same interactions build on prior literature demonstrating that physicians and nurses have disparate experiences of their interprofessional interactions with regards to communication and collaboration.[4-8,10,12] While the intent behind nursing-initiated communication with residents is to improve patient care, this study revealed that for female residents in particular such interactions may increase self-doubt and insecurity. Understanding these differing perspectives highlights the need for further collaborative and longitudinal discussions between the two groups, particularly among females early in residency training, in order to bridge this gap and find ways to both mitigate problematic interactions and clarify the intent and goals of such conversations.[26]

Examples of gender bias shared by both residents and nurses reveal persistent and stark differences in how male and female health professionals experience the workplace. While males were more willing to attribute negative interprofessional interactions to personality differences, females more often identified gender as a defining factor in shaping these relationships. These findings were further underscored in the survey findings, as females of both professions reported experiencing interprofessional gender bias more frequently than their male counterparts (among female vs male nurses, mean frequency 26.4 [95% CI, 21.3, 31.4] vs 9.9 [95% CI, 2.5, 17.3] and among female vs male residents, 66.9 [95% CI, 53.8, 80.0] vs 22.5 [95% CI, 11.6, 33.4)]). Female residents reported both experiencing and witnessing interprofessional gender bias to a much greater degree. Female residents more frequently reported perceiving the various manifestations of gender bias in their cross-professional interactions (Table 4), and similarly were far more likely to report that this adversely affected their experiences in the workplace (Table 5).

The perceived negative impact of interprofessional gender bias on female residents in the ED may in part result from female residents taking on stereotypically gender-discordant professional roles,[26,37-39] through which they are expected or encouraged to take on more typically male characteristics. The persistent and pervasive negative effects of gender bias in interprofessional interactions may have implications for patient care and patient safety. Effective communication across professional lines is a key component in the delivery of high-quality care; there is ample evidence that disrespect and poor team dynamics can harm patients.[8,11-16]

Across both professions, participants in the qualitative study expressed a sense of limited agency in addressing instances of perceived gender bias, which translated into a sense of apathy, frustration, or both. Both residents and nurses felt that additional years of experience may mitigate challenges in interprofessional interactions. Although the study was not primarily designed to explore the interaction

between seniority and the various manifestations of interprofessional gender bias explored in this study, in quantitative analysis no such correlation emerged. Further investigation into the relationship between years of professional experience and the ways in which gender shapes interprofessional interactions may prove fruitful.

Educators and leaders within medicine may find it useful to look to the business world for examples of how gender shapes workplace interactions. Much has been written about gender and leadership in business, including the ways in which stereotypically female leadership styles, which in some sectors may be more democratic and participatory, rely more on communication and relationship building.[40,41] Men may benefit from adopting some of these collaborative styles in business,[42] and this may be true for clinicians of both genders in medicine. Relational coordination, a "mutually reinforcing process of communicating and relating for the purposes of task integration" described by Gittell et al, has proven effective in healthcare settings both for improving quality of care and job satisfaction among clinicians.[43] Fostering strong interprofessional relationships between early-career physicians and nurses, particularly between females, may increase job satisfaction and mitigate perceptions of gender bias.

During residency, physicians not only learn medical knowledge and procedural skills, but also develop leadership styles and other patterns of behavior that can persist throughout their careers. Strong inter-professional relationships are integral to providing excellent patient care.[11-15,17,18] Fostering collaborative interprofessional communication and strong nurse-physician relationships while in residency may result in attending physicians who promote and model more collaborative behaviors throughout their careers. Support from nursing leadership in EDs to foster positive, gender-informed interactions between EM nurses and the residents who work alongside them is equally important to fostering a collegial and respectful work environment for all healthcare providers. Educators and administrators – physicians and nurses alike – must consider and endeavor to understand the ways in which gender affects these interactions.[38]

Several strategies for improving interprofessional communication between residents and nurses have been explored by others, including structured "huddles,"[44] simulation exercises,[45] and collaborative "time-outs" prior to patient discharge,[46] with variable efficacy. Further work is needed to understand, develop, and implement strategies for mitigating the negative impact of gender bias in interprofessional interactions; study participants suggested several possible interventions, which may warrant additional exploration through future research. Most of our study participants perceived gender bias in the clinical environment but demonstrated a reluctance to report this bias. Effective and safe mechanisms to report incidents and to ensure accountability and follow up of these occurrences should be explored.

In this study we identified a variety of suggestions for improving other aspects of interprofessional interactions. One interesting recommendation for improving cross-professional female allyship was to establish mentoring pairs between a female nurse and incoming female resident during intern orientation. Other means of increasing awareness could include workshops, video learning, and simulation exercises. At a local level, the findings from this study have led to the formation of a working group at one of our institutions, through which nurses and residents are exploring strategies for improving communication and assuring mutually respectful interactions. Further study of the effect of gender bias in interprofessional interactions between resident physicians and nursing colleagues should include the ways in which this occurs across specialties and throughout the career cycle of clinicians.

LIMITATIONS

This study has several limitations. First, it was conducted only at large, urban, training hospitals hosting a single residency training program. Findings may not be transferrable to other training environments. The qualitative data was gathered by a social scientist unaffiliated with either the residency program or the hospitals; however, her gender (female) may have influenced the information shared by participants. Similarly, the qualitative analysis team included only female researchers, which inevitably shaped our interpretation of this data. Nursing perspectives were proportionally less represented in the qualitative portion of this study due to logistical challenges in recruitment. Similarly, response bias may have influenced our findings, particularly for the quantitative portion of this study. While the gender balance of respondents was similar to that of eligible participants in both professions, the opinions of study participants may differ significantly from those who chose not to respond to invitations for either interviews/focus groups or the emailed survey.

Lastly, our study included few participants whose backgrounds are historically and contemporarily under-represented in medicine. The intersection of race and sexuality with gender identity inevitably affected our findings; further study is warranted to understand the ways in which other forms of social identity influence interprofessional relationships.

CONCLUSION

Gender shapes interprofessional interactions between resident physicians and nurses. The perception of gender bias contributes to dissatisfaction in the workplace, the effects of which are felt by both male and female nurses and residents, but disproportionately more by females of both professions. Female residents more frequently report experiencing the negative impacts of gender bias in their interprofessional relationships, raising concerns for their residency training and overall wellbeing. Key institutional stakeholders including residency, nursing, and hospital leadership should invest the

resources necessary to develop and integrate evidence-based strategies to improve interprofessional relationships that will ultimately enhance residency training, work climate, and patient care.

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A Novel, Low-cost, Low-fidelity Pericardiocentesis Teaching Model

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Introduction: Pericardiocentesis is a high-risk/low-frequency procedure important to emergency medicine (EM). However, due to case rarity it is not often performed on a patient during residency training. Because the coronavirus disease 2019 pandemic limited cadaver-based practice, we developed a novel, low-cost, low-fidelity pericardiocentesis model using three dimensional-printing technology to provide advances on prior home-made models.

Methods: Residents watched a 20-minute video about performing a pericardiocentesis and practiced both a blind and ultrasound-guided technique. We assessed model fidelity, convenience, and perceived provider competence via post-workshop questionnaire.

Results: A total of 24/26 (93%) individuals practicing on the ultrasound-guided model and 22/24 (92%) on the blind approach model agreed or strongly agreed that the models reasonably mimicked a pericardial effusion.

Conclusion: Our low-cost, low-fidelity model is durable, mimics the clinical case, and is easy to use. It also addresses known limitations from prior low-fidelity models. [West J Emerg Med. 2021;22(4)931–936.]

INTRODUCTION

Pericardiocentesis is a rare but potentially life-saving procedural intervention for release of pericardial fluid in unstable patients with cardiac tamponade. Historically performed by a subxiphoid approach using anatomical guidance in emergent cases, the procedure has now developed into an often ultrasound-guided (USG) procedure with increased success rate and fewer complications.[1-3] Despite this improvement in management, the high-risk, low-occurrence nature of the procedure means providers can go prolonged periods of their career with minimal or no exposure including during their residency training. Furthermore, with the COVID-19 pandemic, residency programs have needed to find innovative ways to continue providing necessary medical education, as access to large-group, in-person, teaching situations and resources such as cadaver labs have been curtailed.[4]

Commercially developed models for pericardiocentesis are available but are often expensive with prices ranging in the several thousands of dollars.[5,6] Furthermore, the use of high-fidelity models has not been shown to improve competency compared to low-fidelity alternatives, and a lack of true anatomical fidelity in the setting of functional fidelity also does not inhibit competency.[7,8] Due to the need for proper training and the expense of high fidelity, a plethora of low-fidelity and home-made models have been made available.[9-15] These models have also addressed common practical limitations such as using non-resin medium for ultrasonography and replaceable components. However, to the best of our knowledge, there are no low-fidelity models employing non-animal rib models.

To address this, we created an affordable pericardiocentesis model employing a low-cost, three dimensional (3D)-printed anatomical rib model from polylactic acid filament (PLA) that provides tactile feedback and appropriate interference during ultrasonography that can be generated with a personal 3D printer and software. The purpose of this study was to assess the feasibility of this model for training providers in both a blind approach (BA) and USG technique. Assessment of feasibility focuses on evaluating

model fidelity, participant convenience, and participant-perceived competency.

Population Health Research Capsule

What do we already know about this issue?
Pericardiocentesis models can be expensive; currently there are no low-fidelity models employing non-animal rib models.

What was the research question?
Is our model feasible to use, convenient, and does it provide competence in training?

What was the major finding of the study?
Over 90% of residents using the ultrasound and blind approach thought the model mimics a pericardial effusion.

How does this improve population health?
During the COVID-19 pandemic, these models provided an inexpensive workshop for a rare procedure that does not require large groups for learning.

METHODS

Basic Study Design

This was a prospective observational study performed at a single, Level I trauma center emergency medicine (EM) residency program between April–June of 2020. All study participants were EM residents between their first and third years of training. Each resident underwent a 20-minute preparatory session that reviewed both the BA and USG pericardiocentesis approaches using the following two videos: [https://www.youtube.com/watch?v=wKYWhutqzyg and https://www.youtube.com/watch?v=M4vHEr25yFk. Participants also watched a one-minute video on how to perform the procedure on the low-fidelity models. After this review, the participants then performed a BA and USG pericardiocentesis approach on two separate pre-made models. The procedures were performed independently to ensure safe, social distancing techniques during the COVID-19 pandemic. Upon completion, a survey was provided on site for participants to evaluate fidelity, convenience, and perceived competency for both approaches (see Supplemental).[14] This study was determined to be exempt by the institutional review board as an anonymous survey and educational training project.

Model Design

The pericardiocentesis model was constructed using materials found within an emergency department (ED) and personal home environment, along with a personal 3D printer and accompanying software. There are two model designs with interchangeable parts (Figure 1). Components include a

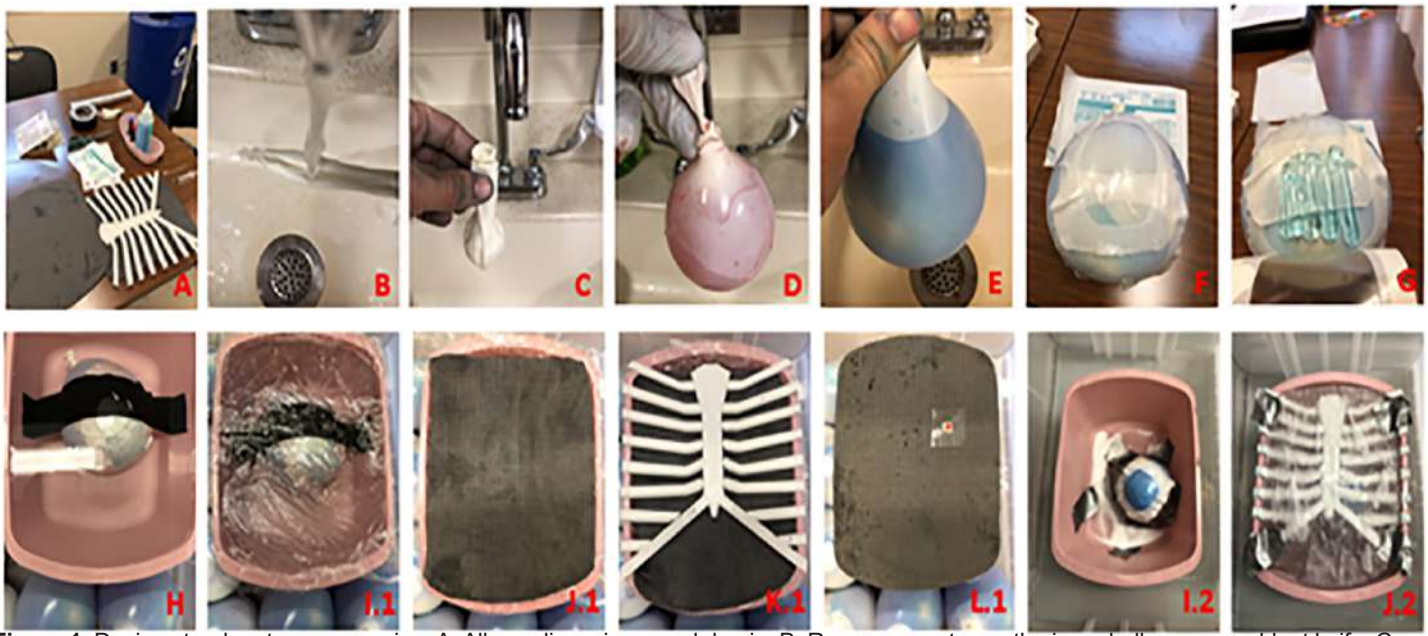

Figure 1. Design step-by-step progression: A. All supplies minus wash basin. B. Run warm water on the inner balloon over a blunt knife. C. Pass balloon inside outer balloon using knife. D. Place a drop of red food coloring and fill the inner balloon. E. Place a drop of blue food coloring and fill the outer balloon. F. Place a layer of Tegaderm on the outer balloon. G. Add a layer of ultrasound gel between layers of Tegaderm. H. Tape balloon to bottom of dry water basin. I.1. Place a layer of plastic wrap. J.1. Place the first layer of ¼" yoga mat. K.1. Clip on anterior chest variant 1 to water basin. L.1. Place the second layer of ¼" yoga mat and add the left shoulder indicator to the mat. I.2. Add polyethylene glycol (or equivalent). J.2. Tape a layer of parchment paper over the anterior chest variant 2 and fill the water top of basin.

seven-quart disposable plastic wash basin, red and blue food coloring, Tegaderm transparent film #1616 10 centimeters (cm) x 12 cm (3M, Minneapolis, MN,), 22.8 cm latex balloons, a Becton, Dickinson and Company spinal needle 18G x 3.5" (BDC, Franklin Lakes, NJ), a Becton, Dickinson and Company 10-milliliter (mL) syringe Luer-Lok tip, duct tape, and tap water. For the BA pericardiocentesis model, additional materials were used including plastic wrap, parchment paper, and one yoga mat ¼" extra thick deluxe. The USG model included Ultrasound Gel Aquasonic 100 transmission squeeze bottle (Parker Labs, Fairfield, NJ), archment paper roll, and Clearlax polyethylene glycol 3350 (Shopko Stores Operating Co., LLC, Greenbay, WI). We used a Creality Ender 3 3D printer (Creality Schenzhen, China) and 1.75 millimeter PLA filament (Hatchbox, Pomona, CA), and used Rhinoceros V6 software (McNeel and Associates, Seattle, WA, USA) for model construction and rendering (Figure 1). Project costs including modeling and rendering software are shown in Table 1. Digital development time for the two models took 10 hours. Prototyping, based on print, assembly, and revision, totaled 30 hours. A complete rendering of the finished anterior chest wall variants is shown in Figure 2. The GrabCAD link for printing details, BA model: https://grabcad.com/library/blind-pericardiocentesis-1; and USG Model: https://grabcad.com/library/ultrasound-guided-pericardiocentesis-1

Workshop

Residents first independently reviewed a 20-minute video introducing the disease processes associated with pericardial effusions, as well as a video reviewing the two procedural approaches (landmark and ultrasound) with demonstrations on the current models. Participants then voluntarily signed up for rotating blocks of up to three people over rotating intervals to practice on the models. Finally, participants were asked to complete a short survey using a six-point Likert scale (5 strongly agree, 4 agree, 3 neutral, 2 disagree, 1 strongly disagree, n/a non-applicable) pertaining to questions regarding model fidelity, convenience, and competency. The workshop director was available for questions after independently attempting the model and questionnaire. The workshop director would also set up the model if the residents did not rebuild the models themselves.

Blind Pericardiocentesis

This model was approached by identifying structurally equivalent anatomical landmarks of bony components of the anterior chest wall through physical exam. A small paper indicator was used to help participants orient caudad and cephalad. Aspiration was achieved using an 18-gauge lumbar needle attached to a 10 mL syringe (Figure 3).

Ultrasound-guided Pericardiocentesis

This model was visualized using a polyethylene glycol solution as previously demonstrated by Sullivan et al (2018) using a Sonosite M-Turbo and a Sonosite MicroMaxx (FUJIFILM Sonosite, Inc., Bothell, WA) ultrasound machines.[14] The goal was to identify an anechoic collection by either a subxiphoid or apical window approach between the two layers of latex balloons. This represented the pericardial effusion (Figure 3).

RESULTS

During the study period 26/47 residents comprising 8/12 incoming interns during intern orientation week, 6/12

Table 1. Products used for the models including itemized costs.

Product	Number of units	Cost per unit ($)	Total cost ($)
Spinal needle 18G 3.50 in	2	3.52	7.04
10 mL syringe	2	0.18	0.36
Ultrasound Gel Aquasonic 100 Transmission	1	13.03	13.03
Duct tape 1.88 in x 45 yd	1	5.97	5.97
Clearlax polyethylene glycol 3350 850 g	1	22.49	22.49
7-quart graduated basin	2	2.20	4.40
22.8 cm latex balloons	5 bags of 20 balloons	1.50	7.50
Red, yellow, blue, green food coloring	4	0.93	3.69
Plastic wrap 100 Ft	1	2.19	2.19
Parchment paper roll sq ft	1	3.29	3.29
1.75mm filament 1 kg	1	22.99	22.99
¼" yoga mat	1	14.99	14.99
Creality Ender 3 3D printer	1	179.99	179.99
Rhinoceros V6	1	195.00	195.00
Total cost			482.93

in, inches; *mL*, milliliters; *yd*, yards; *g*, gram; *cm*, centimeter; *ft*, foot; *kg*, kilogram; *3D*, three dimensional.

Figure 2. Clockwise: Blind approach pericardiocentesis anterior chest model; ultrasound-guided pericardiocentesis rendering; de-atomized model with scale; cross-section of printing lattice; and de-atomized rendering.

Figure 3: (A-D) Ultrasound-guided approach. (E-F) Blind approach. (G-H) Cannulation with pericardiocentesis kit.

postgraduate year (PGY)-1s, 4/12 PGY-2s, and 8/11 PGY-3s completed the preparatory workshop, and used the task trainers; 26/27 consented to use their data for research purposes. Data analysis was performed with Excel 2006 (Microsoft Corp, Redmond, WA). For analyses, the incoming intern class and PGY-1 data were combined into the same PGY-1 category.

Model Construction Practicality

Mean assembly time was 4.2 minutes for each model, based on the average production of six different models—3 BA and 3 USG approaches. Due to intentionally limiting the number of participants in the room, we did not calculate the average number of puncture attempts per model. The production time for the flat 3D printed chest model was 9 hours and 37 minutes. The production time for the 20 millimeter depressed model was 11 hours 3 minutes for the first print and 14 hours 24 minutes for the second print, totaling 25 hours 27 minutes.

Model Feasibility

A total of 26/26 residents (14/14 PGY-1, 4/4 PGY-2, 8/8 PGY-3) completed the model for the USG pericardiocentesis model, and 24/26 (13/14 PGY-1, 4/4 PGY-2, 7/8 PGY-3) (92%) of the same residents completed the survey for the BA pericardiocentesis model. Regarding color of aspirate, 22/24 (13/13 PGY-1, 4/4 PGY-2, 5/7 PGY-3) (92%) commented on the first color aspirated during the BA with 18/22 aspirating blue (11/13 PGY-1, 4/4 PGY-1, 4/7 PGY-3) (82%), 3/22 (2 PGY-1, 1 PGY-2) (14%) aspirating red first, and one balloon rupture (PGY-1). For the USG model 23/26 (PGY-1 12/14, PGY-2 4/4, PGY-3 7/8) (88%) commented on the color aspirated with 19/26 aspirating blue (10/14 PGY-1, 4/4 PGY-2, 5/8 PGY-3), 3/26 aspirating a red color (one PGY-3, two PGY-1, and one balloon rupture (PGY-3). The frequency of distribution to responses are displayed in Figure 4.

Fidelity

A total of 24/26 (92%) individuals practicing on the USG model and 22/24 (92%) from the BA model agreed or strongly agreed that the models mimicked a pericardial effusion. In the USG model, 23/26 (88%) agreed or strongly agreed that the ribs and ribs spaces were easily identifiable and in the BA model, 22/24 (92%) of participants agreed or strongly agreed that the ribs and rib spaces were palpable. Furthermore, 22/26 (85%) from the USG group and 23/24 (96%) from the BA strongly agreed or agreed that the aspiration of pericardial fluid was easily accomplished.

Convenience

Regarding ease of use, 25/26 (96%) participants found the USG model easy to use, and 23/24 (96%) participants found the BA easy to use with one individual not answering.

Competency

A total of 22/24 (92%) in the BA approach model and 21/25 (84%) in the USG group perceived that the training session increased their competency in pericardiocentesis.

DISCUSSION

Here we describe a low-cost, low-fidelity model created with easy-to-purchase components. The rib and sternal mimics were easily constructed with an inexpensive 3D printer for performing a BA and USG pericardiocentesis (Table 1). In terms of cost the printer purchased for model production is one of the most affordable on the market compared to other available home models, and we included the acquisition cost in the overall cost of our model despite this being a one-time expense.[16-20] Multiple high-quality, low-fidelity models have been published, and expensive high-fidelity US simulation trainers exist; however, none of the low- fidelity models provide practitioners with the associated physical exam and anatomical difficulties that are available in expensive, high-fidelity models without using animal products. A majority of the participants found the 3D-model rib structures and rib spaces easy to identify by physical palpation and by ultrasound. These findings are important because providers

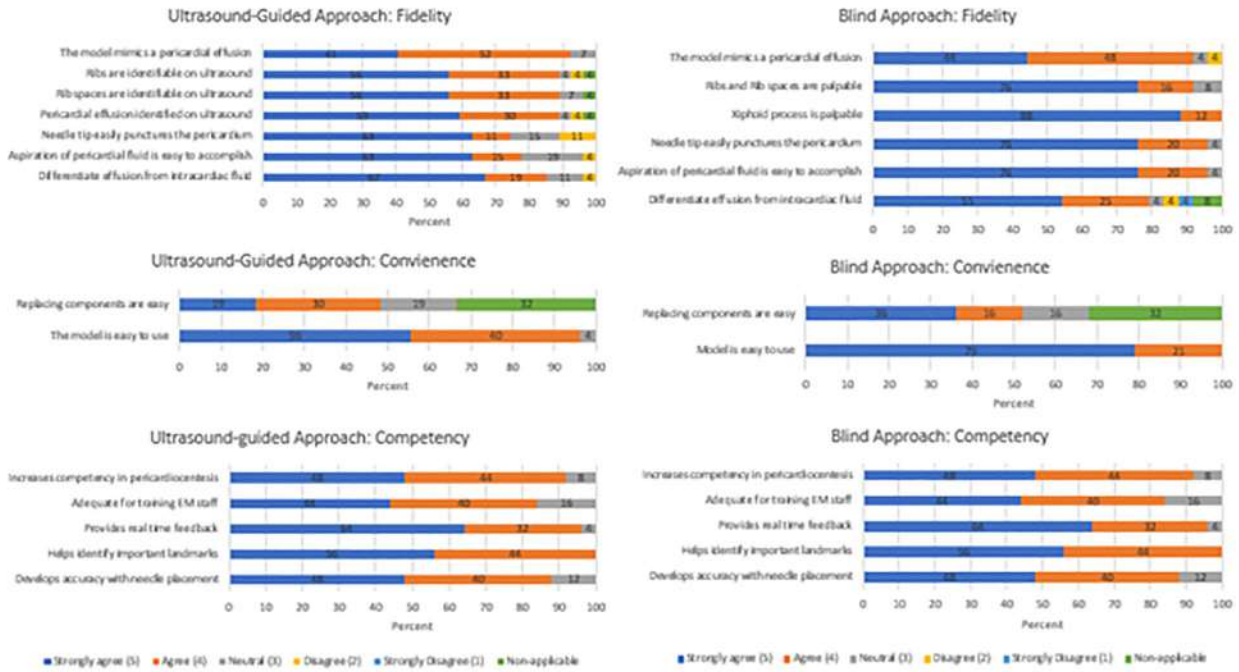

Figure 4. Results from the fidelity, convenience and competency questionnaire provided the participating residents. Values represent percentages. For the proportion of individuals that answered each subcategory refer to supplemental 2.

need to be comfortable with both the physical exam and ultrasound views, as well as being able to effectively aspirate an effusion. Thus, this model aptly prepares providers for navigating the whole procedure.

Our model was designed to make small advances on prior low- and high-fidelity models.[9-15] Our model has a remarkably simple rendering, and it is easy to assemble and replace components after multiple attempts. Using a durable 3D-printed anatomical chest model means we do not need to purchase animal parts or create resin molds; nor does the model degrade. Further, the design can be downscaled or upscaled depending on the size of model an individual wishes to practice on to allow mimicking large children, or small and large adults. Balloons can be prepped days in advance and can last in suspension for weeks at a time. Our model addresses complications created by buoyancy in a water-filled bath by careful positioning and using water-resistant tapes. While not initially offered as an option for our participants, our model could also withstand cannulation with a pericardiocentesis catheter set (Figure 3 [E-F]).

LIMITATIONS

Despite these advances, there are several limitations to our model design. First, while the model components are easy to replace between attempts, we were unable to determine the duration of time nor the number of punctures our model could handle due to social-distancing safety measures. Secondly, during the USG pericardiocentesis simulations, the skin parchment paper would occasionally move when residents tried to puncture the material, which would also affect their ultrasonography. Finding a low-cost material that is replaceable, affordable, and ultrasound compatible would greatly improve the process. Real-time teaching feedback during the sessions was limited due to social distancing. This will be easily corrected when not conducting this learning opportunity during a pandemic. Also, while residents were asked whether the model was easier to use than prior models or cadavers, we did not ask what type of model had been used, their landmark or ultrasound approach, nor did we ask how long ago the procedure was performed. Lastly, free-rendering software, such as Blender, exists but will require time to learn through tutorials. Therefore, we provided the necessary files through a GrabCAD account for printing.

CONCLUSION

During this current pandemic, low-cost, low-fidelity teaching models that do not require large groups, complex preparation, or in-person teaching are extremely valuable. Furthermore, low-occurrence, high-stress procedures often require cadaver models and repetition to develop provider competency. Therefore, our novel low-cost, low fidelity model offers an affordable resource that appropriately mimics human anatomy, provides easily replaceable components, and represents the environment while performing a pericardiocentesis by both a blind and ultrasound-guided approach.

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Descriptive Analysis of Components of Emergency Medicine Residency Program Websites

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Introduction: Most emergency medicine (EM) applicants use the internet as a source of information when evaluating residency programs. Previous studies have analyzed the components of residency program websites; however, there is a paucity of information regarding EM program websites. The purpose of our study was to analyze information on EM residency program websites.

Methods: In April–May 2020, we evaluated 249 United States EM residency program websites for presence or absence of 38 items relevant to EM applicants. Descriptive statistics were performed, including means and standard deviations.

Results: Of the 249 EM websites evaluated, the websites contained a mean of 20 of 38 items (53%). Only 16 programs (6%) contained at least three-quarters of the items of interest, and no programs contained all 38 items. The general categories with the least amount of items were social media use (9%), research (46%), and lifestyle (49%), compared to the other general categories such as application process (58%), resident information (63%), general program information (67%), and facility information (69%). The items provided by programs most often included program description (98%), blocks and rotations (91%), and faculty listing (88%). The items provided least often included housing/neighborhood information (17%) and social media links (19%).

Conclusion: Our comprehensive review of EM residency websites in the US revealed the absence of many variables on most programs' websites. Use of this information to enhance accessibility of desired information stands to benefit both applicants and programs in the increasingly competitive specialty of EM. [West J Emerg Med. 2021;22(4):937–942.]

INTRODUCTION

Emergency medicine (EM) is a popular specialty among medical students, evidenced by the growing number of EM residency applicants over the last 10 years, with 2903 applicants in 2011 and 3640 in 2020.[1] Many applicants depend on the internet as a primary source of information when researching different residency programs.[2] This has been particularly true for the 2020-2021 residency cycle due to COVID-19-related restrictions on travel and in-person activities. Even prior to this change, information available on the internet was often a determining factor in prospective applicants' decisions to apply for rotations or residency interviews. A survey of EM applicants found that 78% claimed information provided in the residency program website influenced their decision to apply to a particular program.[3] In addition, 41% of applicants decided not to apply to at least one program solely based on the information available on the residency program website.[3] Accordingly, website

development, content, and accessibility are increasingly important for residency programs.

To assist medical students in navigating the staggering number of residencies across the United States, databases such as the Fellowship and Residency Electronic Interactive Database (FREIDA) have been designed to allow convenient access to program websites and information on residencies and fellowships.[4] However, little is known about the quality of information available through these websites in the field of EM. Prior studies have evaluated residency websites for other specialties,[5-9] resulting in various recommendations for areas of improvement among their respective program websites to both help applicants and increase recruitment.[6,9-11] The main purpose of our study was to provide an in-depth analysis of EM residency website content for prospective EM applicants. To our knowledge, this study is the first to evaluate these variables in the specialty of EM.

Population Health Research Capsule

What do we already know about this issue?
Residency program websites have been analyzed in other specialties. However, a comprehensive analysis of emergency medicine (EM) residency websites is lacking.

What was the research question?
Which components of EM residency websites are most common, and which are least common?

What was the major finding of the study?
We identified several areas for website renovation, such as social media integration and residency lifestyle.

How does this improve population health?
The results from our study can be used to improve EM residency websites to the mutual benefit of both applicants and residency programs.

METHODS

This study was exempt from institutional review bgoard approval because it involves publicly available information. Our methods were adapted from a previous study analyzing otolaryngology residency websites.[6] We obtained a list of 256 EM programs from FREIDA in April 2020. When a link to a program was not available on FREIDA, we performed a Google search to find the program website. Residency programs without a functional residency website or a website that could not be found were excluded. When two websites were available for the same program, we used information from both the institutional and the non-institutional program website. We did not include Facebook, Instagram, or other social media page information.

We searched the available websites of these programs for 38 items listed in Supplemental Table. Items fell into seven general categories: general program information; application process; research; facility information; current resident information; lifestyle; and social media use. These 38 items were included in our study based on our literature review of previous analyses of residency and fellowship websites in other specialties.[5-13] As descriptive studies, they analyzed a heterogenous list of variables on the websites of interest. The 38 items included in our study are largely based on this literature search.

Understandably, some factors are more important to applicants than others, such as patient volume, curriculum, faculty, research, and simulation training centers.[14] Although the importance of these factors varies from applicant to applicant, the majority of the variables applicants deem as necessary or desirable information were included in our list of 38 items, in addition to many more items of potential interest we included based on our literature review.[15] We also added a few additional items to make our study more comprehensive based on items we believe could be lacking from other studies in our literature review, such as social media, resident pictures, and resident hobbies. We also tested the websites for functionality by determining whether the link provided on FREIDA led directly to the residency homepage or required multiple clicks to get to the homepage. The data were collected by three authors (JW, AR, SS) from April 15–May 15, 2020.

As the data contained in residency websites can be subjective, we created a standardized process to evaluate the websites, similar to the previous studies in other specialties.[5-9,12] First, we only searched for the presence or absence of items, with no attempt made to grade the quality or accuracy of the content. Second, we excluded any information that was not directly listed on the residency website, such as links to external materials, which may contain general, non-specific information for the program of interest. Lastly, we piloted our search criteria for five programs to resolve ambiguity through independent review by four authors. After this instruction, data collectors independently gathered the data from the 251 remaining websites (HW, AR, SS). When these three authors encountered websites or criteria that were unclear, these criteria were marked and reviewed by a fourth author (JP) and classified accordingly.

We performed a descriptive analysis of the data, including means and standard deviations. To calculate the percentage of items present in each subcategory, we added up the total number of items present among all 249 websites in that subcategory. We then divided this number by the denominator, which was calculated by multiplying the number of variables

present in a subcategory by the number of websites examined (249).Microsft Excel 2020 version 16 (Microsoft Corp., Redmond, WA) was used for statistical analysis.

RESULTS

Of 256 EM residency programs included in our study, seven programs did not have websites on FREIDA and were not accessible by Google search. Of the 249 websites evaluated, 110 websites (44%) provided a direct link from FREIDA to the residency homepage, while 107 (43%) programs required multiple clicks to get to the residency homepage. Thirty-two programs (13%) did not have a link on FREIDA.

On average, websites contained 20 of 38 items (53%) with a standard deviation of 6.35. Only 16 programs (6%) contained at least three-quarters of the items of interest. One program contained 37 of 38 items, and no program contained all items. The items that were least commonly available on websites included information on housing and neighborhoods (17%) and social media links (19%) (Table).

Table 1. Presence of items on emergency medicine residency program websites.

General criteria (N=249)	Information found on Emergency Medicine Residency Program websites	% of all Websites
General program information		
	Program description	98%
	Blocks and rotation descriptions	91%
	Faculty listing	88%
	Description for each year of residency	87%
	Message from the program director	69%
	Information for visiting medical students	65%
	Didactic information (A description of didactics or lectures attended)	61%
	Information on tracks and special interests	61%
	Simulation lab information	59%
	Description of each block	48%
	Procedural training nformation	48%
	On-call information	26%
Application process		
	Contact information	78%
	Selection criteria	54%
	Interview dates	53%
	Link to ERAS application	47%
Research		
	Information about research interests and/or active projects	48%
	Information about research requirement	44%
Facility information		
	Description of affiliated hospitals	80%
	Emergency department volume	63%
	Information on the trauma level of the hospitals	63%
Resident information		
	Current residents listed	82%
	Current resident pictures	78%
	Current resident academic history	72%
	Current resident hobbies and/or fun facts	42%
	Current resident biography	40%

ERAS, Electronic Residency Application Service.

Table. Continued.

General criteria (N=249)	Information found on Emergency Medicine Residency Program websites	% of all Websites
Lifestyle		
	Benefits	65%
	Salary	63%
	Vacation and/or sick leave	57%
	Information on surrounding area	48%
	Meal allowance	43%
	Housing and neighborhood information	17%
Social media		
	Link to residency program social media account	19%
	Facebook	12%
	Twitter	15%
	Instagram	8%
	LinkedIn	2%
	Other	2%

Within the social media category, the most common forms of social media were Twitter (15%), Facebook (12%), and Instagram (8%) (Figure 1). The items most commonly provided by websites included program description (98%), blocks and rotations (91%), faculty listing (88%), and description for each year of residency (87%). The percentage of each general category is included in Figure 2.

DISCUSSION

As prospective applicants evaluate EM programs, careful planning and research is essential. The internet is easily accessible, and multiple studies have shown the importance of websites in recruitment.[9,12,16,2] Our study suggests databases such as FREIDA are useful tools to navigate residency options, with 87% of EM programs providing links to their sites. However, over half of these links required multiple steps, suggesting even this resource could be improved. Our results also demonstrate that many websites are lacking information that is potentially valuable to residency applicants, with an average site missing nearly half of the information we evaluated. We believe enhancing website content could improve the application process for all parties.

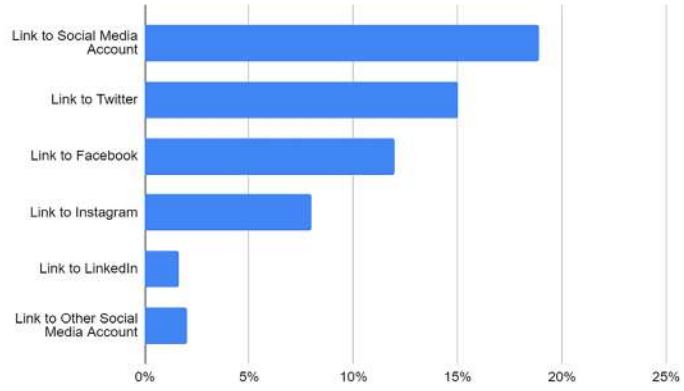

Figure 1. Social media presence of emergency medicine residency programs.

The "People" section on websites provided widely varying amounts of information. Despite previous analyses demonstrating that this is the most popular content on EM residency websites,[17] this information was present on only 63% of EM sites. Similarly, resident biographies and a description of resident hobbies and/or interests were included on fewer than half of EM residency websites. Because an applicant is unlikely to meet all current residents during an interview, resident information on program websites could be the only exposure of such applicants to the unique personalities and backgrounds of residents in the program. Emergency medicine residency programs may benefit from improving these areas of their websites, while being cautious to protect the personal information of their residents.

The presence of social media on residency websites was also limited. Despite the rise of social media for recreational and professional purposes, only 19% of programs contained links to a form of social media for their EM program. In a study done involving nearly 1000 medical students, 68% of students reported using social media to learn about residency programs and 10% reported that the information found in the social media pages influenced their decisions on where to apply.[18] Similarly, a survey of 142 prospective EM residents led

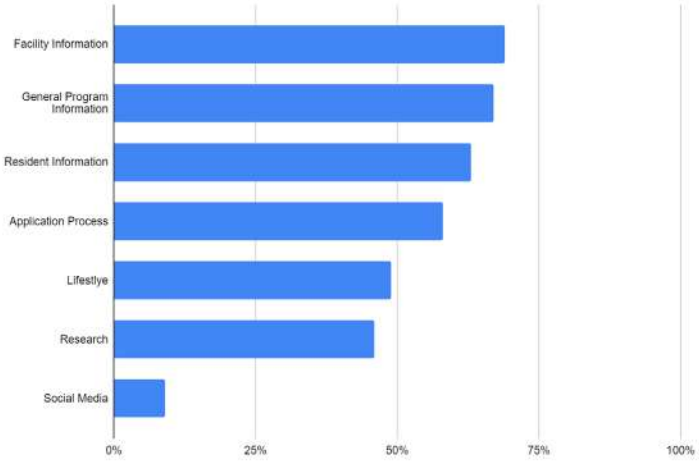

Figure 2. Content available on emergency medicine residency websites.

to the recommendation that programs should highlight social activities to improve resident recruitment,[2] and social media is an efficient way to display social activities. Professional social media integration with EM residency websites appears currently underutilized.

Additionally, lifestyle factors including salary, vacation, meal allowance, and housing costs were often not found on websites. For example, salary information was listed on 63% of websites, vacation time was listed on 57% of websites, and housing and neighborhood information was listed on 17% of websites. Not only are these items important factors to consider when choosing a residency program, but they can be difficult to ask about during an interview, as applicants may worry that asking questions about compensation and benefits give the wrong impression to the program leadership and residents. These topics are discussed during interviews, but these details can be forgotten. Accessible information on lifestyle, which is currently lacking among many EM residency websites, could eliminate this source of potential inquiry or recall concern for applicants.

As the number of residency programs in EM continues to grow,[19] it has become increasingly difficult for applicants to choose where to apply for visiting clerkships or residency interviews. In 2020. US medical school graduates applying for EM residency applied to an average of 58 programs[1] despite data from the Association of American Medical Colleges demonstrating diminishing returns for applicants applying to more than 32-39 programs.[20] While the increased number of applications may be due to the increasingly competitive nature of EM,[21,22] future studies should aim to determine whether lack of online information affects the number of applications. The residency application and interview process is costly for applicants and programs. Providing applicants with more information to guide decisions regarding which programs to apply to and interview at stands to benefit both parties, especially if it results in a better matching of applicants likely to fit a particular program.

The 2020-21 residency application cycle posed a new challenge for applicants and programs. The lack of availability of visiting rotations and in-person interviews contributed to increased uncertainty among applicants, and most were unable to evaluate programs in person. In-person interviews served not only for programs to interview candidates, but for candidates to evaluate programs. Therefore, more than ever, a robust source of information available to applicants on a residency website serves to benefit both applicant and program alike.

LIMITATIONS

Limitations of our study include the subjective nature of analyzing residency program websites. However, we feel our method of data collection was standardized sufficiently to control for ambiguity. Another limitation was the lack of established standardized criteria for evaluating websites. We based our list of 38 items on our literature search of previous residency website analyses in other specialties, and also relied on papers relating to what EM applicants deem important and the expertise of the authors of our study.[5-13] However, the purpose of our study was not to define the most important items for EM residency applicants, but rather to assess the presence or absence of items on EM residency websites. Inherently, there are items present in our list that may not be very important to some applicants, and items missing which may be important to some applicants.

Future study is needed to provide an updated list of the most important criteria EM applicants could be interested in. The number of programs with "People" sections could be underestimated as many of these programs might have these sections on their social media websites rather than their official residency program websites. Lastly, only including items listed directly on the EM residency website rather than on external links could underestimate the presence of items on websites in our study. However, this was an important factor to determine the accessibility of information and user-friendly status of the websites. Our study does not address accuracy or quality of information contained on websites.

CONCLUSION

Residency program website quality is important to EM applicants, and our study identifies several areas where programs could focus efforts for website renovation, including improving the integration of social media and providing information on residents and residency lifestyle. The results from our study can be used to improve EM residency websites to the mutual benefit of both applicants and residency programs.

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Management of Minor Traumatic Brain Injury in an ED Observation Unit

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Introduction: Traumatic intracranial hemorrhages (TIH) have traditionally been managed in the intensive care unit (ICU) setting with neurosurgery consultation and repeat head CT (HCT) for each patient. Recent publications indicate patients with small TIH and normal neurological examinations who are not on anticoagulation do not require ICU-level care, repeat HCT, or neurosurgical consultation. It has been suggested that these patients can be safely discharged home after a short period of observation in emergency department observation units (EDOU) provided their symptoms do not progress.

Methods: This study is a retrospective cross-sectional evaluation of an EDOU protocol for minor traumatic brain injury (mTBI). It was conducted at a Level I trauma center. The protocol was developed by emergency medicine, neurosurgery and trauma surgery and modeled after the Brain Injury Guidelines (BIG). All patients were managed by attendings in the ED with discretionary neurosurgery and trauma surgery consultations. Patients were eligible for the mTBI protocol if they met BIG 1 or BIG 2 criteria (no intoxication, no anticoagulation, normal neurological examination, no or non-displaced skull fracture, subdural or intraparenchymal hematoma up to 7 millimeters, trace to localized subarachnoid hemorrhage), and had no other injuries or medical co-morbidities requiring admission. Protocol in the EDOU included routine neurological checks, symptom management, and repeat HCT for progression of symptoms. The EDOU group was compared with historical controls admitted with primary diagnosis of TIH over the 12 months prior to the initiation of the mTBI protocols. Primary outcome was reduction in EDOU length of stay (LOS) as compared to inpatient LOS. Secondary outcomes included rates of neurosurgical consultation, repeat HCT, conversion to inpatient admission, and need for emergent neurosurgical intervention.

Results: There were 169 patients placed on the mTBI protocol between September 1, 2016 and August 31, 2019. The control group consisted of 53 inpatients. Median LOS (interquartile range [IQR]) for EDOU patients was 24.8 (IQR: 18.8 – 29.9) hours compared with a median LOS for the comparison group of 60.2 (IQR: 45.1 – 85.0) hours ($P < .001$). In the EDOU group 47 (27.8%) patients got a repeat HCT compared with 40 (75.5%) inpatients, and 106 (62.7%) had a neurosurgical consultation compared with 53 (100%) inpatients. Subdural hematoma was the most common type of hemorrhage. It was found in 60 (35.5%) patients, and subarachnoid hemorrhage was found in 56 cases (33.1%). Eleven patients had multicompartment hemorrhage of various classifications. Twelve (7.1%) patients required hospital admission from the EDOU. None of the EDOU patients required emergent neurosurgical intervention.

Conclusion: Patients with minor TIH can be managed in an EDOU using an mTBI protocol and discretionary neurosurgical consults and repeat HCT. This is associated with a significant reduction in length of stay. [West J Emerg Med. 2021;22(4)943–950.]

INTRODUCTION

Traumatic brain injury (TBI) is a frequent cause for emergency department (ED) visits. The US Centers for Disease Control and Prevention (CDC) estimated there were 2.5 million ED visits related to TBI in 2013, which represents an increase from 2007.[1] Traumatic brain injury is grossly classified as mild, moderate, and severe based on the presenting Glasgow Coma Scale (GCS) score with mild TBI (mTBI) defined as a GCS of 13-15.[2]

Clinical policies and decision tools exist to aid the emergency physician (EP) in deciding which patients with mTBI need brain imaging.[3,4] Once traumatic intracranial hemorrhages (TIH) are identified with head computed tomography (HCT), patients are typically admitted or transferred to a trauma center with neurosurgical capabilities. This can happen regardless of the size and location of the hemorrhage, or clinical condition of the patient. Inpatient care is typically in an intensive care unit (ICU) setting so that they can be monitored closely for clinical deterioration. In addition, patients routinely receive repeat HCT and neurosurgical consultation.[5]

Recent studies show routine follow-up HCT in many patients are not predictive of the need for neurosurgical intervention and this practice should be reserved for patients who demonstrate deterioration of neurologic exam.[6-9] Retrospective studies by Joseph et al have concluded that minor TIH patients have low risk of requiring neurosurgical intervention and, therefore, can be managed without neurosurgical consultation.[10,11] Multiple studies have examined the necessity of ICU admission for minor TIH. Patients with isolated traumatic subarachnoid hemorrhage have low rates of clinical and radiographic deterioration.[12-14] Other studies have suggested that patients with minor TIH largely do not receive critical care interventions and, therefore, do not benefit from ICU admission.[15,16] These are retrospective analyses with no universal definition of minor TIH. Hence, the question has come up about using ED observation units (EDOU) to monitor patients with minor TIH.[14,17]

In their 2015 validation of the Brian Injury Guideline (BIG) protocol, Joseph et al recommended up to 24-hour observation for patients with minor TIH without repeat HCT or neurosurgical consultation.[18] Minor TIH fits with other conditions commonly managed in the EDOU setting, as it is a single condition and patients can be managed in under 24 hours.[19] This allows the visits to be more focused, which leads to decreased length of stay (LOS) and decreased healthcare costs.[20-27] Randomized controlled trials (RCT) that have compared EDOU and inpatient care for conditions such as chest pain, asthma, atrial fibrillation, and transient ischemic attack have found EDOU care to be more efficient and cost effective.[28-36] Yun and colleagues have looked at managing patients with TIH in an EDOU setting where they performed a retrospective analysis of TIH patients before and after an EDOU protocol was implemented.[37] They reported that use of the protocol was associated with decreased need for admission and lower likelihood of worsening TIH on repeat CT. There was no difference in LOS in EDOU patients pre-protocol and during the protocol.

This study evaluates the outcomes of patients managed in the EDOU using an mTBI protocol based on BIG criteria.

Population Health Research Capsule

What do we already know about this issue?
Patients with small traumatic intracranial hemorrhages (TIH) often utilize intensive care, serial head computed tomographies (CT) and neurosurgical consultation, even though they rarely benefit from these resources.

What was the research question?
Can management of patients with minor traumatic intracranial hemorrhages be accomplished in emergency department observational units (EDOUs) and use fewer resources?

What was the major finding of the study?
Minor TIH patients in EDOUs are associated with a shorter length of stay, fewer repeat CTs and neurosurgical consults.

How does this improve population health?
Stable patients with small traumatic hemorrhages may not benefit from more interventions and critical care. This could lead to cost savings for this group of patients.

METHODS

This is a retrospective cross-sectional study performed at a Level I trauma center. Initial workup in the acute phase of care was provided primarily by the emergency medicine (EM) team consisting of an EM attending and either an EM resident or an EM advanced practice provider. Here, the trauma team was either activated to co-manage patients based on pre-set protocols or consulted at the discretion of the EM attending.

The EDOU mTBI protocol was created by a multidisciplinary team of physicians from the trauma surgery service, EM, and neurosurgery. The EDOU protocol was based on the BIG protocol.[11,18] We altered the protocol slightly to exclude epidural hematomas based on institutional expert opinion. This practice change was implemented as a quality improvement project first piloted September 1–December 31, 2016. In this phase, patients who met BIG 1 criteria (Table 1) were eligible for the EDOU protocol.

Table 1. Traumatic intracranial hemorrhage classification based on Brain Injury Guidelines (BIG).[11]

	BIG 1	BIG 2	BIG 3
Neurological examination findings	Normal	Normal	Normal or abnormal
Intoxication	No	No	Yes
Anticoagulation	No	No	Yes
Skull fracture	No	Nondisplaced	Displaced
SDH,	≤ 4 mm	5-7 mm	≥ 8 mm
EDH, mm	No	No	Any size
IPH	≤ 4 mm, 1 location	5-7 mm, 2 locations	≥ 8 mm, multiple locations
SAH	Trace	Localized	Scattered
IVH	No	No	Yes

SDH, subdural hematoma; *mm*, millimeters; *EDH*, epidural hematoma; *IPH*, intraparenchymal hemorrhage; *SAH*, subarachnoid hemorrhage; *IVH*, intraventricular hemorrhage.

Trauma and neurosurgical consultations were required for each patient. Beginning January 1, 2017, patients who met BIG 1 or 2 criteria were permitted in the EDOU. Trauma and neurosurgical consultations were at the discretion of the EM attending in all phases of care. Patients who were unable to ambulate independently, had intractable pain or vomiting, or other significant traumatic injuries were considered ineligible for EDOU. The guidelines for this protocol are summarized in Table 2.

Interventions in the EDOU consisted of neurologic checks every two hours for up to 23 hours. These standard assessments, performed by nursing, involve testing for level of alertness, orientation, and gross deficits in limbs. Evidence of decreased mental status, seizure, or focal neurologic deficit prompted an emergent repeat HCT and consultation with both trauma surgery and neurosurgery. Symptoms were controlled with antiemetics and analgesics as needed. In the absence of clinical deterioration, repeat HCT was ordered at the discretion of the EDOU team. Patients were discharged home if symptoms were controlled with oral medication and they were able to eat and perform activities of daily living unassisted. Patients who were unable to do this were converted to inpatient status. They were admitted to the trauma service if they needed further treatment for their head injuries. Some were admitted to internal medicine due to occult medical issues that were identified during observation.

The intervention group was identified through an EDOU census report generated through the electronic health record (EHR). Because the EHR allowed use of the discrete variable "EDOU Pathway" it was not necessary to use *International Classification of Diseases, 10th Modification* (ICD-10) codes to identify all the patients in the EDOU on this pathway. The database was queried for all patients on the mTBI protocol from its inception on September 1, 2016, through August 31, 2019. The report provides patient level ED and EDOU LOS data as well as final disposition: inpatient conversion or discharge from EDOU. Trained chart abstractors (EM residents) obtained age, gender, mechanism of injury, initial HCT reading by radiologist, TIH category as determined by trauma surgeons, disposition from the EDOU (be it admission or discharge to home), and follow-up information. Length of stay for the intervention group was calculated on the EHR report unless specified below. We defined ED LOS as patient arrival until they physically left the department. Length of stay in the EDOU was calculated as time of arrival in the EDOU until the time of the admission or discharge order in the EHR. Admission and discharge order times were manually abstracted via chart review. Total LOS was calculated as the sum of ED and EDOU LOS.

The comparison group was made up of patients admitted to the trauma service for TIH from September 1, 2015–August 31, 2016. Patients were identified by querying the trauma registry for all patients who were admitted with a primary diagnosis of TIH based on ICD-10 code. The trauma registry is a database maintained by the Trauma and Acute Care Surgery service. Minor TBI inclusion criteria were retrospectively applied to these patients to select the group that would have been eligible for EDOU. Trained chart abstractors obtained demographic, imaging, disposition, and follow-up information on comparison group patients. Although the group for comparison was derived from the registry database at our institution and the intervention group was derived from an EHR report, ultimately the chart abstractors used the same EHR system (Epic Systems Corporation, Verona, WI) to obtain the results used in the analyses.

We described LOS using medians and interquartile ranges. All other variables were described using counts and percentages. The primary research question regarded whether the mTBI protocol reduced the median LOS. This was tested using quantile regressions. Quantile evaluates the association between some predictor and a given quantile/percentile of the outcome while controlling for

Table 2. Emergency department observation unit guidelines for patients with minor traumatic brain injury.

EDOU transfer criteria
Meets Brain Injury Guideline (BIG) 1 or BIG 2 criteria
Patient has spine cleared or is in Aspen collar and is able to ambulate without assistance
No other traumatic injuries that need continued evaluation or treatment. Splinted extremities are acceptable provided the patient is able to ambulate
Patient not having intractable pain/vomiting
Stable vital signs
Consultation in ED by trauma surgery and neurological surgery teams as deemed appropriate by ED attending
Exclusion criteria
Not meeting all of BIG 1 or BIG 2 criteria
Other injuries that still need evaluation/treatment
Inability to ambulate
Intractable pain/vomiting
Unstable vital signs (persistent tachycardia; tachypnea; hypotension)
Other indications for admission
Potential interventions
Serial neurologic exams including vital signs every 2 hours
6-23 hour observation for change in neurological status
Advance diet as tolerated
Antiemetics/analgesics as needed
Repeat CT as indicated
Decision points/acute interventions
STAT repeat CT head and call to neurosurgery and trauma residents on call for
Decreased mental status based on Q2 hour checks
Seizure at any point
New focal neurologic deficits found on neuro checks
STAT trauma evaluation for:
Development of abnormal vital signs
Intractable pain
Inability to ambulate
Discharge criteria
Home
Acceptable vital signs
Normal serial neurologic exams
Tolerating diet as they were prior to admission
Able to ambulate and perform activities of daily living without assistance
Admit
Deterioration in clinical condition
Development of any exclusion criteria – including over read of initial CT head that includes BIG 2 or 3 criteria

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

other variables (eg, whether an intervention reduces the 50th percentile/median or 75th percentile of an outcome). Adjusted analyses controlled for the effects of age, gender, mechanism of injury, neurosurgery consultation, repeat HCT, and BIG level. We computed *P*-values and 95% confidence intervals (CI) as bootstrapped estimates (10,000 resamples). Categorical patient characteristics were compared across groups using the χ^2 test. Analyses were conducted using R v. 3.5.2 (R Foundation for Statistical Computing, Vienna, Austria).

Table 3. Patient characteristics.

Characteristic	Control (n = 53)	Intervention (n = 169)	P
Age	36 (26.5 – 55)	41 (27.5 – 57)	.39
Gender			.34
Male	35 (66.0)	98 (58.0)	
Female	18 (34.0)	71 (42.0)	
Mechanism			.08
Assault	15 (28.3)	26 (15.4)	
Bike/ ATV/ Scooter	1 (1.9)	8 (4.7)	
Fall	10 (18.9)	57 (33.7)	
MVC	20 (37.7)	67 (39.6)	
Ped vs Vehicle	4 (7.5)	7 (4.1)	
Other	3 (5.7)	4 (2.4)	
Big Protocol			.40
1	41 (77.4)	135 (79.9)	
2	12 (22.6)	30 (17.8)	
3	0 (0)	4 (2.4)	
NSGY	53 (100)	106 (62.7)	<.001
Repeat HCT	40 (75.5)	46 (27.4)	<.001
LOS	60.2 (45.1 – 85.0)	24.8 (18.8 – 29.9)	<.001

ATV, all terrain vehicle; *MVC*, motor-vehicle collision; *Ped*, pedestrian; *NSGY*, neurosurgery; *HCT,* head computed tomography; *LOS*, length of stay.

RESULTS

During the study period 209 patients were placed on the mTBI protocol. We excluded 40 patients from this analysis because they did not have an acute TIH or were admitted as inpatients to the trauma service but boarding in the EDOU. The control group consisted of 53 patients. Demographic and clinical information for the intervention and comparison groups are summarized in Table 3.

The primary outcome is presented in Figure 1. Median LOS (IQR) for EDOU patients was 24.8 (IQR: 18.8 – 29.9) hours compared with a median LOS for the comparison group of 60.2 (IQR: 45.1 – 85.0) hours. This 35.4 (95% CI, 27.3 – 43.5) hour reduction was significant ($P < .001$). In the adjusted analyses, the intervention was associated with a 35.5 (95% CI, 27.2 – 43.8, $P < .001$) hour reduction is LOS. In the EDOU group 47 (27.8%) patients got a repeat HCT compared with 40 (75.5%) inpatients, and 106 (62.7%) had a neurosurgical consultation compared with 53 (100%) inpatients (Figure 2). Subdural hematoma was the most common type of hemorrhage. It was found in 60 (35.5%) of patients, and subarachnoid hemorrhage was found in 56 cases (33.1%). Eleven patients had multicompartment hemorrhage of various classifications.

Twelve (7.1%) patients required hospital admission from the EDOU. Reasons for admission are explained in Table 4. Average inpatient LOS was 3.25 days. Only three patients required ICU care, and four were admitted to the internal medicine service. Ten of the admitted patients were able to be discharged home following their hospitalization. One

Table 4. Patients admitted following emergency department observation unit observation period.

Patient number	Age/gender	HCT finding	Reason for admission	Type of bed	Inpatient LOS
15	25/F	Trace SAH (overread as negative)	Persistent tachycardia	Trauma floor	2 days
16	59/M	Subacute subdural	Dizziness, bradycardia	Medical telemetry	4 days
17	25/F	Trace SAH	Vomiting, worsening CT	Trauma ICU	2 days
22	31/F	Trace SAH vs artifact	Pain control	Trauma floor	3 days
58	40/M	Subdural skull fracture	Worsening CT	Trauma ICU	5 days
107	51/M	Scattered punctate hyperdensities likely artifact	Persistent Confusion	Trauma floor	6 days
108	79/F	4mm SDH	Gait instability	Trauma floor	2 days
114	77/M	3mm SDH	Worsening mental status	Medical ICU	11 days
115	77/M	Small SAH vs artifact	New atrial flutter	Medical telemetry	1 day
119	90/F	Trace SAH	Unable to ambulate	Medical floor	1 day
133	27/F	Streak artifact vs hemorrhagic contusion	Dizziness	Trauma floor	1 day
134	18/F	R frontal SAH, R IPH	CT over-read	Trauma floor	1 day

HCT, head computed tomography; *LOS*, length of stay; *M*, male; *F*, female; *SAH*, subarachnoid hemorrhage; *mm*, millimeters; *ICU*, intensive care unit; *SDH*, subdural hematoma; *IPH*, intraparenchymal hemorrhage.

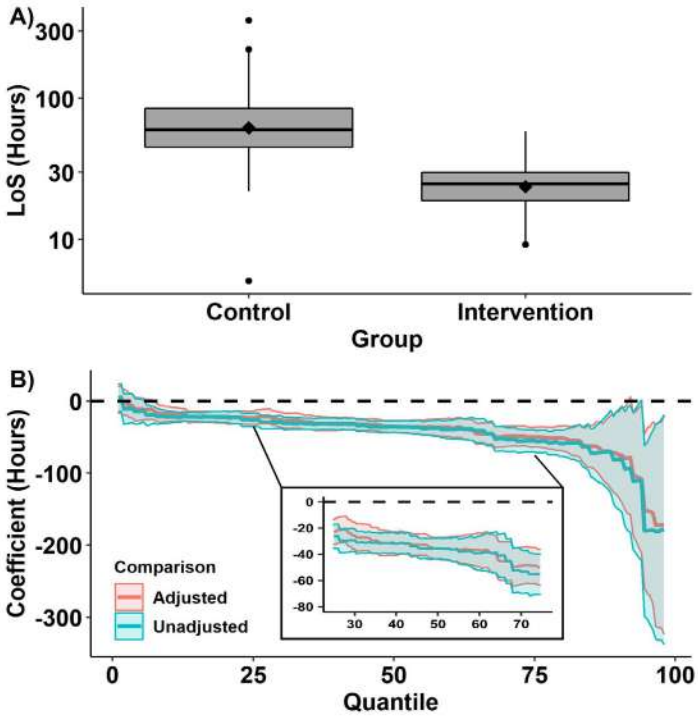

Figure 1. A) A box and whisker plot depicting length of stay as a function of intervention group. The solid lines within the boxes depict the median for each group and the diamonds within the boxes depict the means for each group. Note that the data are presented on a log10 scale. B) The results of the quantile regressions evaluating the association between the protocols and length of stay. The solid lines depict the difference between the intervention and control groups (eg, the median/50th percentile for the intervention group was approximately 35 hours shorter than for the control group; however, the 75th percentile was approximately 55 hours shorter for the intervention group than for the control group). Negative coefficients indicate that the intervention group had reduced lengths of stay relative to the control group. Shaded regions depict the 95% confidence intervals. The inset section of panel B highlights the change in cost between the 25th and 75th percentiles
LOS, length of stay.

patient was transferred to hospice, and one was discharged to rehab. None of the patients managed in the EDOU required neurosurgical intervention. There was only one patient death in the EDOU group. Based on review of clinical records, this was thought to be due to metabolic encephalopathy and not head injury.

Follow-up information was available on only 45 (26.6%) patients. Twelve patients reported mild symptoms of headache or dizziness. One patient had persistent headache three months later. No patients required readmission or neurosurgical intervention due to their head injuries. Two patients were called back to the ED due to CT over-reads. Neither of these visits resulted in an admission. Seven patients received outpatient imaging due to persistent symptoms, but no neurosurgical intervention was required for these patients.

DISCUSSION

We found a significant difference in our primary outcome of EDOU vs inpatient LOS. Management of patients with mTBI in the EDOU was associated with significant reduction in LOS when compared with patients in inpatient settings. This is consistent with the above studies on EDOU vs inpatient care. This finding differs somewhat from the EDOU study by Yun et al in that they did not compare EDOU and inpatient data, but rather the LOS in the ED portion of care only.[37] This difference is not as surprising as the preponderance of other studies showing benefit in LOS for EDOU pathways when compared to usual care in an inpatient setting.

Overall, our protocol is similar to the one reported in the Yun study. There were minor differences in inclusion criteria such as the upper limit of subdural hematoma. Interventions in the EDOU were similar between the two groups including frequent neurologic checks and repeat HCT for clinical deterioration. In addition, we found a low rate of adverse events in the EDOU group, which is consistent with previous studies on minor TIH. None of the patients in the intervention group required emergent neurosurgical intervention. The most common reasons for inpatient admission were persistent symptoms due to head injury or other traumatic or medical issues that presented during the observation period. This is summarized in Table 4. Further study is needed to determine predictors for inpatient conversion in this group.

Patients in the EDOU had a lower rate of neurosurgical consultation and repeat HCT when compared with their inpatient counterparts. Repeat HCTs were ordered based on clinical concern or recommendations from radiology or neurosurgical consultants. Further study is needed to determine the clinical necessity of these interventions in the EDOU setting.

LIMITATIONS

There are many limitations to this study given its single-center, retrospective design. A large, multicenter RCT is needed to better understand the true relationship between EDOU care and LOS. In addition, because adverse outcomes in BIG 1 and 2 class TIH are rare, larger numbers are needed to truly understand the safety of this approach. However, because TIH patient are a high-risk population a more precise understanding of the rates of hemorrhage progression and need for emergent neurosurgical intervention is essential before EDOU care can be widely recommended.

The biggest limitation of this study is the limited follow-up information in the intervention group. Because this study began as a quality improvement initiative, there initially was not a robust mechanism to conduct follow-up interviews to investigate whether patients were still experiencing symptoms or had repeated medical visits due to their injuries. This is an important area for future study. Patients were chosen for the EDOU based on clinician gestalt that the patient fit within the inclusion/exclusion guidelines. This could introduce bias

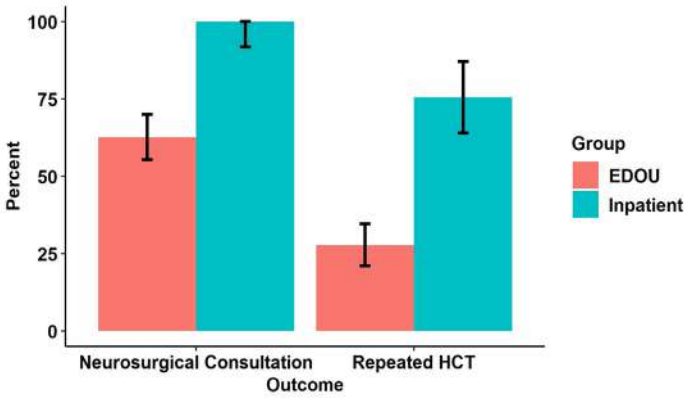

Figure 2. Graphic representation of difference in neurosurgical consultation and repeat head computed tomography between intervention (EDOU) and control (Inpatient) groups.
HCT, head computed tomography; *EDOU*, emergency department observation unit.

into the results as patients who were thought to be sicker or more complicated were likely admitted to inpatient units. The control group for this study is small and thus may limit the strength of association of some of the outcomes. This study was conducted in an urban teaching facility and Level 1 trauma center; thus, it may not be translatable to smaller or rural centers without trauma or neurosurgical services. Further studies involving non-Level I trauma centers are necessary.

CONCLUSION

Use of an EDOU to observe patients with minor traumatic hemorrhage as defined by the Brain Injury Guidelines classification was associated with significantly reduced length of stay and low overall incidence of adverse events. Care in the ED observation unit was also associated with fewer repeat head computed tomography and neurosurgical consultations. Further study is needed to determine predictors for inpatient conversion, follow-up needs, and ability of smaller, non-trauma centers to use this protocol.

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The FAST VIP (First Aid for Severe Trauma "Virtual" in-Person) Educational Study

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Introduction: Trauma is the leading cause of death for young Americans. Increased school violence, combined with an emphasis on early hemorrhage control, has boosted demand to treat injuries in schools. Meanwhile, coronavirus disease 2019 (COVID-19) has made educating the public about trauma more difficult. A federally funded high school education program in development, called First Aid for Severe Trauma™ (FAST™), will teach students to aid the severely injured. The program will be offered in instructor-led, web-based, and blended formats. We created a program to prepare high school teachers to become FAST instructors via "virtual" in-person (VIP) instruction. We used a webinar followed by VIP skills practice, using supplies shipped to participants' homes. To our knowledge, no prior studies have evaluated this type of mass, widely distributed, VIP education.

Methods: This study is a prospective, single-arm, educational cohort study. We enrolled a convenience sample of all high school teachers attending FAST sessions at the Health Occupations Students of America–Future Health Professionals International Leadership Conference. Half of the participants were randomized to complete the Stop the Bleed Education Assessment Tool (SBEAT) prior to the webinar, and the other completed it afterward; SBEAT is a validated tool to measure learning of bleeding competencies. We then performed 76 VIP video-training sessions from June–August 2020. The FAST instructors assessed each participant's ability to apply a tourniquet and direct pressure individually, then provided interactive group skills training, and finally re-evaluated each participant's performance post-training.

Results: A total of 190 (96%) participants successfully applied a tourniquet after VIP training, compared to 136 (68%) prior to training ($P < 0.001$). Participants significantly improved their ability to apply direct pressure: 116 (56%) pre-assessment vs 204 (100%) post-assessment ($P < 0.001$). The mean score for the SBEAT increased significantly from pre-training to post-training: 2.09 with a standard deviation (SD) of 0.97 to 2.55 post-training with a SD of 0.72 ($P < 0.001$).

Conclusion: This study suggests that a webinar combined with VIP training is effective for teaching tourniquet and direct-pressure application skills, as well as life-threatening bleeding knowledge. VIP education may be useful for creating resuscitative medicine instructors from distributed locations, and to reach learners who cannot attend classroom-based instruction. [West J Emerg Med. 2021;22(4)951–957.]

INTRODUCTION

Trauma is the leading cause of death for Americans between the ages of 1-44 years old.[1] The 180 school shootings during the past decade, as well as recent evidence demonstrating the utility of early hemorrhage control in preventing deaths, has increased interest in training laypeople to treat injuries in school settings.[2-6] The challenge of educating the public to treat trauma increased since the coronavirus disease 2019 (COVID-19) pandemic began, especially since the normal classroom settings in which teachers and students learn were altered significantly.

In 2018 the Department of Homeland Security awarded a grant to the Uniformed Services University of the Health Sciences' (USU) National Center for Disaster Medicine and Public Health (NCDMPH) to create a nationwide, high school trauma-education program. This program, called First Aid for Severe Trauma™ (FAST™), is being developed by clinical and educational experts in collaboration with the American Red Cross.[7] FAST emphasizes recent military medical lessons, especially point-of-injury hemorrhage control championed by the national Stop the Bleed campaign.[8-10]

The FAST curriculum, which launches in August 2021, is designed to foster lifesaving knowledge and skills to aid a severely injured person prior to the arrival of an ambulance. It includes lessons about scene safety, effective communication among rescuers and with 911 dispatchers, differentiating life-threatening from non-life-threatening bleeding, using direct pressure and tourniquets to stop bleeding, and positioning of the injured. The FAST program will be offered in instructor-led, web-based, and blended (combination of web and instructor-led elements) formats. A 2020 study demonstrated high school students' ability to learn hemorrhage control knowledge and skills via these three educational modalities.[11] In this study, the students demonstrated strong proficiency for learning didactic content via all modalities. They also learned to apply tourniquets via all modalities, although the blended and instructor-led modalities led to better performance compared to the online-only version, which did not include skills practice.[11] A 2018 study showed that adults also have an ability to learn tourniquet application knowledge and skills via web-based instruction.[12]

Prior to the FAST program's nationwide launch in 2021, NCDMPH had planned to facilitate train-the-trainer sessions in June 2020 during the Health Occupations Students of America–Future Health Professionals International Leadership Conference (HOSA ILC), a live symposium with approximately 2000 health science teacher attendees, to prepare a nationwide group of teachers to become Red Cross FAST instructors. However, since the COVID-19 pandemic forced the HOSA ILC to become a virtual conference, we designed an educational program and accompanying research protocol for high school teachers to learn FAST concepts and materials as part of their FAST instructor training via "virtual" in-person(VIP) instruction.The process consisted of a group webinar followed by VIP instruction consisting of small-group skills practice via video calls using supplies shipped to the teachers' homes. These small groups re-emphasized material from the didactic session, and then used hands-on training to ensure skill competency. To our knowledge, no prior studies have evaluated this type of mass, widely distributed, VIP trauma or resuscitative medicine education.

Population Health Research Capsule

What do we already know about this issue?
Prompt hemorrhage control with a limb tourniquet can be lifesaving. Previous studies have shown lay adults' ability to learn tourniquet application via in-person training.

What was the research question?
Can laypeople learn bleeding control knowledge and skills from instructor-led virtual instruction?

What was the major finding of the study?
A webinar combined with "virtual" in-person skills training is effective for teaching hemorrhage control skills.

How does this improve population health?
Instructor-led virtual education may reach more learners than classroom-based instruction alone, thereby enhancing efforts to teach lifesaving medical skills.

METHODS

Study Design

This study is a prospective, single-arm, educational cohort study. The USU Institutional Review Board reviewed and approved it as an exempt educational study (protocol DBS 2020.116).

Study Setting and Population

Study enrollment occurred from June–August 2020. The didactics sessions were held during the virtual HOSA ILC from June 23–June 26, 2020, and the VIP skills training occurred during a series of 76 small-group video conference sessions from June 30–August 7, 2020. High school health education teachers who self-selected for a "train-the-trainer" session at the HOSA ILC were eligible to become provisional FAST instructors.

Study Protocol

The provisional FAST instructor training consisted of two components: a webinar for didactic material; and a VIP hands-on skill component. After attending both sessions,

participants received a completion certificate. Following the final FAST course release in 2021, provisional instructors can become certified Red Cross FAST instructors after completing an online bridge training that discusses specific course policies using the finalized content.

High school teachers attending the HOSA ILC signed up for the FAST train-the-trainer sessions while registering for the conference online. Session attendees were not required to participate in the research, there was no cost to attend the sessions, and participants received no compensation. After registration, we emailed attendees who signed-up for train-the-trainer sessions to ask whether they would participate in the research. Inclusion criteria included being a teacher signed up to attend a FAST train-the-trainer session. After reviewing the study's information sheet, 14 teachers declined to participate in the research, and all others assented to participate.

Participants provided demographic information and then received an appointment for one of five FAST webinars. At enrollment, half of the participants were randomly selected to complete the Stop the Bleed Education Assessment Tool (SBEAT) prior to each webinar, while the remaining half of the participants were instructed to complete the SBEAT within 48 hours after attending the webinar. We employed the SBEAT, which was previously validated in the general population, to measure learning outcomes for life-threatening bleeding competencies.[13,14] We elected to randomize participants to complete either the pre-or post-test SBEAT, which is supported by SBEAT's Rasch analysis, in an effort to avoid biasing results of the post-test.[15] By not priming learners for the upcoming webinar with a pre-test, we sought to increase the external validity of our results. Furthermore, we predicted a higher completion rate if participants were asked to complete only a single SBEAT test, rather than two. We used block randomization to create an equal sample size in the pre- and post-test SBEAT groups. Each didactic session was divided into two blocks, which were thereafter randomized in an A-B-B-A order, with "A" representing pre-test and "B" representing post-test (ie, the first block of the first didactic session and the second block of the second didactic session were both assigned to take the pre-test SBEAT). An a priori power analysis was not performed, as we enrolled a convenience sample of all participants who enrolled in the FAST training.

The webinar included a standardized PowerPoint (Microsoft Corporation, Redmond, WA) lecture with embedded videos, animations, and images derived from the draft FAST materials, as well as an interactive question-and-answer session. The sessions lasted approximately two hours and were all taught by the same emergency physician who is a FAST curriculum expert. Following the completion of the webinar, participants were scheduled for the VIP skills training. Military medical students at USU who had been trained as FAST instructors previously, hosted VIP hands-on skills sessions with groups of three to five participants per session. One or two instructors led each session, and all sessions lasted about an hour. The sessions occurred in a standardized format, and instructors used scripts for consistency. Training supplies, including a windlass rod tourniquet (a generation 6 or 7 Combat Application Tourniquet) and a limb simulator were shipped to participants prior to the training. The study team emailed Google Meet or Zoom weblinks for the sessions to participants in advance of their sessions.

At the beginning of each VIP session, the FAST instructors assessed each participant's ability to apply a tourniquet and direct pressure correctly by meeting with each participant in separate virtual rooms. The participant applied the tourniquet to the limb simulator. The instructor, watching via webcam, determined whether the tourniquet application was successful by using a checklist to assess the technique, positioning, and tightness. A similar checklist has been used in multiple prior studies to evaluate proper tourniquet application.[11,12,16,17] The instructor did not provide feedback or corrections during this pre-assessment phase. Next, the instructor evaluated each participant's ability to perform direct pressure by observing the participant apply direct pressure to the limb simulator using the "cardiopulmonary resuscitative (CPR) posture" taught during the webinar.[18] An instructor scored the participant's direct pressure as successful, if he or she applied pressure to the wound using the appropriate posture, and the limb simulator was deformed from body weight.

After the pre-assessment, instructors facilitated an interactive group session with the participants to describe and demonstrate the skills of tourniquet and direct pressure application, highlight points from the didactic webinar, and allow for group practice and clarifying questions with instructor feedback. The primary focus of these VIP sessions was learner skill acquisition. Following the group session, each participant returned to a separate virtual room with a single instructor for repeat evaluation of the participant's tourniquet and direct pressure application skills. The instructor performed the post-assessment using an identical checklist to the pre-assessment. Each participant had up to two opportunities to perform tourniquet and direct pressure application correctly. If a participant failed after the first attempt, the instructor provided corrective instruction prior to performing the second attempt. Participants who did not perform a skill successfully after two attempts were remediated to ensure they could perform the skills; however, the performance was counted as a failure for the purposes of study enrollment.

Key Outcome Measures

The primary outcome of the study was successful performance of tourniquet and direct pressure application. Secondary outcomes included performance on the SBEAT, time for tourniquet application, and reasons for tourniquet application failure.

Data Analysis

The data gathered about tourniquet application, specifically the location, the tightness, and the completion of all steps, and data about direct pressure, specifically regarding correct CPR posture, are presented as binary outcomes, with attempts being either successful or not successful. The amount of time participants took to apply a tourniquet is presented as a continuous outcome. Comparisons between pre- and post-training skill difference were conducted using a paired-sample *t*-test for the continuous outcome and chi-square tests for the binary outcomes. We conducted all analyses using two-tailed tests, and *P* values less than 0.05 were considered statistically significant. Analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) software version 25.0 (IBM Corporation, Armonk, NY).

Demographic information is presented as counts and percentages for categorical data and as means and standard deviations (SD) for continuous data. We transformed SBEAT item-response data, which are non-equal scores, to a linear measure through Rasch modeling, yielding individual person measures using Winsteps 2020 software (Zoominfo Technologies, LLC, Beaverton, OR). Rasch modeling calculates linear person ability estimates (interval scale) that can then be statistically assessed. Scores can range from –4 to 4, where 0 refers to a 50/50 probability of success.[19] Independent *t*-tests were then performed in IBM SPSS software version 26.0 to identify differences between groups in pre- and post-test scores.

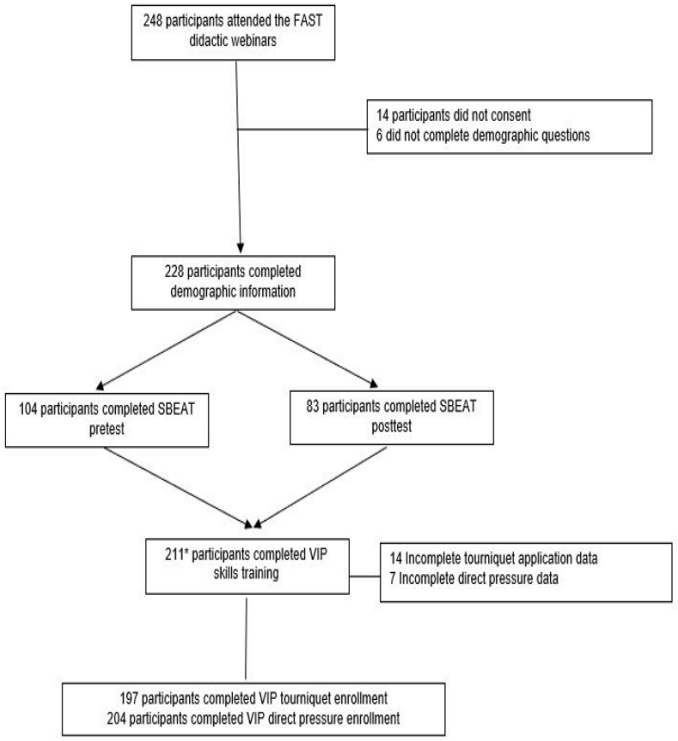

Figure 1. Study flow.
FAST, First Aid for Severe Trauma; *SBEAT,* Stop the Bleed Education Assessment Tool; *VIP,* virtual-in-person.

RESULTS

A total of 248 high school teacher participants attended the FAST webinars. Of these, 228 participants completed the demographic information questions, 211 completed the VIP skills training, and 187 completed the SBEAT (Figure 1). Of the participants 208 (91%) were female, and the average age was 46 with a range of 23–70 years old (Table 1). The participants had an average of 12 years of teaching experience with a SD of eight years, and 83% had bachelor's or master's degrees. Teachers from 45 of the United States and Washington, DC, participated in the study (Figure 2).

A total of 190 (96%) participants successfully completed tourniquet application after VIP training, compared to 136 (68%) prior to training ($P < 0.001$) (Table 2). Participants also significantly improved their ability to apply direct pressure correctly with 116 (56%) participants performing it correctly during the pre-assessment and 204 (100%) performing direct pressure correctly after VIP training ($P < 0.001$). The primary reason participants did not apply the tourniquet correctly was due to inadequate tightness. This error decreased significantly post-training (3 [2%]) compared to pre-training (36 [18%]) ($P < 0.001$). The mean time to apply a tourniquet decreased from 42 seconds pre-training to 29 seconds post-training ($P < 0.001$).

Of the 187 participants who completed the SBEAT, 104 completed the pre-test and 83 completed the post-test. The mean score for SBEAT at pre-training was 2.09 with a SD of 0.97 and the mean score for SBEAT at post-training was 2.55 with a SD of 0.72, which was a statistically significant difference ($P < 0.001$).

DISCUSSION

This study suggests that synchronous web-based and "virtual" hands-on training are effective for teaching the technical skills of tourniquet and direct pressure application, as well as the cognitive knowledge of life-threatening bleeding, contained in the FAST course. Sixty-eight percent of study participants applied tourniquets correctly following the webinar didactic, and prior to the VIP training. This is similar to the 75% of successful tourniquet applications found in a 2018 study assessing the public's ability to apply tourniquets after web-only training.[12] Following the VIP skills training, the participants demonstrated statistically significant improvement of their tourniquet skill demonstrations with 96% of participants applying a tourniquet correctly, and 100% of participants performing direct pressure application correctly. This is similar to the 88% of successful tourniquet applications found after in-person training following a Stop the Bleed course.[20] Unfortunately, due to the COVID-19 pandemic, we could not execute the desired in-person training control arm of this study, and its absence prevents us from making conclusions about non-inferiority or superiority of the VIP training to in-person training.

Table 1. Participant demographics.

	Mean (SD) or n (%)
Age	46 (10)
Years of teaching experience	12 (8)
Gender	
Male	19 (8)
Female	208 (91)
Race	
White	207 (91)
Black or African American	9 (4)
Asian	7 (3)
American Indian or Alaska Native	1 (0)
Native Hawaiian and Pacific Islander	1 (0)
Other or multiple race	3 (1)
Ethnicity	
Hispanic origin	15 (7)
Not hispanic origin	209 (92)
Highest level of education	
High school	6 (3)
Bachelor's degree	81 (36)
Master's degree	110 (48)
Doctorate degree	13 (6)

SD, standard deviation.

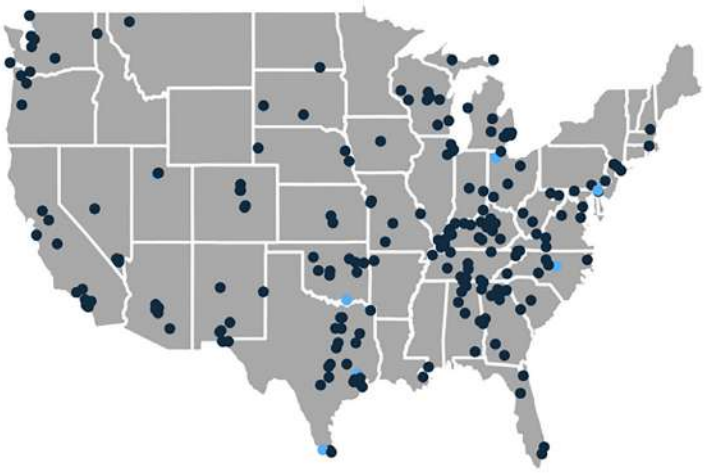

Figure 2. Locations of high school teachers trained during study. *Light color dots indicate multiple people in the same area.

The SBEAT analysis showed statistically significant improvement in participant knowledge demonstration from the pre- to post-test. The instrument noted good item separation from novice to expert in the knowledge and behaviors of life-threatening bleeding, which is the primary focus of the FAST course. Similar to previous studies assessing the public's ability to learn Stop the Bleed knowledge with brief education, the significant difference between the pre- and post-test SBEAT scores in this study demonstrates that the public can learn hemorrhage control knowledge rapidly using a variety of modalities.[11,12]

This study provides the field of first aid and resuscitative education proof of concept that harmonization of knowledge and skills can be achieved through synchronous online modalities. The combination and sequence of the introduction of FAST concepts via webinar followed by individual practice and validation via VIP skills practice led to the improvement of learning outcomes. Training and educational organizations that previously relied on face-to-face interactions can use this approach to maintain or expand their cohort of educators. Specific to the development of FAST instructors, this process may serve as a multiplier to disseminate training more broadly by reducing costs and increasing access, which is a known barrier to implementing resuscitative medicine programs.[21] Furthermore, VIP training can reduce the need for classroom-based training and its associated challenges, such as finding childcare and transportation, even during non-pandemic times.[22] The VIP concept could be tailored to include additional elements. As an example, since our study participants were all active high school teachers, our VIP train-the-trainer process did not include a requirement for participants to "teach" the new material they had just learned. A "demonstration of teaching" could be adopted readily to a VIP model if needed.

This proof of concept of VIP skills training may have significant utility, especially during this time of a global pandemic without a clear endpoint in sight. There is an ongoing need for the public to complete a variety of types of resuscitative medicine and public health training, such as CPR and workplace first aid, in addition to hemorrhage control. This study could serve as a model for other trainings to be conducted from the safety and convenience of people's homes. The study is consistent with a growing body of literature that alternative modalities of education, such as airport kiosks, videos, and just-in-time education, are feasible for teaching resuscitative medicine knowledge and skills.[11,12,16,17,23-25]

LIMITATIONS

This study has several limitations. The low-fidelity limb simulator used in the study could not provide real-time pressure data for direct pressure application, although we think it supported adequate remote skill assessment. While the study design increased external validity by reducing test-retest bias and participant priming for the course, having two separate groups take the pre- and post-test limited the ability to conclude that the groups taking the SBEAT were not significantly different. The skill teaching and assessment were not blinded to the participant or evaluator, which may have introduced bias. Since the pandemic precluded the ability to implement an in-person education control arm, no direct comparison to another educational modality could be

Table 2. Results for primary and secondary outcomes.

Binary variables	Pre-training n (%)	Post-training n (%)	P-value
Successful tourniquet application	136 (68%)	190 (96%)	< .001
Reasons for failed tourniquet application			
Incorrect location	24 (12%)	4 (2.0%)	< .001
Inadequate tightness	36 (18%)	3 (2%)	< .001
Failure to complete all steps	36 (18%)	3 (2%)	< .001
Correct direct pressure application	116 (56%)	204 (100%)	< .001
Continuous variables	Mean (SD)	Mean (SD)	P-value
SBEAT score	2.09 (0.97)	2.55 (0.72)	< .001
Time of tourniquet application (seconds)	41.55 (25.03)	28.60 (12.66)	< .001

SBEAT, Stop the Bleed Education Assessment Tool.

made. However, given the extremely high performance of participants in this study, as well as supporting data from other studies, we have little reason to suspect that in-person training would be dramatically different.[11,20]

This study did not assess knowledge or skill retention. Multiple studies have demonstrated the rapid degradation of resuscitative medicine skills by the public, including an in-person hemorrhage control education study that showed a decrease in successful tourniquet application of about 40% in just a few months.[20,25] It would be important to consider the need for re-training, periodic assessment, or learning adjuncts for anyone trained via a VIP instructional modality. The Red Cross FAST course will require instructors to teach a minimum number of courses and re-certify periodically to maintain credentials.

Generalizability across the US population may also be limited as the participants were predominantly female, White, well educated, had access to remote learning technology, and worked as health science educators. The study also trained people who desired to become instructors, rather than an undifferentiated learner population, so the results may be biased by a highly motivated learner population. While these results may or may not be directly translatable to other populations, it is likely that other groups of learners desiring to become instructors would be similarly motivated. It is also noted that studies of the undifferentiated general public have demonstrated similar performance in knowledge and skills after web and in-person training.[12,20]

CONCLUSION

This study suggests that a didactic webinar combined with "virtual" in-person skills training is effective for teaching the cognitive hemorrhage-control knowledge and the technical skills of tourniquet and direct pressure application. This VIP educational modality may be particularly useful for building or expanding new resuscitative medicine instructors from broad geographic locations, as well as for educators who would like to reach a broader audience than those who can or will attend classroom-based instruction.

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A Review of COVID-19-Related Publications and Lag Times During the First Six Months of the Year 2020

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Introduction: Considering the need for information regarding approaches to prevention and treatment of coronavirus disease 2019 (COVID-19), we sought to determine publication lag times of COVID-19-related original research articles published in top general medicine and emergency medicine (EM) journals. We further sought to characterize the types of COVID-19 publications within these journals.

Methods: We reviewed 125 top-ranked general medicine journals and 20 top-ranked EM-specific journals for COVID-19-related publications. We abstracted article titles and manuscript details for each COVID-19-related article published between January 1–June 30, 2020, and categorized articles as one of the following: original research; case report; review; or commentary. We abstracted data for preprint publications over the same time period and determined whether articles from the general medicine and EM journals had been previously published as preprint articles. Our primary outcomes were the following: 1) lag time (days) between global cumulative World Health Organization (WHO)-confirmed cases of COVID-19 and publications; 2) lag times between preprint article publication and peer-reviewed journal publication; and 3) lag times between submission and publication in peer-reviewed journals. Our secondary outcome was to characterize COVID-19-related publications.

Results: The first original research publications appeared in a general medicine journal 20 days and in an EM journal 58 days after the first WHO-confirmed case of COVID-19. We found median and mean lag times between preprint publications and journal publications of 32 days (19, 49) and 36 days (22) for general medicine journals, and 26 days (16, 36) and 25 days (13) for EM journals. Median and mean lag times between submission and publication were 30 days (19, 45) and 35 days (13) for general medicine journals, and 23 days (11, 39) and 27 days (19) for EM journals. Of 2530 general medicine journal articles and 351 EM journal articles, 28% and 23.6% were original research. We noted substantial closing of the preprint to peer-reviewed publication (160 days pre-pandemic) and peer-reviewed journal submission to publication (194 days pre-pandemic) lag times for COVID-19 manuscripts.

Conclusion: We found a rapid and robust response with shortened publication lag times to meet the need for the publication of original research and other vital medical information related to COVID-19 during the first six months of 2020. [West J Emerg Med. 2021;22(4)958–962.]

INTRODUCTION

The first reports of coronavirus disease 2019 (COVID-19) surfaced in December 2019. COVID-19 has infected nearly 173 million people and claimed more than 3.7 million lives globally as of June 7, 2021, ushering in a need for rapid dissemination of information and original research regarding approaches to prevention and treatment.[1,2] Given this need for critical information, we sought to determine publication lag times of COVID-19-related original research articles published in the top-ranked 125 general medicine journals and the top 20 emergency medicine (EM) journals during the first six months of the year 2020. We further sought to characterize the types of COVID-19-related publications in these top-ranked journals.

METHODS

We abstracted data regarding World Health Organization (WHO)-confirmed COVID-19 cases and deaths from the WHO COVID-19 dashboard.[1] We reviewed the 125 top-ranked, peer-reviewed journals under the category of "medicine," as ranked by the *Scimago* Journal & Country Rank website for articles published between January 1–June 30, 2020.[3] We included all journals listed in this category, regardless of focus (clinical vs lab) and excluded the one journal that required login to access article titles and abstracts. No EM journals were ranked in the top 125 general medicine category. We reviewed the 20 top-ranked, peer-reviewed EM journals as ranked in a recent EM journal review for the same time period.[4]

Outcomes

Focusing on original research articles from the top peer-reviewed general medicine and EM journals, our primary outcome was to determine lag times (days) between 1) global cumulative WHO-confirmed cases of COVID-19 and peer-reviewed journal publications; 2) preprint publication of articles and publication in peer-reviewed journals; and 3) submissions to peer-reviewed journals and publication within these journals. Our secondary outcome was to characterize COVID-19-related publications.

We performed data collection using a systematic approach designed by the senior and lead author, who generated a written template and algorithm for data abstraction. They conducted individual and group orientation meetings with the other authors. The lead author conducted weekly meetings to assure continued consistency, and reviewed samples of the data with the other abstractors for real-time data quality assurance. We searched all the remaining 144 journals' official publication websites using their embedded search functions. We used the keywords "COVID-19" OR "SARS-CoV-2" OR "coronavirus" to abstract article titles and manuscript details, including date of publication, date of submission, and primary author's country affiliation. When available on some websites, a "COVID-19 collection" of articles was used for article abstraction in leu of a keyword search. We included all articles in the keyword and "COVID-19 collections" searches.

We screened and abstracted articles according to standard definitions of study designs derived from the *JAMA* "Instructions for Authors: Determine my Study Type": original research (presentation of original data); case report (single patient presentation); review (literature summary on a given topic); or commentary (correspondence, editorials, perspectives, news, and proposed guidelines). We further classified original research articles into the following categories (more than one option applicable): case series; case-control; cohort (retrospective and prospective); cross-sectional survey; randomized control trial (RCT); drug trial; basic science/laboratory; epidemiological; or observational-other. We defined epidemiological studies as those that focused on surveillance, modeling or tracking the spread of COVID-19. We defined "observational-other" as prospective and retrospective observational study designs not meeting the standard, aforementioned observational design definitions. Most of these studies were published as correspondence (letters). Categorizations were reviewed by the lead and senior author.

We abstracted data for preprint publications from the Dimensions database (Digital Science & Research Solutions Ltd, London, England), a repository using artificial intelligence and machine learning to compile information pertaining to the complete research cycle, over the same time period (January 1–June 30, 2020).[5] We screened the Dimensions data abstracted and determined whether articles from the top general medicine and EM journals had been previously published as preprint articles.

We calculated median (interquartile range [IQR]) and mean (standard deviation [SD]) lag times between article preprint publication and peer-reviewed journal publication, and between article submission and publication in peer-reviewed journals. We did not intend to compare lag times between the two groups of journals (general medicine and EM), and therefore did not perform hypothesis testing or other statistical comparisons.

Because of the exponential increase in numbers over time, we present data regarding total numbers of COVID-19 cases, deaths, and publications on a logarithmic scale to allow for more practical visual inspection. We included COVID-19 deaths in the figure to add another critical perspective regarding the burden of the pandemic, although not explicitly measured in our original outcomes.

RESULTS

125 Top-Ranked General Medicine Journals

The first three original research articles were published on January 24, 2020, 20 days after the first WHO-confirmed case of COVID-19.[1] The median (IQR) and mean (SD) lag times between preprint publication and peer-reviewed journal publication were 32 days (19, 49) and 36 days (22). The median and mean lag times between submission to and publication in peer-reviewed journals were 30 days (19, 45) and 35 days (13). Data for lag times was normally distributed. Of the 2,530 COVID-19-related articles published from

January 1–June 30, 2020 in the 125 top general medicine journals, 1565 (61.9%) were commentaries, 709 (28.0%) were original research, 173 (6.8%) were reviews, and 83 (3.3%) were case reports. We found 74 unique countries of primary author affiliation, most commonly the United States (40%), the United Kingdom (16.7%), and China (13.4%) (Table 1). Of the 709 original research articles, the top three study designs were observational-other (205 [28.9%]), epidemiological (124 [17.5%]), and case-series (103 [14.5%]). Of the 17 clinical trials published, 10 (1.4% of all original research articles) were randomized control trials (RCT); the other seven clinical trials were non-randomized drug trials. One hundred and eight (15.2%) of the original research publications were previously published on preprint servers, and 282 (37.8%) had article original submission dates publicly available.

Table 1. Characteristics of the 125 top-ranked general medicine journal articles published between January 1, 2020 and June 30, 2020.

	n (%)
General Medicine Journal Article Type (n=2,530)	
Commentary	1,565 (61.9)
Original research	709 (28.0)
Observational- other	205 (28.9)
Epidemiological	124 (17.5)
Case Series	103 (14.5)
Cohort	80 (11.3)
Basic Science/ laboratory	79 (11.1)
Survey	56 (7.9)
Case control	25 (3.5)
Cross sectional	20 (2.8)
Clinical trial	17 (2.4)
Review	173 (6.8)
Case report	83 (3.3)
Primary author country of origin	Articles published
United States	1,011 (40.0)
United Kingdom	422 (16.7)
China	339 (13.4)
Italy	190 (7.5)
France	74 (2.9)
Canada	69 (2.7)
Germany	56 (2.2)
Singapore	45 (1.8)
Switzerland	38 (1.5)
Spain	34 (1.3)

20 Top-Ranked Emergency Medicine Journals

The first original research article in an EM journal was published on March 2, 2020, 58 days after the first WHO-confirmed case of COVID-19.[1] The median (IQR) and mean (SD) lag times between preprint publication and EM journal publication were 26 days (16, 36) and 25 days (13). The median and mean lag times between article submission and publication within EM journals were 23 days (11, 39) and 27 days (19). Data for lag times was normally distributed.

Of the 351 COVID-19-related articles published from January 1–June 30, 2020 in the 20 top EM journals, 191 (54.4%) were commentaries, 83 (23.6%) were original research, 49 (14%) were reviews, and 28 (8%) were case reports. We found 28 unique countries of primary author affiliation, most commonly the United States (40.7%), Italy (13.7%), and Canada (10.3%) (Table 2). Of the 83 original research articles, the top three study designs were observational-other (41 [49.4%]), cohort (13 [15.7%]), and survey (8 [9.6%]). We found only one (1.2%) clinical trial (non-randomized). Nine (10.8%)

Table 2. Characteristics of the 20 top-ranked emergency medicine journal articles published between January 1, 2020 – June 30, 2020.

	n (%)
Emergency Medicine Journal Article Type (n=351)	
Commentary	191 (54.4)
Original research	83 (23.6)
Observational- other	41 (49.4)
Cohort	13 (15.7)
Survey	8 (9.6)
Basic Science/ laboratory	7 (8.4)
Case Series	6 (7.2)
Cross sectional	4 (4.8)
Case control	2 (2.4)
Epidemiological	1 (1.2)
Clinical trial	1 (1.2)
Review	49 (14.0)
Case report	28 (8.0)
Primary author country of origin	Articles published
United States	143 (40.7)
Italy	48 (13.7)
Canada	36 (10.3)
China	18 (5.1)
Spain	13 (3.7)
United Kingdom	11 (3.1)
France	10 (2.8)
Taiwan	9 (2.6)
Australia	8 (2.3)
India	8 (2.3)

of the original research publications were previously published on preprint servers, and 67 (80.7%) had article original submission dates publicly available.

In the figure we present a graph of numbers of cumulative global COVID-19 cases, deaths, top 125 general medicine journal articles, top 20 EM journal articles, original research general medicine and EM journal articles, and preprint articles plotted logarithmically across the first six months of the year 2020. The figure demonstrates relatively symmetric and parallel curves with the slopes of the top 125 general medicine and EM journal original research publications lagging roughly one and three months behind the pandemic curve, respectively.

DISCUSSION

In this review of COVID-19-related publications in top general medicine and EM journals we found a rapid and robust response to meet the need for original research and other vital medical information during the first six months of 2020. Within one month, COVID-19 publications in the top 125 general medicine journals skyrocketed and the slopes of subsequent publications mirrored the slope of the pandemic. Emergency medicine journal publications and EM journal original research publications lagged roughly two and three months behind the pandemic curve, respectively. While original research constituted just one quarter of all COVID-19 journal article publications, the rapidity of its production remains nevertheless impressive.

Given their greater complexity, the lack of early RCTs is not surprising. The first randomized controlled drug trial, which evaluated the effectiveness of a lopinavir–ritonavir combination, was published on March 18, 2020, 74 days after the first WHO-confirmed case. Two more RCTs were published in April, five in May, and two in June. The first and only clinical trial within the EM-specific journals (evaluating the effectiveness of plasma taken from convalescent donors) was published on May 28, 2020, 145 days after the first WHO-confirmed case.

A number of mechanisms are available to accelerate dissemination of critical research findings. Prior to or in tandem with submission to peer-reviewed journals, investigators can choose to publish their work on preprint servers for immediate dissemination. Concerns about inadequate review and controls for validity notwithstanding, preprint publication may afford investigators the added benefits of gaining feedback and claiming provenance of an idea.[6] Journal editors can also accelerate publication and rejection of manuscripts by leveraging *fast-tracking* protocols.[7] Although we did not find specific language in journal mastheads regarding fast-tracking of COVID-19 articles, journal editors and reviewers may have informally adopted this practice.

Investigating the lag time between preprint publication and journal publication dates, Herbert et al evaluated 8711 articles published on the preprint repository bioRxiv in 2019 and found a median lag time of 160 days.[8] We found only 15.2% and 10.8% of original research articles published in general medicine and EM journals had been deposited on preprint repositories. However, a closing of the preprint-peer review publication gap for COVID-19 manuscripts was noted with

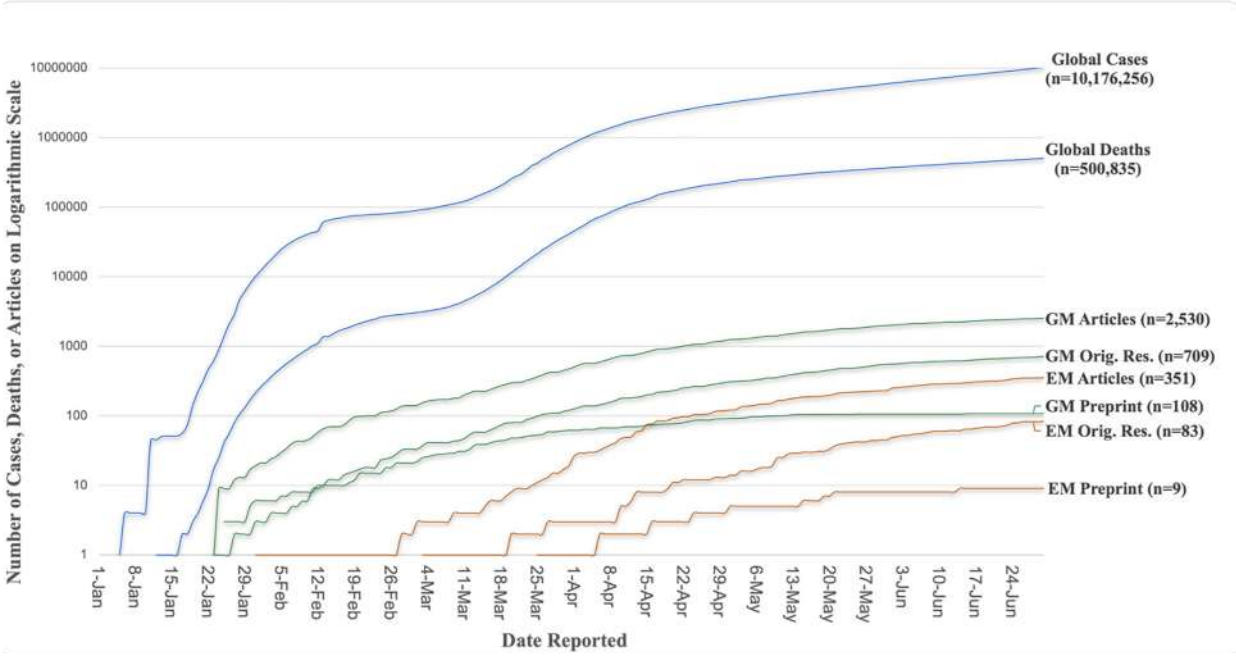

Figure. Global COVID-19 cases and deaths compared to journal publications over time.
GM articles, 125 top general medicine journal article publications; GM Orig. Res., 125 top general medicine journal original research article publications; GM Preprint, 125 top general medicine journal original research articles published as preprint articles; EM Articles, 20 top emergency medicine (EM) journal articles published; EM Orig. Res., 20 top EM journal original research articles published; EM Preprint, 20 top EM journal original research articles published as preprint articles.

significantly shorter median lag times of 32 days and 26 days for general medicine and EM journals, respectively, consistent with the findings of Krumholz et al (46 days for COVID-19 vs 141 days for non-COVID-19 papers).[9]

There is little prior literature regarding baseline lag times before the COVID-19 pandemic. In 2019, Shan et al found a median lag time between article submission and publication of 194 days for articles published in the *British Medical Journal* (included in the top 125 general medicine journals).[10] In terms of EM journals, the only relevant study is one we published in which we characterized a different metric – median decision times (time from submission to a decision).[4] Nevertheless, the relatively short 30-day general medicine journal and 23-day EM journal median lag times between initial submission and publication date suggest that journals are expediting reviews and publication decisions, either through a formal fast-track process or otherwise.

The longer delay for original research to appear in EM-specific journals may be due to investigators' customary submission process of starting with the highest impact factor journals and working their way down – most of the top 125 journals have substantially higher impact factors than the EM journals.[4] Drawing articles from all fields of medicine and public health instead of just EM-related topics, the broader scope of general medicine journals may also contribute to faster emergence of COVID-19 publications in these journals.

LIMITATIONS

The main limitation of this work is that we only reviewed articles from the top journals as assessed by one organization (*Scimago*) and one group of EM investigators. Sixty-two general medicine and six EM journals published fewer than five COVID-19-related articles. Numbers of COVID-19 articles, percentages of original research, and lag times may differ for publications in other medical journals not on these lists. Another limitation, as mentioned above, is that we do not have standardized true baselines for pre-COVID-19 pandemic lag times. Additionally, although the lead and senior authors reviewed the other abstractors' categorizations, these classifications may still be subjective and we did not calculate inter-rater reliability. Finally, the over-representation of observational study designs in COVID-19 publications may skew the data toward shorter median lag times.

CONCLUSION

We found remarkably short publication lag times at the early stage of the COVID-19 pandemic, indicating that journal editors and reviewers responded appropriately to the need for vital information. Yet with over 13,000 worldwide COVID-19-related deaths per day on average in January 2021,[1] editors and journal managers should seek to streamline review and publishing processes even further. If the speed of the peer-review process has reached its ceiling, preprint publications may serve to bridge the critical need for relevant information during times of medical crisis.

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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.

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Evaluating Reproducibility and Transparency in Emergency Medicine Publications

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Introduction: We aimed to assess the reproducibility of empirical research by determining the availability of components required for replication of a study, including materials, raw data, analysis scripts, protocols, and preregistration.

Methods: We used the National Library of Medicine catalog to identify MEDLINE-indexed emergency medicine (EM) journals. Thirty journals met the inclusion criteria. From January 1, 2014–December 31, 2018, 300 publications were randomly sampled using a PubMed search. Additionally, we included four high-impact general medicine journals, which added 106 publications. Two investigators were blinded for independent extraction. Extracted data included statements regarding the availability of materials, data, analysis scripts, protocols, and registration.

Results: After the search, we found 25,473 articles, from which we randomly selected 300. Of the 300, only 287 articles met the inclusion criteria. Additionally, we added 106 publications from high-impact journals of which 77 met the inclusion criteria. Together, 364 publications were included, of which 212 articles contained empirical data to analyze. Of the eligible empirical articles, 2.49%, (95% confidence interval [CI], 0.33% to 4.64%] provided a material statement, 9.91% (95% CI, 5.88% to 13.93%) provided a data statement, 0 provided access to analysis scripts, 25.94% (95% CI, 20.04% to 31.84%) linked the protocol, and 39.15% (95% CI, 32.58% to 45.72%) were preregistered.

Conclusion: Studies in EM lack indicators required for reproducibility. The majority of studies fail to report factors needed to reproduce research to ensure credibility. Thus, an intervention is required and can be achieved through the collaboration of researchers, peer reviewers, funding agencies, and journals. [West J Emerg Med. 2021;22(4)963-971.]

INTRODUCTION

Reproducible research is a hallmark of the scientific enterprise. The National Science Foundation defines reproducibility as "the ability of a researcher to duplicate the results of a prior study using the same materials and procedures" and considers reproducibility "a minimum necessary condition for a finding to be believable and informative."[1,2] Similarly, the National Institutes of Health (NIH) has implemented a rigor and reproducibility initiative for federally funded studies after NIH leadership called for "immediate and substantive action" to be taken to address the reproducibility crisis.[3] Reproducibility occurs when independent investigators are able to validate a study's findings using resources such as raw data, analysis scripts, study materials, and the protocol provided by the original investigators,[2] and it is crucial to establishing credible and reliable research that governs clinical practice.

The current reproducibility problem in biomedical literature is cause for concern because up to 90% of preclinical

research may not be reproducible.[4] The reproducibility of emergency medicine (EM) studies is unclear and warrants further attention. A 2017 study found that only 4% of simulation-based education studies—which comprise one-quarter of all EM studies—provided the materials necessary to reproduce the intervention.[5] Niven et al[6] conducted a scoping review of reproducibility attempts for clinical studies in the critical care literature and reported that more than half of these attempts failed to demonstrate effects consistent with the original investigation. Thus, the limited available evidence calls into question the reproducibility of EM research.

The importance of reproducible findings is well illustrated by the controversy within the EM community over research on tissue plasminogen activator (tPA) for acute ischemic stroke. Some emergency physicians believe that of the 13 major randomized controlled trials conducted to evaluate the efficacy of tPA in stroke patients, only two provided evidence supporting its use. Among the 11 remaining studies, seven found no significance, three were terminated prematurely because of patient harm, and one provided evidence of increased mortality.[7,8] However, the current clinical guidelines from the American College of Emergency Physicians recommend the use of tPA with moderate clinical certainty.[9] Relying heavily on evidence from the two major trials with positive results, which have not been reproduced in the other 11 major trials, showcases the importance of reproducibility to generate stable results because standards of care may be affected.

Given the recent attention to the reproducibility crisis in science and the limited knowledge of study reproducibility in the EM literature, we undertook an investigation to explore the current climate of reproducible research practices within the EM research community. We applied indicators of reproducible research practices developed by Hardwicke et al[10] to a broad, random sample of EM literature to evaluate whether investigators used reproducible research practices and provided necessary documentation for subsequent reproduction attempts. Ultimately, results from this investigation may serve as baseline data to determine whether reproducible practices improve over time.

Population Health Research Capsule

What do we already know about this issue?
Most biomedical research cannot be reproduced due to lack of key information (ie, reproducibility indicators) in the published research.

What was the research question?
Does this relationship of lack of reproducibility indicator sharing and irreproducible research hold true in emergency medicine (EM)?

What was the major finding of the study?
Nearly all of EM research is lacking indicators of reproducibility which makes assessing the reliability of EM research and its findings difficult.

How does this improve population health?
By addressing irreproducibility, others can confirm EM research findings through reproducing a study. This is important as EM research dictates the standard of care in EM.

MATERIALS AND METHODS

This study was observational and used a cross-sectional design based upon the methodology of Hardwicke et al,[10] with modifications. Our study is reported in accordance with guidelines for meta-epidemiological methodology research.[11] To aid in reproducibility, we have uploaded pertinent materials for this study onto the Open Science Framework (https://osf.io/n4yh5/).

Journal and Study Selection

We used the National Library of Medicine (NLM) catalog to search for all journals, using the subject terms tag "Emergency Medicine[ST]." This search was performed on May 29, 2019. The inclusion criteria required that journals were in English and MEDLINE-indexed. The final list of journals had the electronic International Standard Serial Number (ISSN) extracted (or linking ISSN if electronic was unavailable) to be used in a PubMed search. The PubMed search was performed on May 31, 2019. We limited our search to studies published from January 1, 2014–December 31, 2018. From the final list of studies and using the RANDBETWEEN function in Excel (Microsoft Corp., Redmond, WA), we assigned a random number to each and sorted them from lowest to highest value. The top 300 studies were chosen to be coded with additional studies available if necessary. Studies found from our search string are found: (https://osf.io/2964g/).

After peer review, we expanded the search strategy to include EM publications from high-impact factor general medicine journals. These four non-EM journals (*New England Journal of Medicine, Lancet, Journal of the American Medical Association, and British Medical Journal*) were based on Google Scholar Metrics and the H-5 index. PubMed was searched using these journals and a search string based on one from Brown et al[12]. We have included the exact search string here: (https://osf.io/rg8f5/). From this search, a total of 106 EM publications from the four non-EM journals were sampled.

Data Extraction Training

Two investigators assigned to data extraction (BJ and SR) underwent a full day of training to ensure reliability. The training began with an in-person session that familiarized the two investigators with the standardized protocol, Google extraction from, and areas for which data may be located within two standardized practices publications. The authors were given three example articles from which to extract data independently. Following extraction, the investigators reconciled differences between data. This training session was recorded and listed online for reference (https://osf.io/tf7nw/). As a final training example, the investigators extracted data from the first 10 articles in their specialty list followed by a final consensus meeting. Data extraction on the remaining 290 articles was then conducted. A final consensus meeting was held by the pair to resolve disagreements in which the investigators were able to reference the original articles to settle disputes. A third author was available for adjudication, if necessary.

Data Extraction

Data extraction on the remaining 290 articles was conducted in a duplicate and blinded fashion. A final consensus meeting was held by the pair to resolve disagreements. A third author (DT or MV) was available for adjudication but was not required. A pilot-tested Google Form was created based on the one provided by Hardwicke et al,[10] with additions. This form prompted coders to identify whether a study had important information necessary to be reproducible, such as the availability of data, materials, protocols, and analysis scripts (https://osf.io/3nfa5/). The data extracted varied, based on the study design, with studies having no empirical data being excluded (eg, editorials, commentaries [without reanalysis], simulations, news, reviews, and poems). In our form, we included the five-year impact factor, if available, and the impact factor for the most recent year found. We also expanded the options of the study design to include cohort, case series, secondary analysis, chart review, and cross-sectional. Finally, we increased the funding options from public, private, or mixed to be more specific, such as university, hospital, public, private/industry, nonprofit, and mixed.

Open Access Availability

Open access evaluation is a necessary aspect of our reproducibility analysis due to paywalls preventing others from accessing the components of reproducibility. We analyzed publications for accessibility through the openaccessbutton.org. Investigators used publication's title or digital object identifier (DOI) to search the open access website. If openaccessbutton.org was not successful in providing access to the manuscript, the investigators searched for access through Google (https://www.google.com/) and PubMed (https://www.ncbi.nlm.nih.gov/pubmed/).

Statistical Analysis

We report descriptive statistics for each category with 95% confidence intervals (CI), using Microsoft Excel.

RESULTS

Sample Characteristics

Our search of the NLM catalog identified 52 journals, with only 30 meeting our inclusion criteria. The ISSN for each of these journals was used in a PubMed search, yielding 90,380 publications. For this analysis, we included 25,473 publications from January 1, 2014–December 31, 2018. We randomly sampled 300 publications from this list. Additionally, we included a second search string that resulted in 106 publications from the *New England Journal of Medicine, Lancet, JAMA,* and *BMJ* to be added to our analysis.

We assessed articles from EM journals with a broad range of most recently available impact factors (median 2.333, range 1.408 to 5.441). A total of 406 articles were assessed, with 364 eligible for inclusion. The 42 ineligible article had full texts that were inaccessible or were not related to EM (Figure 1). Other sample characteristics are presented in Table 1.

Reproducibility and Related Characteristics

The number of studies that included each indicator of reproducibility and the significance of the indicator can be found in Supplementary Table 1. Among the 364 eligible articles, 122 (33.52%; 95% CI, 28.67% to 38.37%) were publicly available through the OpenAccess website, 127 (34.89%; 95% CI, 29.99% to 39.79%) were accessible through other means, and 115 (31.59%; 95% CI, 26.81% to 36.37%) were accessible only through a paywall. A variety of tools are used to describe how a research study is performed, including research protocols (may include the hypothesis, methods, and analysis plan) and research materials (may include equipment, questionnaire items, stimuli, computer programs, etc). Of the 364 eligible articles, 212 had study designs capable of including a protocol and data availability statement, providing analysis scripts, and being preregistered. Fifty-five of the 212 (25.94%; 95% CI, 20.04% to 31.84%) articles contained a statement about protocol availability. In addition, 191 of the 212 (90.09%; 95% CI, 86.07% to 94.11%) did not include a statement about data availability. Analysis scripts are needed for step-by-step documentation of how an analysis was performed. None of the 212 examined articles contained a reference to the analysis script. Preregistration is the process of documenting a time-stamped, read-only study protocol in a public database such as ClinicalTrials.gov prior to the start of the study. Eighty-three (39.15%; 95% CI, 32.58% to 45.72%) of the 212 examined articles were preregistered. Lastly, 201 of the 364 were study designs capable of containing a materials availability statement in which five of the (2.49%; 95% CI, 0.33% to 4.64%) articles reported a materials availability statement

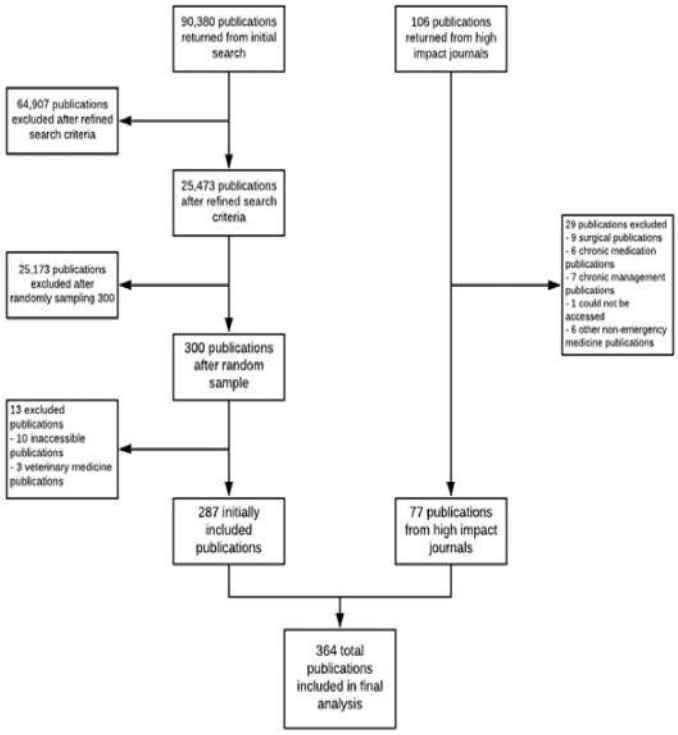

Figure 1. Flow diagram for included and excluded studies.

(Table 2). Supplementary Table 2 includes the percentage of publications that contain each reproducibility indicator from each journal. Additionally, we compared those findings to journal requirements found on each journal's "guide for authors" webpage.

Conflict of Interest and Funding Statements

Statements regarding conflicts of interest and funding sources are needed to assess the possibility of bias of the study's authors. Of the 364 examined articles, 62 (17.03%; 95% CI, 13.17% to 20.89%) stated that there were one or more conflicts of interest, 170 (46.70%; 95% CI, 41.55% to 51.82%) stated that there was no conflict of interest, and 132 (36.26%; 95% CI, 31.32% to 41.20%) did not include a conflict-of-interest statement (Table 2). Of the 364 included articles, 47 (12.91%; 95% CI, 9.47% to 16.36%) stated that there was no funding received and 190 (52.20%; 95% CI, 47.07% to 57.33%) did not include a funding statement. The remaining articles included detailed statements about their funding sources, detailed in Table 1.

Replication and Evidence Synthesis

Replication studies help to ensure the validity and reliability of previous scientific claims made by research studies by replicating the methodology used in novel studies. None of the examined publications self-reported that it was a replication study. On a large scale, evidence that is gathered across numerous studies related to a single topic can be aggregated and synthesized through meta-analyses and systematic reviews. Of the 241 examined articles, 153 (63.49%; 95% CI, 57.41% to 69.56%) of the examined articles were not included in a meta-analysis or systematic review (Table 2).

DISCUSSION

Our findings indicate that EM studies lack the components needed for reproducibility. Overall, the studies in our sample were deficient in most of the reproducibility and transparency indicators, such as data availability, material availability, and protocol availability. In addition, we found no replication attempts. Thus, the current climate of EM research is not indicative of such practices.

Our analysis indicated that only 3% of publications provided a materials availability statement and only 1 in 4 publications made protocols readily accessible. Similar trends have been seen in other areas of medicine.[10,13] A lack of access to full protocols and materials used during a study, may hinder reproducibility of experiments. Furthermore, data availability statements were lacking among EM studies, with only 13 providing statements that offered at least partial data. Ultimately, nearly all EM studies in our sample gave no method for retrieving raw data. These findings are consistent with studies conducted in other disciplines.[13,14] This trend is disappointing given the value of data sharing to study integrity.

Data availability allows readers to gain greater insight into a study's methodology and may reveal inconsistencies

Table 1. Characteristics of included publications.

Characteristics	Variables	
	N (%)	95% CI
Funding (N=364)		
University	5 (1.37)	0.18-2.57%
Hospital	7 (1.92)	0.51-3.33%
Public	46 (12.64)	9.22-16.05%
Private/Industry	23 (6.32)	3.82-8.82%
Non-Profit	3 (0.82)	0-1.75%
Mixed	43 (11.81)	8.50-15.13%
No Statement Listed	190 (52.20)	47.07-57.33%
No Funding Received	47 (12.91)	9.47-16.36%
Type of study (N=364)		
No Empirical Data	112 (30.77)	26.03-35.51%
Meta-Analysis	10 (2.74)	1.07-4.43%
Commentary	1 (0.27)	0-0.81%
Clinical Trial	84 (23.08)	18.75-27.41%
Case Study	38 (10.44)	7.30-13.58%
Case Series	2 (0.55)	0-0.75%
Cohort	75 (20.60)	16.45-24.76%
Case Control	1 (0.27)	0-0.81%
Survey	20 (5.49)	3.15-7.84%
Laboratory	1 (0.27)	0-0.81%
Other	20 (5.49)	3.15-7.84%
5-Year impact factor (N=241)		
Median	2.333	-
1st Quartile	1.408	-
3rd Quartile	5.441	-
Interquartile Range	1.408 - 5.441	-

CI, confidence interval.

between the raw data and the study conclusions. However, data sharing is a complex, multifactorial issue. Longo and Drazen,[15] in a *New England Journal of Medicine* editorial, described the potential dangers of data sharing that may arise from "research parasites"— scientists who use others' data for personal gain, without contributing to the methodology or execution of the study. These authors also argued that secondary investigators are not likely to understand the choices made when defining the parameters regarding the data (ie, differences in patient populations and special modifications to the protocol).[15] Data sharing is also complicated and time consuming. A 2018 survey of 7700 scientists found that they had difficulty with data organization, data repository selection, and handling copyright issues.[16] Also, some scientists indicated that the additional time needed to share their data was a challenge.[16]

We encourage researchers to gain familiarity with both the FAIR guiding principles for scientific data management and open science principles for data sharing. FAIR principles ensure the findability, accessibility, interoperability, and reusability of study data, placing an emphasis on data being provided to the right people, in the right way, and at the right time. In contrast, open data refers to unrestricted use of study data free of copyrights, patents, or licenses. An understanding of these principles will allow researchers to make their own informed decisions about sharing data and under what conditions sharing should occur. While the lack of data sharing is due to a whole host of reasons in general, a small portion of the studies that fail to provide raw data may be associated with unethical behavior.

The current research culture of "publish or perish"[17] may entice credible entities to falsify data to compete for grant funding. For example, researchers at Duke University were discovered to be fabricating data in their grant application, resulting in $112 million in penalties in 2019.[18] The court case revealed that none of the researchers' data were reproducible from 2006–2013.[18] A laboratory research analyst in the pulmonary asthma critical care division of the Duke University health system explained that members of the laboratory had trusted the results without verifying their raw data for over a decade.[19] Overall, the cause for the small number of data availability statements in EM is complex but needs to be addressed.

Extensive evidence shows that a reproducibility problem exists within various fields of science and medicine.[4–6] Our findings validate this problem within EM. However, this problem provides leaders within EM the opportunity to be pioneers for change within medical research. Most of the reproducibility problems stem from either motivation to remain competitive for research funding or the difficult, time-consuming nature of including all factors needed for reproducing a study. Additionally, it is important to include the journal's role in the discussion of reproducibility as they ultimately dictate what authors share through journal requirements, word limits, and other restrictions. In fact, one study found that nearly two-thirds of the 799 scientists surveyed listed journal requirements as a motivator for data sharing.[20] If authors are not expected to include reproducibility indicators, they would likely not include these indicators due to limited word count. This may result in the undesired removal of study details. The complexity of this reproducibility issue may explain why many experts have recommended solutions directed at the problem, but none have been completely successful. We propose a series of recommendations to help leaders in EM solve the reproducibility problem. This is outlined in Figure 2.

Our first recommendation is to spread the findings of our study and encourage journals to accept commentaries regarding the reproducibility crisis. Second, we recommend all EM studies consider including a statement of availability for data, protocol, and materials. Including availability statements is a tangible way for authors to improve the reproducibility

Table 2. Additional characteristics of reproducibility in emergency medicine studies.

Characteristics	Variables	
	N (%)	95% CI
Open access (N=364)		
Yes - found via Open Access Button.com	122 (33.52)	28.67-38.37%
Yes - found article via other means	127 (34.89)	29.99-39.79%
Could not access through paywall	115 (31.59)	26.82-36.37%
Protocol availability (N=212)		
Full Protocol	55 (25.94)	20.04-31.84%
No Protocol	157 (74.06)	68.16-79.96%
Data availability (N=212)		
Statement, some data are available	13 (6.13)	2.90-9.36%
Statement, data are not available	8 (3.77)	1.21-6.34%
No data availability statement	191 (90.09)	86.07-94.12%
Analysis Script Availability (N=212)		
Statement, analysis scripts are not available	0	-
No analysis script availability statement	212	-
Pre-registration (N=212)		
Statement, says was pre-registered	83 (39.15)	32.58-45.72%
Statement, says was not pre-registered	1 (0.47)	0-1.39%
No, there is no pre-registration statement	128 (60.38)	53.79-66.96%
Material availability (N=201)		
Statement, some materials are available	5 (2.49)	0.33-4.64%
Statement, materials are not available	0	-
No materials availability statement	196 (97.51)	95.36-99.67%
Conflict of interest statement (N=364)		
Statement, one or more conflicts of interest	62 (17.03)	13.17-20.89%
Statement. no conflict of interest	170 (46.70)	41.58-51.83%
No conflict-of-interest statement	132 (36.26)	31.32-41.20%
Replication studies (N=212)		
Novel study	211 (99.53)	-
Replication	1 (0.47)	-
Cited in a systematic review/meta-analysis (a) (N=212)		
No citations	153 (72.17)	66.14-78.20%
A single citation	22 (10.38)	6.27-14.48%
One to five citations	8 (3.77)	1.21-6.34%
Greater than five citations	26 (12.26)	7.85-16.68%
a - No studies were explicitly excluded from the systematic reviews or meta-analyses that cited the original article.		
Most recent impact factor year (N=364)		
2014	0	-
2015	0	-
2016	0	-
2017	242	-
2018	85	-
Not found	37	-

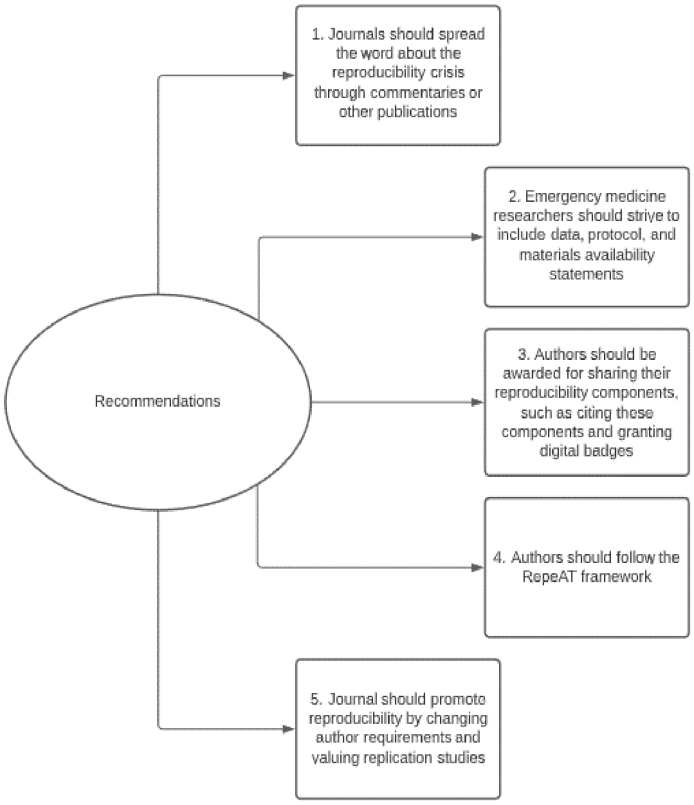

Figure 2. Recommendations for Promoting Reproducibility

of their studies. Evidence shows that when journals require authors to include a data availability statement, the authors share their data more often.[14]

Third, we recommend leaders in EM research to motivate authors to share their reproducibility components through reproducibility component citation and awarding digital badges. Allowing authors' data, materials, and protocols to be cited in other studies provides an opportunity for authors to be rewarded for their efforts to enhance reproducibility because including raw data has been shown to increase the number of citations a study receives.[21] Digital badges can be awarded to authors as a stamp of approval for reproducible science. A 2016 study revealed that digital badges significantly increased the sharing of raw data.[22]

Fourth, we encourage authors to use the RepeAT framework to help ensure that their study is reproducible. RepeAT is an experimental framework designed by experts in reproducibility to increase the reproducibility of a study through use of a list of 119 variables that can act as a checklist for authors. Taken from the RepeAT framework, Appendix 1 is a full list of the framework's variables along with its relations to transparency or accessibility.[23] RepeAT can be an additional resource for authors to ensure they include everything that is needed for reproducible research. Finally, we encourage EM journals to promote reproducibility by changing journal policies and author instructions to include reproducibility indicators. These journals can also promote reproducibility by valuing replication studies as they do novel findings because both have the potential to change the standard of care. There are numerous examples of studies having altered clinical practice and later found to be harmful.[24] Reproducibility encourages the replication and validation of a study's findings prior to influencing change in clinical practice guidelines. These recommendations are backed by expert opinion and evidence, which we hope will help leaders in EM to act to solve the reproducibility problem in their field.

LIMITATIONS

Our study has many strengths, including double-blinded data extraction, to ensure any bias was limited. The dual data extraction is considered a gold standard practice in meta-research.[25] However, we acknowledge limitations within our study. For example, our analysis only included studies taken from a certain time period, possibly limiting the ability to generalize our results to studies outside that time period. Next, we did not attempt to retrieve any of the components of reproducibility from the authors directly. Authors may have made these components available or given us an adequate explanation for exclusion. However, for the sake of feasibility, we believe our methods are adequate for describing the trend of irreproducibility within EM.

CONCLUSION

Reproducibility in EM research is lacking in many indicators studied. To ensure that reliable research drives the standard of care we outline a plan that includes informing experts in EM about the reproducibility problem, requiring authors to include an availability statement, helping authors to include everything needed for reproducible research, providing incentives for authors, and giving a reason for journals to value reproducibility more. Emergency medicine journals and researchers must promote reproducibility to maintain and assure the credibility of research.

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Clinical, Operational, and Socioeconomic Analysis of EMS Bypass of the Closest Facility for Pediatric Asthma Patients

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Introduction: Pediatric hospital care is becoming increasingly regionalized, with fewer facilities providing inpatient care for common conditions such as asthma. That trend has major implications for emergency medical services (EMS) medical care and operations because EMS historically transports patients to the closest facility. This study describes EMS transport patterns of pediatric asthma patients in greater depth, including an analysis of facility bypass rates and the association of bypass with demographics and clinical outcomes.

Methods: This was a retrospective study of pediatric asthma patients ages 2-18 years transported by Lee County, FL EMS between March 1, 2018 – December 31, 2019. A priori, we defined bypass as greater than five minutes extra transport time. We performed geospatial analysis and mapping of EMS pediatric asthma encounters. We used the Pediatric Destination Tree (PDTree) project's tiered approach to characterize receiving hospital facility pediatric capability. We analyzed incidence and characteristics of bypass, and bypass and non-bypass patient characteristics including demographics, emergency department (ED) clinical outcomes, and socioeconomic disadvantage (SED).

Results: From the study period, there were a total of 262 encounters meeting inclusion criteria, 254 (96.9%) of which could be geocoded to EMS incident and destination locations. Most encounters (72.8%) bypassed at least one facility, and the average number of facilities bypassed per encounter was 1.52. For all 185 bypass encounters, there was a median additional travel time of 13.5 minutes (interquartile range 7.5 – 17.5). Using the PDTree's classification of pediatric capability of destination facilities, 172 of the 185 bypasses (93%) went to a Level I facility. Bypass incidence varied significantly by age, but not by minority status, asthma severity, or by the area deprivation index of the patient's home address. Overall, the highest concentrations of EMS incidents tended to occur in areas of greater SED. With regard to ED outcomes, ED length of stay did not vary between bypass and non-bypass patients (P = 0.54), and neither did hospitalization (P = 0.80).

Conclusion: We found high rates of bypass for pediatric EMS encounters for asthma exacerbations, and that bypass frequency was significantly higher in younger age groups. With national trends pointing toward increasing pediatric healthcare regionalization, bypass has significant implications for EMS operations. [West J Emerg Med. 2021;22(4)972–978.]

INTRODUCTION

Pediatric hospital care is becoming increasingly regionalized, with fewer facilities capable of providing inpatient care for common childhood conditions such as asthma.[1] That trend has major implications for emergency medical services (EMS) medical care and operations because EMS historically transports patients to the closest facility. Additionally, pediatric regionalization has implications for children and their families as inpatient pediatric care may be farther away from medical homes and family support systems, especially for families of low socioeconomic status.[2] Thus, EMS transport of pediatric patients directly to definitive care may now involve bypassing the closest facility.

A previous study in urban, suburban, and rural agencies in Maryland found that EMS bypassed the closest facility in nearly 50% of pediatric encounters.[3] In that study, medications for asthma exacerbations (eg, bronchodilators, oxygen, and systemic corticosteroids) comprised three of the top five medications given to bypass patients.[3] A statewide study in Florida found that the EMS provider's destination decision was patient / family choice in nearly one-third of pediatric encounters (as opposed to closest facility), and that for 60% of patients with respiratory distress, provider destination decision was something other than the closest facility.[4] Another Florida study analyzed the average distance for EMS to directly travel to a hospital that currently admits children for asthma exacerbations, and found average transport distances of 30 miles or greater for 11 counties.[5]

Because asthma is a common cause of pediatric emergency care[6] and disproportionately affects minority and rural children,[7] we sought to describe EMS transport patterns of pediatric asthma patients in greater depth. This study describes EMS bypass rates specifically for pediatric asthma exacerbations and whether bypass resulted in transport to facilities with greater pediatric care capability, and compares demographics, socioeconomic disadvantage (SED), and clinical outcomes of bypass and non-bypass patients.

Population Health Research Capsule

What do we already know about this issue?
Pediatric hospital care is becoming regionalized, and in parallel, studies show emergency medical services (EMS) bypasses the closest facility for many pediatric encounters.

What was the research question?
What are EMS bypass rates and characteristics for pediatric asthma patients?

What was the major finding of the study?
Bypass was frequent (72.8%) and more likely in younger patients. Bypass transport times were 13.5 minutes longer.

How does this improve population health?
EMS bypass impacts ambulance availability as it increases travel and turnaround times. Public health officials should quantify local bypass patterns and determine their local impact.

METHODS

Study Setting, Inclusion and Exclusion Criteria

This was a retrospective study of pediatric asthma patients transported by Lee County, FL EMS between March 1, 2018 – December 31, 2019. The study was approved by the University of Florida Institutional Review Board. We obtained emergency department (ED) outcome data by EMS via their usual pediatric quality review processes. Of note, Lee County EMS asthma and respiratory distress standard operating protocols suggest that EMS providers who suspect the patient will require admission should transport to a facility with a pediatric inpatient unit.

We included encounters if the patient was between ages 2-18 years (lower limit of age two to avoid confounding with bronchiolitis), and if the EMS provider's primary impression was asthma. We also included encounters with primary impressions indicative of respiratory distress (eg, difficulty breathing, common cold, pneumonia, etc) if the provider secondary impression was asthma *or* if albuterol was administered (either alone or in combination with ipratropium bromide). We manually reviewed charts with the provider impression allergic reaction to distinguish between allergic reactions and asthma exacerbations, as both may involve administration of albuterol. We excluded non-transports, and patients whose EMS provider primary or secondary impression was anaphylactic / anaphylactoid reaction, congestive heart failure, or chronic obstructive pulmonary disease. When examining the relationship of facility bypass to ED outcomes, we excluded encounters where ED outcome data were not available.

Bypass, Patient, and Facility Characterizations

A priori, we defined bypass based on EMS transport time (from the EMS scene to the receiving ED) rather than distance, as time is more relevant to EMS operations and, therefore, a more transferrable metric to compare with other agencies and studies. Based on prior studies, we defined bypass as greater than five minutes extra transport time.[8,9] We also performed sensitivity analyses (see Supplemental Data File) with bypass definitions of greater than three and greater than 10 minutes extra transport time.

To classify patients by asthma exacerbation severity, we used a previously published EMS pediatric asthma

severity score created with elements of the 2007 National Heart, Lung, and Blood Institute's Expert Panel Report 3 recommendations.[7] To describe patient's racial/ethnic background we used the race data variable from the EMS record, which combines both race and ethnicity descriptions. Therefore, we categorized patients by minority and non-minority status (Black, Asian, Hispanic/Latino, other vs White, non-Hispanic/Latino, respectively). We used the area deprivation index (ADI) to characterize SED based on the patient's home address. The ADI is a composite measure of SED based on 17 different US Census Bureau's (USCB) variables representing poverty, education, housing, and employment.[10, 11] We used the national rank of the 2015 version ADI, which is based on demographic variables from the USCB 2011-2015 American Community Survey.[12] We used the Pediatric Destination Tree (PDTree) project's tiered approach to characterize receiving hospital facility pediatric capability (Level 1 – pediatric specialty center designation, Level II – pediatric intensive care unit capability, Level III – pediatric inpatient unit or separate pediatric ED, Level IV – all other facilities including freestanding EDs).[13, 14]

Geospatial Analysis Methods and Area Deprivation Index Descriptions

We performed geospatial analysis and mapping of EMS pediatric asthma encounters with ArcGIS 10.5.1 (Esri, Redlands, CA). EMS scene address (incident location), destination facility address, and patient home address were geocoded using a 2018 HERE street network dataset.[15] When home address was not available or could not be geocoded, we used the address of the EMS scene

To map neighborhood SED, ADI national rank was joined to the 2015 US Census Block groups.[16] That information was then joined to each patient based on their home address. We categorized patients into groups based on quintiles of their ADI national rank scores. Quintile groups correspond to the following ADI scores: ADI 1 (1 – 45); ADI 2 (46 – 59), ADI 3 (60 – 77), ADI 4 (78 – 89), ADI 5 (90 – 100). The top 20th percentile of ADI scores (ADI 1) represents patients with a home address in the least disadvantaged areas, while the bottom 20th percentile (ADI 5) represents patients with a home address in the most disadvantaged areas.

Using the Network Analyst extension in ArcGIS, we calculated estimated transport time, in minutes, from each incident location to the actual destination facility, as well as from incident location to all other possible destination facilities within the study area. For patients who were hospitalized, we also calculated estimated travel time from patient home locations to the admitting facilities. In a supplemental analysis, we assessed the accuracy of estimated transport time by comparing it to actual transport time using simple linear regression. The supplemental figure shows a moderately strong association between estimated and actual transport time ($R^2 = 0.697$). On average, transport time modeled using Network Analyst underestimated actual transport time by 3.9 (±0.7) minutes. However, the degree of underestimation remained fairly consistent across the entire range of estimates.

For each transport, we used the results of the network analysis to identify the total number of bypassed facilities along the route from incident location to the actual destination facility. If the estimated time it took to arrive at the actual facility was five minutes or greater compared to that of an alternative facility, the alternative facility was considered a bypassed location. Patient characteristics and transport/travel times were compared across bypass groups using Wilcoxon rank-sum and Fisher's exact tests, with bypass status treated as a binary variable (no bypasses vs one or more bypasses). For analyses comparing EMS transport time as the outcome variable, we used actual recorded EMS transport time. For analyses comparing travel time from patients' homes to admitting facilities, we used the Network Analyst-estimated travel time. For all analyses, we used descriptive statistics (mean, standard deviation [SD], median, interquartile range [IQR]) as appropriate, and univariate comparison tests (chi square for categorical variables, Wilcoxon rank-sum for continuous variables).

RESULTS

From the study period, there were a total of 262 pediatric asthma EMS transports meeting inclusion criteria, 254 (96.9%) of which had EMS scene encounter information that we were able to geocode to incident and destination locations. Eight transports (3.1%) lacked sufficient address information at either incident location, destination location, or both, and thus could not be geocoded. For home address, 226 patients (86.3%) were geocoded. Using the five-minute definition of bypass, 72.8% of those encounters bypassed at least one facility, and the average number of facilities bypassed per encounter was 1.52. Using that five-minute bypass definition, we noted 69 incidents with 0 bypasses, 40 incidents with 1 bypass, 97 incidents with 2 bypasses, 39 incidents with 3 bypasses, and 9 incidents with 4 bypasses. Table 1 displays the incidence of bypass and descriptive statistics for number of bypasses per EMS encounter.

Emergency medical services travel time varied greatly by number of facilities bypassed and between bypass and non-bypass patients. Figure 1 displays box and whisker plots for EMS travel time (from EMS scene to destination facility) by the number of facilities bypassed. Figure 2 shows the significantly longer EMS transport time for bypass patients compared to non-bypass patients ($P < 0.0001$, Wilcoxon rank-sum test). For all 185 bypass encounters, there was a median additional travel time of 13.5 minutes (IQR 7.5 – 17.5).

Using the PDTree classification of pediatric capability of destination facilities, we found that 195 patients were transported to a Level I facility, 15 patients to a Level II facility, and four patients to a Level IV facility overall. For

Table 1. Bypass incidence for pediatric asthma emergency medical services encounters.

Bypass threshold	Encounters with at least 1 bypass, N (%)	Total Bypassed Facilities	Bypasses per route Mean (SD)	Bypasses per route Median (IQR)
5 minutes	185 (72.8)	387	1.52 (1.15)	2 (1 - 3)
3 minutes	192 (75.6)	460	1.81 (1.32)	2 (0 - 2)
10 minutes	126 (49.6)	169	0.67 (0.77)	0 (0 - 1)

SD, standard deviation; *IQR*, interquartile range.

bypasses, 172 of the 185 bypasses (93%) went to a Level I facility, 10 went to a Level II facility, and three went to a Level IV facility. Figure 3 shows the variation in destination facility pediatric capability by number of facilities bypassed en route to that ultimate destination. For the 185 bypass encounters, the median travel time to a Level I facility was significantly longer at 26.5 minutes (IQR 22 - 32), vs all other facilities levels (median 19 minutes (IQR 17 - 23) (P = 0.0009, Wilcoxon rank-sum test).

Examining bypass at the patient level (Table 2), we found that bypass incidence varied significantly by age but not by minority status, asthma severity, or patient's home address ADI. Although bypass incidence did not vary by ADI or by asthma severity, there was a higher incidence of severe/critical asthma encounters in higher ADI categories (ie, more disadvantaged neighborhood groups). When breaking down ADI into quintiles, 63.5% of the fifth quintile patients were rated as severe or critical, compared to 38.8% in the first quintile (P = 0.01). Figure 4 shows the spatial distribution of EMS incidents in relation to ADI within Lee County.[17] Overall, the highest concentrations of EMS incidents tended to occur in areas of greater SED.

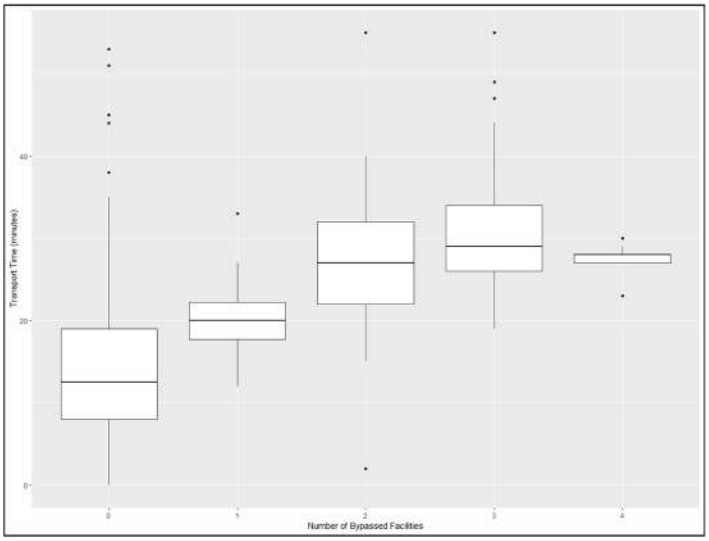


Figure 1. Actual transport time by number of bypasses per route. Box and whisker plots represent median (middle line), IQR (borders of box from 25th (Q1) to 75th (Q3) percentiles), edges of lines represent values within Q1 – 1.5*IQR to Q3 + 1.5*IQR; isolated dots represent outliers beyond the ±1.5*IQR values. *IQR*, interquartile range.

Emergency department outcomes were available for 189 of the 254 total geocoded patients. Of those 189 patients, 166 (87.8%) were bypasses, and 58 (30.7%) were admitted to the hospital. Length of stay in the ED did not vary between bypass and non-bypass patients (P = 0.54), and neither did hospitalization (P = 0.80). After geocoding the admitted patient's home address, we used Network Analyst to calculate estimated travel time from home to the admitting facility, as bypass to a facility farther away may strain family resources. Figure 5 displays how travel time from home to admitting facility was significantly longer for bypass patients vs non-bypass patients (P = 0.04, Wilcoxon rank-sum test).

DISCUSSION

In this prehospital study of asthma exacerbations, one of the most common pediatric emergency conditions, we found nearly three-quarters of EMS encounters bypassed the nearest facility, and 93% of those bypasses were to go to a Level I pediatric specialty facility. Those bypass transports included not only passing one facility, but in some cases, bypassing up to four other facilities. This study's 72.8% overall rate of bypass is more frequent than a study of three counties in Maryland, which found an overall 50% rate of bypass when studying rural, suburban, and urban counties. This study's high rate of bypass may reflect increasing pediatric inpatient care regionalization for asthma (despite its commonality) since that Maryland study,[1] and/or family preference for transport to a children's hospital in a study setting where there is one Level I pediatric facility option.[4] Since the study EMS agency's guidelines recommend transport to a facility with a pediatric inpatient unit if the need for admission is suspected, the bypass rates may also reflect EMS provider's impressions of the likelihood of admission. However, bypass did not vary by asthma severity, and only 30% of bypass patients transported to the Level I facility were admitted.

The choice to transport to a higher level of pediatric facility also did not vary by SED, as represented by ADI or minority status. Interestingly, our lack of variance by SED is in contrast to a similar study of bypass from Baltimore City, which found bypass rates did vary by census tract median poverty levels.[2] However, we did find that the highest concentrations of EMS incidents occurred in areas of the greatest SED, which is in keeping with many other studies.[18] Therefore, the SED results and bypass rates overall may reflect an increased number of emergency destination options

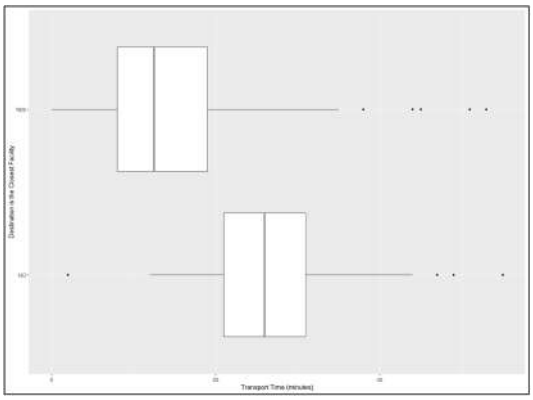


Figure 2. Comparison of actual transport time between bypass and non-bypass patients.
Box and whisker plots represent median (middle line), IQR (borders of box from 25th (Q1) to 75th (Q3) percentiles), edges of lines represent values within (Q1 - 1.5*IQR) to (Q3 + 1.5*IQR); isolated dots represent outliers beyond the ±1.5*IQR values.
SD, standard deviation; *IQR*, interquartile range.

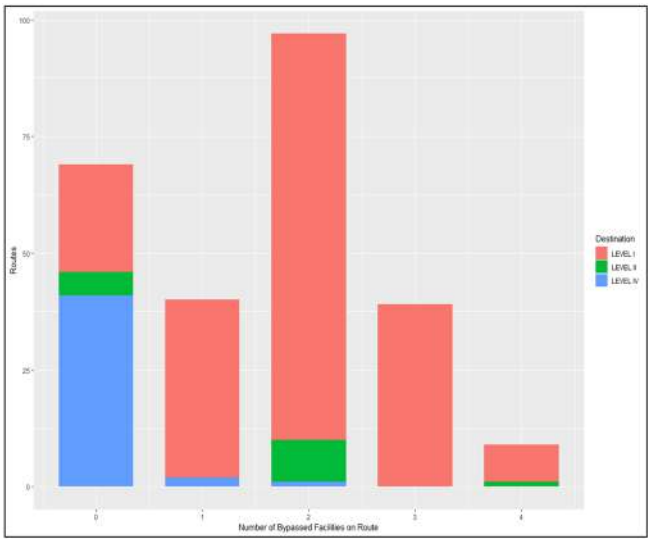


Figure 3. Destination facility level and number of facilities bypassed.
Y axis shows number of emergency medical services encounters in the study sample; X axis shows number of facilities bypassed en route to ultimate destination. Shaded bars represent the pediatric capability of the destination facility.

(Level I to IV) available for EMS transport, and this should be considered when applying our results to other areas.

Bypass did vary by patient age, with younger infants and toddlers more likely to experience bypass encounters than teenagers. That variation in age has similarly been found in studies of increasing pediatric interfacility transfers,[1] as well as in studies of pediatric secondary transport (interfacility transport following primary EMS transport).[19] More comprehensive studies of bypass, to include other pediatric conditions, are required to determine whether younger age is the main factor driving bypass, or if other factors related to the patient's condition or parental preference contribute as well. Additionally, in-depth qualitative studies with EMS providers may be required to ascertain whether anchoring bias (eg, dispatch call for pediatric patient with difficulty breathing) or treatment bias (eg, being able to tell caregivers transport will be to a pediatric specialty facility) plays a role in bypass for pediatric prehospital asthma patients.

Regardless of the reason(s) for bypass, its frequency has major implications for EMS operations. We found significantly longer transport times for bypass patients with a median increase of 13.5 minutes. An extra 13.5 minutes to a layperson may not sound significant. However, a statewide study of pediatric EMS transports in Florida found an overall median transport time of 13 minutes.[4] Therefore, bypass in this study doubled that transport time. Because EMS operates as a public service, ambulance and crew availability must be optimized for all citizens. Thus, additional travel time to definitive care must be balanced against potential additional turnaround time at specialty facilities and the further distance / time required to travel back to the ambulance's home station. In fact, turnaround time can be significant (ranging from minutes to nearly an hour), and varies greatly between receiving facilities.[20] Additionally, ambulance availability is a critical component to time-sensitive care for other emergencies such as stroke, trauma, ST-elevation myocardial infarction, and other medical emergencies.[21-23]

Aside from the public health service considerations, that additional transport time can also strain families and caregivers of pediatric asthma patients. Of the 30% of bypass patients who required admission, we found a slight but statistically significant increase in the amount of travel time from the patient's home address to the admitting facility. Being admitted to a hospital farther from home can strain family resources when trying to visit children in the hospital while potentially caring for other children at home and/or working. Therefore, Level I pediatric facility's social resources should be aware of this additional strain and strategize ways to help alleviate that burden.

LIMITATIONS

This study has limitations to consider. It is a study of one EMS agency serving a specific region in Florida, and of pediatric asthma encounters only. As such, its results may not be generalizable to all regions (particularly those without Level I pediatric facilities) or conditions besides asthma. However, the study agency serves a large volume of pediatric encounters, and asthma is one of the most common reasons for pediatric EMS encounters,[6] and may be representative of overall pediatric EMS trends. We used admission rate as a surrogate for the need to bypass closer facilities; however, this does not take into account any subspecialty consultations (eg, pediatric pulmonology or allergy) that may have occurred in the ED prior to discharge. However, given pediatric care regionalization, pediatric subspecialty consultations are usually only available at specialized pediatric facilities.

Additionally, we were not able to obtain ED outcomes for all patients, which may have biased results relating to admission rates and extra distance from home for admitted patients.

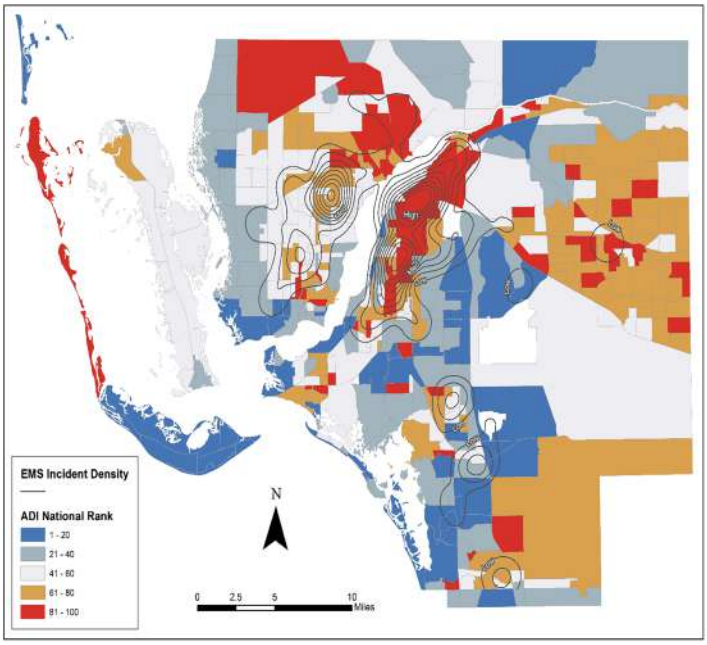
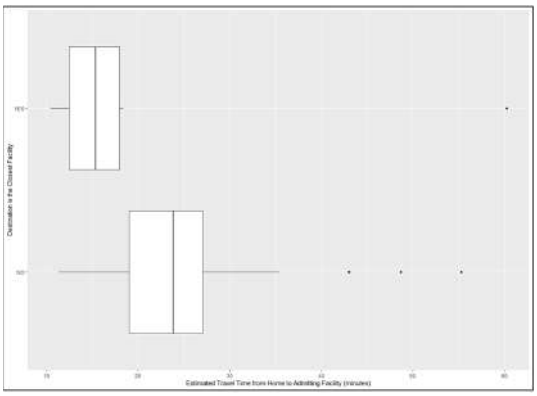


Figure 4. Smoothed density of emergency medical services incidents overlaid with area deprivation index quintile.
EMS, emergency medical services; *ADI*, area deprivation index.



Time in minutes

Non-Bypass:
Mean = 21.9
Median = 15.4
SD = 19
IQR = 12.5 - 18
N = 6

Bypass:
Mean = 24.7
Median = 23.8
SD = 8.9
IQR = 19 - 27
N = 51

Figure 5. Estimated travel time from home to facility among admitted patients with home address (N = 57).
Box and whisker plots represent median (middle line), IQR (borders of box from 25th (Q1) to 75th (Q3) percentiles), edges of lines represent values within Q1–1.5*IQR to Q3+1.5*IQR; isolated dots represent outliers beyond the ±1.5*IQR values.
SD, standard deviation; *IQR*, interquartile range.

CONCLUSION

This study of pediatric EMS encounters for asthma exacerbations found a high rate of bypass to a Level I pediatric facility, and that bypass frequency was significantly higher in younger age groups. With national trends pointing toward increasing pediatric healthcare regionalization, bypass has significant implications for EMS operations, and in certain regions may strain families and caregivers of children with asthma.

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Emergency Department-initiated High-flow Nasal Cannula for COVID-19 Respiratory Distress

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Introduction: Patients with coronavirus disease 2019 (COVID-19) can develop rapidly progressive respiratory failure. Ventilation strategies during the COVID-19 pandemic seek to minimize patient mortality. In this study we examine associations between the availability of emergency department (ED)-initiated high-flow nasal cannula (HFNC) for patients presenting with COVID-19 respiratory distress and outcomes, including rates of endotracheal intubation (ETT), mortality, and hospital length of stay.

Methods: We performed a retrospective, non-concurrent cohort study of patients with COVID-19 respiratory distress presenting to the ED who required HFNC or ETT in the ED or within 24 hours following ED departure. Comparisons were made between patients presenting before and after the introduction of an ED-HFNC protocol.

Results: Use of HFNC was associated with a reduced rate of ETT in the ED (46.4% vs 26.3%, P <0.001) and decreased the cumulative proportion of patients who required ETT within 24 hours of ED departure (85.7% vs 32.6%, P <0.001) or during their entire hospitalization (89.3% vs 48.4%, P <0.001). Using HFNC was also associated with a trend toward increased survival to hospital discharge; however, this was not statistically significant (50.0% vs 68.4%, P = 0.115). There was no impact on intensive care unit or hospital length of stay. Demographics, comorbidities, and illness severity were similar in both cohorts.

Conclusions: The institution of an ED-HFNC protocol for patients with COVID-19 respiratory distress was associated with reductions in the rate of ETT. Early initiation of HFNC is a promising strategy for avoiding ETT and improving outcomes in patients with COVID-19. [West J Emerg Med. 2021;22(4):979–987.]

INTRODUCTION

Background

Global healthcare resources have been tested by the rapid spread of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) leading to increased prevalence of the infectious syndrome known as coronavirus disease 2019 (COVID-19). Patients with COVID-19 can develop rapidly progressive respiratory failure over a period of hours to days.[1] Early reports from Wuhan, China, suggested that early endotracheal intubation (ETT) was crucial for treating respiratory failure in patients with COVID-19 pneumonitis.[2]

Contemporary concerns regarding the risk of bio-aerosol dispersion during the use of non-invasive ventilation methods led to hospital policies and approaches that favored ETT with closed ventilatory circuits and viral filters over non-invasive ventilation to limit infectious spread to medical professionals.[3-7]

Importance

Ventilation strategies during the COVID-19 pandemic seek to minimize patient mortality while also reducing infectious risk to medical professionals. With limited supplies of ventilators, negative pressure rooms and personal protective equipment (PPE), the rapid spread of COVID-19 within communities experiencing severe outbreaks can quickly overwhelm hospital resources.[8] Prior to COVID-19, it was known that high-flow nasal cannula (HFNC) may decrease the need for ETT in patients with acute hypoxemic respiratory failure without increasing mortality.[9] And HFNC has shown promising results for reducing ETT in patients with other severe respiratory viruses such as H1N1.[10] Developing a better understanding of the impact of HFNC on patient outcomes and healthcare worker safety is critical.

Goals of This Investigation

At the beginning of the COVID-19 pandemic, our institution restricted the use of HFNC in the ED for COVID-19 patients; however, after noting improved outcomes in patients receiving HFNC in our medical intensive care unit (ICU), our ED instituted the use of HFNC in select negative pressure rooms. The timeline of institutional policies supporting early ETT of COVID-positive patients in the ED and subsequent implementation of ED-initiated HFNC provided a natural before-and-after experiment of two patient cohorts whose outcomes could be studied.

The objective of this retrospective cohort study was to determine the potential impact of ED-initiated HFNC for the treatment of COVID-19 respiratory failure by looking at patient outcomes before and after its availability. We hypothesized that the availability of HFNC in the ED would be associated with a decreased proportion of patients intubated in the ED, decreased proportion of patients intubated within the first 24 hours of hospitalization, decreased hospital and ICU length of stay, and improved survival.

Population Health Research Capsule

What do we already know about this issue?
Patients diagnosed with coronavirus disease 2019 (COVID-19) frequently develop severe respiratory distress requiring significant ventilatory support.

What was the research question?
Does the availability of ED-initiated high flow nasal cannula (HFNC) reduce the rate of endotracheal intubation (ETT) for patients with COVID-related respiratory distress?

What was the major finding of the study?
For patients with severe COVID, the availability of ED-HFNC reduced the rate of ETT in the ED, within the first 24 hours of hospitalization, and throughout their entire hospitalization.

How does this improve population health?
The use of ED-HFNC reduces the need for ETT, allowing efficient allocation of ventilators, which may be a scarce resource, while also reducing exposure to ventilator-associated complications.

Methods

Study Design and Setting

This retrospective, non-concurrent cohort study was approved by the University of Chicago Institutional Review Board (IRB20-0781) and conducted at the University of Chicago Medical Center, a large, urban, quaternary, academic medical center and Level I trauma center. According to the hospital's 2018-2019 Community Health Needs Assessment, the population of the 12 ZIP code service area is 625,707, and is 76.7% non-Hispanic Black/African American, 12.3% Hispanic/Latino, and 7.8% non-Hispanic. Annual ED volume was 108,188 as of June 2020, 68.9% of which were adult visits. On January 24, 2020, the University of Chicago Hospital Incident Command System (HICS) was activated and travel-screening for COVID-19 was initiated. On March 18, 2020, in response to international reports of healthcare worker SARS-CoV-2 transmission following aerosolizing procedures, HICS restricted the use of all aerosol-generating procedures including nebulizers and non-invasive positive pressure ventilation (NIPPV) in all non-ICU settings, including the ED. All patients requiring greater than six liters per minute of supplemental oxygen by nasal cannula, those with severe

respiratory fatigue, hypercarbia, or those unable to protect their airways received ETT in the ED.

On April 6, institutional policies changed to allow for the use of high-flow nasal cannula (HFNC) in the ED for COVID-positive patients requiring greater than six liters of oxygen per minute by nasal cannula. Patients receiving HFNC were required to be placed in a negative pressure room with an anteroom to limit the spread of aerosolized virus. The HFNC was initiated at a flow rate of 40 liters per minute and 100% fraction of inspired oxygen (FiO_2). The flow rate was titrated up to 60 liters per minute as needed to decrease work of breathing and maintain a respiratory rate of less than 30 breaths per minute. FiO_2 was titrated to maintain an oxygen saturation between 92-96%. Decisions about which patients needed ETT rather than HFNC prior to ED departure were made by the bedside emergency physician. Some patients were transiently placed on HFNC while in the ED but were able to be de-escalated to nasal cannula prior to ED departure. Results of this study are reported in accordance with the STROBE Guidelines (Strengthening the Reporting of Observational Studies in Epidemiology).[11]

Selection of Participants

We included in the study all patients greater than or equal to 18 years old who screened positive for COVID-19, were admitted to the hospital from the University of Chicago adult ED between March 1–May 22, 2020, and required HFNC or ETT within the first 24 hours of hospitalization. Exclusion criteria included patients who were discharged from the ED, sent directly to labor and delivery, expired in the ED, had an operative procedure during their admission, or patients who were transiently placed on HFNC in the ED but de-escalated to nasal cannula prior to ED departure. COVID-19 infections were confirmed using Roche cobas (Roche Diagnostics Corporation, Indianapolis, IN) or Cepheid Xpert Xpress (Cepheid, Sunnyvale, CA) SARS-CoV-2 qualitative reverse transcriptase polymerase chain reaction assays. Testing may have occurred at an outpatient clinic or curbside locations prior to visiting the ED, in the ED, or after admission. Patients were considered positive during their hospital encounter if they had a positive result within 14 days prior to ED arrival or prior to hospital discharge. The study was approved by the University of Chicago Institutional Review Board (IRB20-0781), and the need for informed consent was waived as all patient data were obtained through a de-identified data mart.

Measurements

All data provided for this study were obtained through a de-identified COVID-19 data mart created and maintained by the University of Chicago Center for Research Informatics (CRI). The CRI data mart comprised multiple tables, including the following: patient demographic information; admit/discharge/transfer (ADT) events, encounters, flowsheets, diagnosis and problem lists; smoking history; lab values; inpatient diagnosis-related groups (DRG); de-identified notes; and medication administrations.

Patient ages were calculated for each encounter using the number of years between patient birth date and the ADT timestamp of ED arrival. The timing of respiratory interventions was determined by grouping respiratory flowsheet events by patient ID and oxygen delivery method. The earliest timestamps for HFNC and intubation during each encounter were saved for each patient where applicable. Patient comorbidities were determined using *International Classification of Diseases, 10th Revision* (ICD-10) codes from their diagnosis and problem lists. We mapped ICD-10 codes using methods previously described by Charlson, Elixhauser, and van Walraven.[12-14] Hypertension, diabetes, chronic obstructive pulmonary disease (COPD), and chronic kidney disease were codified according to Elixhauser. Acute myocardial infarctions were codified according to Charlson. Total weighted Charlson and van Walraven-weighted Elixhauser scores were also reported. We determined survival at hospital discharge using a status within the patient demographics table provided by CRI. This status was compared and corrected using death notes and hospital discharge disposition status for patients in our cohorts.

To assess for potential confounding bias due to patient-level differences in the composition of each cohort, we compared the cohorts to one another regarding patient age, gender, race, ethnicity, comorbidities, ED vital signs, illness severity, and lab values/biomarkers. Comorbidities controlled for included those previously associated with increased mortality in COVID-19 (hypertension, diabetes mellitus, coronary artery disease, COPD, chronic kidney disease, anemia), as well as those that comprise the Charlson and Elixhauser scoring systems, which have strong prior validity evidence to predict inpatient mortality for both COVID and non-COVID patients.[11-15] We compared illness severity using each patient's mean arterial oxygen partial pressure/fractional inspired ratio (PaO_2/FiO_2) ratio within the first 24 hours of hospitalization, as well as initial sequential organ failure assessment (SOFA) score upon arrival to the ICU. The labs/biomarkers that were selected to ensure similarities between patient cohorts are those that have been previously associated with increased mortality, including complete blood counts, serum bicarbonate, blood urea nitrogen, serum creatinine, glucose, alanine aminotransferase (ALT), lactate dehydrogenase, creatinine kinase, troponin, prothrombin time, D-dimer, ferritin, interleukin-6 and C-reactive protein.[16-18] We also attempted to control for confounding by comparing differences in the rate of in-patient treatment with remdesivir, which has previously been shown to decrease hospital length of stay.[19]

Additional details regarding variable transformation are available in the Supplemental Methods.

The primary outcome variables were the maximum levels of respiratory support at ED departure, within the first 24 hours after ED departure, and through the entire duration of hospitalization, as well as survival at hospital discharge.

Secondary outcome variables included total inpatient and ICU lengths of stay.

Data Analysis

We performed an *a priori* sample size calculation to detect a 50% decrease in the proportion of patients requiring ETT within 24 hours of hospitalization, from 90% prior to the availability of ED HFNC to 45% following the availability of ED HFNC, resulting in a minimum sample size of 42 patients, using alpha of 0.05 and a power of 90% (G*Power v3.1; Faul, Erdfelder, Buchner, & Lang [2009]). The decision to power our study to detect a 50% reduction in ETT was based upon our personal experiences in caring for patients during the time periods prior to and following the availability of ED HFNC. We performed all data extraction, transformation, and analysis using RStudio version 1.2.5001 running R version 3.5.1 and *tidyverse* 1.2.1 (RStudio, PBC, Boston, MA). We mapped ICD-10 codes for each patient to individual comorbidities using the *comorbidity* package.[20] The distribution of all variables for each cohort was visualized using the *explore* package,[21] and summary statistics were calculated using the *arsenal* package.[22] All missing values were imputed using *missForest,* a non-parametric, random forest-based method.[39] As the visualizations of the distributions of our continuous variables displayed that they were not normally distributed, continuous variables were reported using medians and interquartile ranges (IQR). Categorical variables were described using frequency and percentages. We compared continuous variables using the Wilcoxon rank-sum test and categorical variables using Fisher's exact test. *P*-values less than 0.05 were considered to be statistically significant.

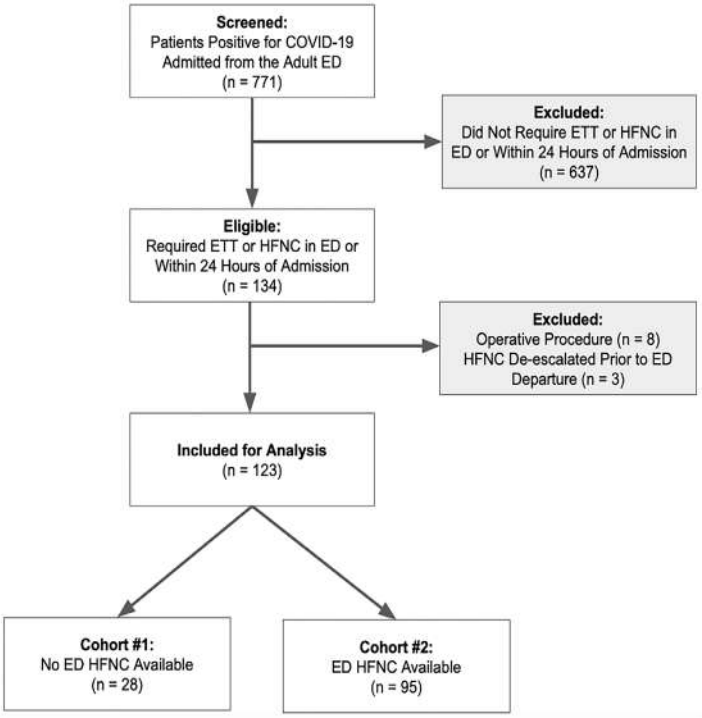

Figure 1. Flow chart of patient screening, eligibility, inclusion, exclusion.
ED, emergency department; *ETT,* endotracheal intubation; *HFNC,* high-flow nasal cannula.

RESULTS

Characteristics of Study Subjects

There were 771 encounters with COVID-19-positive patients greater than or equal to 18 years old seen in the adult ED resulting in hospital admission. A total of 134 patients required HFNC or ETT within 24 hours of admission. We excluded eight patients who underwent operative procedures during hospitalization and three patients who were started on ED-HFNC but de-escalated to nasal cannula prior to ED departure. Of the 123 patients meeting both the inclusion and exclusion criteria, 28 were seen prior to the availability of ED-HFNC and 95 were seen following the availability of ED-HFNC. See Figure 1 for a flow diagram of patient screening, eligibility, inclusion, and exclusion.

The median age of the study population was 65 years (IQR 57-75). Patients were predominantly Black/African-American (85.4%) and non-Hispanic (90.2%). Participants were 52.0% male. There were no statistically significant differences between the demographics of each group.

The median body mass index was 31.4 (IQR 25.2-38.5], and there were no differences in smoking status or the prevalence of comorbidities between the two groups (48.8% diabetes, 83.7% hypertension, 44.7% chronic kidney disease, 27.6% COPD, 22.8% myocardial infarction). The median weighted Charlson score was 4 (IQR 2-6), and the median van Walraven (Elixhauser) score was 17 (IQR 9.0-26.5). There were no differences in Charlson or van Walraven scores or any of their component comorbidities between the two groups.

When comparing the worst ED vital signs for each patient, as defined by the maximum recorded heart rate, temperature, and respiratory rate, and minimum recorded systolic blood pressure and oxygen saturation, we found no statistically significant differences between the two cohorts. Similarly, there were no statistically significant differences between the two cohorts in terms of illness severity, as defined by the median PaO2/FiO2 ratio during the first 24 hours of hospitalization and the SOFA score upon ICU admission. There were no differences in lab values between the two groups. Overall, 34.1% of patients received remdesivir after admission. There was no statistical difference in the rate of treatment with remdesivir between the two groups. Table 1 shows some characteristics between the two groups. Please see Supplemental Table for complete information on the demographics, comorbidities, vital signs, and laboratory values between the two groups.

Main Results

For patients with COVID-19 respiratory distress requiring ETT/HFNC within the first 24 hours of hospitalization, the introduction of ED-initiated HFNC was associated with a

Table 1. Characteristics COVID-19-positive patients seen in the emergency department (ED) before and after the availability of high-flow nasal cannula in the ED.

	1: No ED HFNC Available (n = 28)	2: ED HFNC Available (n = 95)	Total (n = 123)	P-value
Demographics				
Age				0.849
Median	69.0	65.0	65.0	
Q1, Q3	57.8, 73.0	57.0, 76.0	57.0, 75.0	
Gender				0.668
Male	16 (57.1%)	48 (50.5%)	64 (52.0%)	
Female	12 (42.9%)	47 (49.5%)	59 (48.0%)	
Race				0.642
Black/African-American	25 (89.3%)	80 (84.2%)	105 (85.4%)	
White	2 (7.1%)	6 (6.3%)	8 (6.5%)	
More than one race	0 (0.0%)	6 (6.3%)	6 (4.9%)	
Other/unknown	1 (3.6%)	3 (3.2%)	4 (3.3%)	
Ethnicity				0.239
Not Hispanic or Latino	26 (92.9%)	85 (89.5%)	111 (90.2%)	
Hispanic or Latino	0 (0.0%)	7 (7.4%)	7 (5.7%)	
Unknown	2 (7.1%)	3 (3.2%)	5 (4.1%)	
Comorbidities				
Body mass index				0.263
Median	31.9	30.8	31.4	
Q1, Q3	29.8, 38.8	24.9, 38.0	25.2, 38.5	
Chronic kidney disease	12 (42.9%)	43 (45.3%)	55 (44.7%)	0.999
Chronic obstructive pulmonary disease	7 (25.0%)	27 (28.4%)	34 (27.6%)	0.813
Diabetes mellitus	15 (53.6%)	45 (47.4%)	60 (48.8%)	0.668
Hypertension	20 (71.4%)	83 (87.4%)	103 (83.7%)	0.07
Myocardial infarction	6 (21.4%)	22 (23.2%)	28 (22.8%)	0.999
Smoking status				0.058
Current Smoker	1 (3.6%)	6 (6.3%)	7 (5.7%)	
Former Smoker	13 (46.4%)	27 (28.4%)	40 (32.5%)	
Never Smoker	3 (10.7%)	32 (33.7%)	35 (28.5%)	
Unknown	11 (39.3%)	30 (31.6%)	41 (33.3%)	
Weighted Charlson score				0.989
Median	3.5	4	4	
Q1, Q3	1.8, 5.0	2.0, 6.0	2.0, 6.0	
Weighted Elixhauser score (Van Walraven)				0.959
Median	15	18	17	
Q1, Q3	8.2, 22.2	9.0, 27.5	9.0, 26.5	

*Full table included as a supplemental.
ED, emergency department; *HFNC,* high-flow nasal cannula.

reduced rate of ETT in the ED (46.4% vs 26.3%, P <0.001). The availability of ED-HFNC was also associated with a significant decrease in the cumulative proportion of patients who required ETT within 24 hours of hospitalization (85.7% vs 32.6%, P <0.001) and throughout their entire admission (89.3% vs 48.4%, P <0.001).

While there were trends toward increased survival (50.0% vs 68.4%) and decreased ICU length of stay (median 8.6 days

[IQR 5.1-10.9] vs. 6.0 days [IQR 2.9-13.5]), these findings were not statistically significant. There was no difference in the median total inpatient length of stay between the two study periods. See Table 2 for complete information comparing the primary and secondary outcomes between patient cohorts.

DISCUSSION

Overall, our study suggests that making HFNC available as a treatment option in the ED for patients experiencing respiratory distress due to COVID-19 was associated with a significantly reduced rate of ETT in the ED and reduced intubation through the entire period of hospitalization. While there were trends toward improved survival and decreased ICU length of stay, these findings were not statistically significant.

A prior case series evaluating the use of HFNC for patients with severe H1N1 influenza pneumonitis found that 45% of patients receiving HFNC (9/20) never required intubation, suggesting that HFNC may play a role in the treatment of infectious severe hypoxemic respiratory failure.[10] For COVID-19-associated respiratory failure, Jiangsu Province in China reported better survival outcomes than Hubei Province (3.33% vs. 4.34%), which they attributed to early recognition of high-risk and critically ill patients to allow early intervention with a multi-pronged approach that included HFNC or NIPPV, along with fluid restriction and early proning.[23] This approach was associated with <1% of Jiangsu Province patients requiring ETT compared to the national average of 2.3%.[24]

While the results of this study support the use of ED-initiated HFNC for COVID-19-associated respiratory distress, there are some risks and limitations of HFNC that must be considered. Given the potential for aerosolization of the SARS-CoV-2 virus,[25] we recommend that HFNC be used only in single-occupancy, negative pressure airborne isolation rooms that are entered by a limited number of care team members who are appropriately trained in the proper donning and doffing of personal protective equipment.[26] To facilitate the safe use of HFNC, our hospital constructed negative anteroom chambers for some of our existing negative pressure rooms. Also, not all patients are suitable candidates for HFNC; these include patients who are unable to protect their

Table 2. Patient outcomes before and sfter the availability of high-flow nasal cannula initiated in the emergency department.

	No ED HFNC Available (n = 28)	ED HFNC Available (n = 95)	Total (n = 123)	*P*-value
Primary outcomes				
Maximum respiratory support at ED departure				< 0.001
ETT	13 (46.4%)	25 (26.3%)	38 (30.9%)	
HFNC	0 (0.0%)	59 (62.1%)	59 (48.0%)	
No ETT/HFNC	15 (53.6%)	11 (11.6%)	26 (21.1%)	
Maximum respiratory support within 24 hours of hospitalization				< 0.001
ETT	24 (85.7%)	31 (32.6%)	55 (44.7%)	
HFNC	4 (14.3%)	64 (67.4%)	68 (55.3%)	
Maximum respiratory support during entire hospitalization				< 0.001
ETT	25 (89.3%)	46 (48.4%)	71 (57.7%)	
HFNC	3 (10.7%)	49 (51.6%)	52 (42.3%)	
Survival at hospital discharge				0.115
Alive	14 (50.0%)	65 (68.4%)	79 (64.2%)	
Deceased	14 (50.0%)	30 (31.6%)	44 (35.8%)	
Secondary outcomes				
Inpatient length of stay (days)				0.713
Median	9.9	10.1	10.0	
Q1, Q3	7.6, 18.5	6.9, 16.1	7.0, 16.7	
ICU length of stay (days)				0.305
Median	8.6	6.0	6.9	
Q1, Q3	5.1, 10.9	2.9, 13.5	3.0, 13.5	

ED, emergency department; *HFNC,* high-flow nasal cannula; *ETT,* endotracheal intubation; *ICU,* intensive care unit.

airways, need operative procedures, or with severe acidosis or hypercarbia, and those who have continued respiratory distress despite being treated with HFNC. Furthermore, there may be risks associated with the overuse of HFNC and some pre-COVID-19 reports have suggested that failure of HFNC may delay intubation and increase mortality.[27] The "ROX index," calculated as the ratio of oxygen saturation to FiO_2, has recently been developed to help predict which patients will succeed with HFNC or progress to needing ETT; [28,29] however, this was not part of our institutional protocol.

Some studies have shown that HFNC causes minimal bio-aerosol dispersion,[3-4] while others have shown that HFNC increased droplet dispersion to levels that are unacceptable according to World Health Organization guidelines.[5] Early recommendations favored ETT over HFNC as ETT creates a closed circuit with high efficiency particulate air or viral filters that limit infectious spread to medical professionals.[6] It was recommended that patients not be placed on HFNC until viral clearance had been proven.[7] Compared to NIPVV, HFNC has been shown to generate fewer aerosols.[30] Nurses treating patients with SARS-CoV-1 were also found to be at higher risk for developing SARS when patients were being treated with NIPPV.[31]

Although not formally included as part of our study, we did not see an increased rate of COVID-19 among healthcare workers as a result of treating COVID-positive patients with HFNC. During the period before ED-HFNC two physicians and four nurses working in our ED tested positive for SARS-CoV-2; in the time period following ED-HFNC, no physicians and six nurses tested positive, none of whom were found to have provided direct patient care to any COVID-19-positive patient on HFNC.

We hypothesize that the two primary mechanisms by which HFNC might improve patient outcomes include the following: 1) earlier respiratory support for patients who need it; and 2) decreased complications associated with ETT. When the only available option to emergency physicians is ETT or no ETT, we observed that nearly half of all patients who ultimately required ETT/HFNC within 24 hours of ED departure did not have these interventions in the ED. This finding indicates that there may have been an opportunity to provide earlier respiratory support and prevent later decompensation, a trajectory that may have ultimately impacted survival. The widely known FLORALI trial showed that HFNC did not reduce the risk of intubation in patients with acute hypoxemic respiratory failure but was associated with improved 90-day mortality[32]; however, a more recent meta-analysis has shown the opposite—that HFNC reduces the need for intubation with no reductions in mortality or hospital or ICU length of stay.[9]

The risks of ETT are numerous, including increased risk of ventilator-associated infections, barotrauma, extended ICU stays, and adverse reactions to sedation.[33] Furthermore, concerns about patient self-induced lung injury (P-SILI) that have been cited in earlier viewpoints favoring early intubation have been called into question. The idea that patients with heightened respiratory drive have maladaptively high tidal volumes that then induce more severe acute respiratory distress syndrome is based on only two studies, each of which has significant limitations.[34]

While these data provide compelling support for the use of ED-HFNC in the treatment of COVID-19 pneumonitis, it will be important to consider which patients are at high risk of HFNC-failure as determined by their ROX index, as well as other treatments that could be initiated in the ED that could augment patient outcomes. A recent study of early self-proning in awake, non-intubated, COVID-19-positive patients in the ED found significant improvements in oxygen saturation within five minutes,[35] and a randomized controlled trial comparing early prone positioning with HFNC vs HFNC alone is currently underway.[36] It may also be worth further studying ways to use HFNC in austere settings such as temporary alternative care locations or in EDs operating beyond capacity where individual treatment rooms are not available, along with a more protocolized approach to measuring the risk of transmission to healthcare workers.

LIMITATIONS

This study has several limitations. As part of a retrospective cohort study, patients were not randomized with respect to which interventions they received and thus causation could not be established. We also recognize the risk of chronology bias in studying non-concurrent cohorts during a pandemic where practice is likely to quickly evolve in response to emerging literature in ways that were not captured by our analyses. Such unmeasured changes in practice would likely have the most impact upon distal outcomes such as hospital discharge. The sample size for this study was calculated to detect a 50% reduction in the rate of ETT; therefore, it was underpowered to detect differences in mortality rates associated with ED-HFNC. Also, as a study of a single, urban, academic medical center with a predominately African-American/Black patient population, our results may not be entirely generalizable, although given the increased incidence of COVID-19 in Black communities, these results may be of particular importance for this population.

While it may seem surprising that patients requiring HFNC or ETT did not have higher temperatures, this may be related to the use of infrared forehead thermometers, which have previously been shown not to be as accurate as other measurement methods.· Additionally, analysis was performed using de-identified information contained within a data mart rather than having the ability to review individual patient charts directly in the electronic health record, which limited the ability to control for certain potential confounders, such as prone positioning and traditional or radiographic-based pneumonia severity scores, since these were not included in the data mart.

CONCLUSION

Given our findings, we believe that despite early recommendations against its use, high-flow nasal cannula is a treatment option that should be considered for patients with COVID-19. We encourage hospital systems and emergency departments to closely evaluate their internal resources and consider deploying HFNC as a front-line treatment for patients with suspected or confirmed COVID-19 presenting with respiratory distress.

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Risk Factors of Fall-Related Emergency Department Visits by Fall Location of Older Adults in the US

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Introduction: Prior evidence indicates that predictors of older adult falls vary by indoor-outdoor location of the falls. While a subset of United States' studies reports this finding using primary data from a single geographic area, other secondary analyses of falls across the country do not distinguish between the two fall locations. Consequently, evidence at the national level on risk factors specific to indoor vs outdoor falls is lacking.

Methods: Using the 2017 Nationwide Emergency Department Sample (NEDS) data, we conducted a multivariable analysis of fall-related emergency department (ED) visits disaggregated by indoor vs outdoor fall locations of adults 65 years and older (N = 6,720,937) in the US.

Results: Results are compatible with findings from previous primary studies. While women (relative risk [RR] = 1.43, 95% confidence interval [CI], 1.42-1.44) were more likely to report indoor falls, men were more likely to present with an outdoor fall. Visits for indoor falls were highest among those 85 years and older (RR = 2.35, 95% CI, 2.33-2.37) with outdoor fall visits highest among those 84 years and younger. Additionally, the probabilities associated with an indoor fall in the presence of chronic conditions were consistently much higher when compared to an outdoor fall. We also found that residence in metropolitan areas increased the likelihood of an indoor elderly fall compared to higher outdoor fall visits from seniors in non-core rural areas, but both indoor and outdoor fall visits were higher among older adults in higher income ZIP codes.

Conclusion: Our findings highlight the contrasting risk profile for elderly ED patients who report indoor vs outdoor falls when compared to the elderly reporting no falls. In conjunction, we highlight implications from three perspectives: a population health standpoint for EDs working with their primary care and community care colleagues; an ED administrative vantage point; and from an individual emergency clinician's point of view. [West J Emerg Med. 2021;22(4)988–999.]

INTRODUCTION

Older patients represent a quarter of United States (US) emergency department (ED) visits,[1] and falls are among the most common conditions encountered in EDs.[1] With the progressive aging of the US population, the number of falls and fall-related ED visits among older adults (≥65 years) is increasing.[2] Prior studies document the high volume of ED visits for falls,[2,3] the substantial medical costs,[4] and the health burden[4] associated

with falls among US older adults. Accordingly, Healthy People 2020 aims to reduce fall-related ED visits by 10%,[5] making fall prevention a priority in public health.[6]

The etiology of older adult falls is complex. Falls may result from an underlying pathology related to chronic conditions[7-9] or may be due to general frailty.[7] In addition to intrinsic (personal) conditions, the literature[10,11] highlights situational (activity at the time of fall) and extrinsic (environmental) factors as significant drivers of older adult falls. In conjunction, prior US studies[12,13] have distinguished falls by location – indoors vs outdoors – and highlighted that the intrinsic predictors associated with each are different. Despite their significance, the generalizability and reliability of these prior findings[12-15] are limited by the single geographic area, small sample size, and the self-reported data on falls considered in these analyses.

Conversely, a large body of research[2,16] examines characteristics of fall-related ED visits in the US at the national level, but no studies have conducted analysis disaggregated by fall location. Consequently, national trends differentiating indoor from outdoor falls and/or fall-related ED visits among older adults remain unknown. Our goal in this study was to evaluate whether the predictors of fall-related ED visits across the US differed by fall location. Using the 2017 Nationwide Emergency Department Sample (NEDS) data, we examined the role of patient characteristics (gender, age groups, and multiple chronic conditions) after controlling for personal- (insurance) and community-level (location and income) enabling resources.

Population Health Research Capsule

What do we already know about this issue?
Personal and environmental predictors of older adult falls, specifically indoor vs outdoor falls, have been explored in prior, small sample studies.

What was the research question?
Across the US, do the predictors of falls-related ED visits differ by indoor vs outdoor fall locations of older adults?

What was the major finding of the study?
Indoor and outdoor falls varied significantly based on gender, age, urbanity, and chronic health conditions of older adults.

How does this improve population health?
Targeted indoor-falls prevention based on contrasting risk profile of indoor/outdoor elderly falls has the potential to address increasing volume of fall-related ED visits in this population.

METHODS

Study Design and Setting

We used the 2017 NEDS dataset for our analysis. While national-level statistics on falls in the US arise out of self-reported information (for example, the Behavioral Risk Factor Surveillance System or the National Health Interview Survey), NEDS is the one exception. This dataset has a robust sample size (N = 33 million [unweighted], 145 million [weighted] observations in 2017) and is also the largest, all-payer ED database in the US. It provides national estimates of hospital-based ED visits using a stratified, single-stage cluster sample across 20% of the community, non-rehabilitation hospitals in the US. The NEDS dataset includes information on both patient- and hospital-level characteristics, principal and secondary payers for ED services rendered, and principal diagnosis with up to 35 secondary diagnoses reported using the *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM) codes. Our study was exempt from a review by Marymount University's institutional review board, and all coauthors completed the Healthcare Cost and Utilization Project data use agreement.

Outcome and Predictor Variables

We identified fall-related ED visits (N = 6,720,937) for older adults using ICD-10-CM diagnosis codes for an initial visit (W00-W19) as the sole listed fall diagnosis code across all 35 diagnoses. In Figure 1, we provide a visual representation of the sample extraction and sample selection/exclusion criteria using NEDS 2017. The definition of indoor/outdoor falls in Kelsey et al (2010)[12] guided how we identified and grouped the W codes into the two fall categories of indoors and outdoors. The W codes we could not assign either as an indoor or an outdoor fall were grouped together into the "other" fall category. Additional details on the W codes and our indoor-outdoor fall classification are provided in Table 1. The unit of our analysis was an ED visit, and the outcome variable was fall-related ED visits for indoor and outdoor falls. We considered the following patient (personal/intrinsic) characteristics: age (age groups), gender, and health status (multiple chronic conditions). Sociodemographic characteristics are consistently identified in the literature as significant predictors of falls,[7,8] falls by location,[10,12-15] and fall visits.[2,16] The role of poor health, especially multiple chronic health conditions, is also identified in prior studies[7-9] on older adult falls, and we were particularly interested in examining associations for fall visits disaggregated by fall location. Given that the pattern of chronic conditions significantly predicts the risk of falls[7-9] and increases the likelihood of mortality of older adults[10,18] we aimed to interpret the impact of multiple chronic health conditions. We therefore examined the likelihood of a fall in the presence of a group as well as

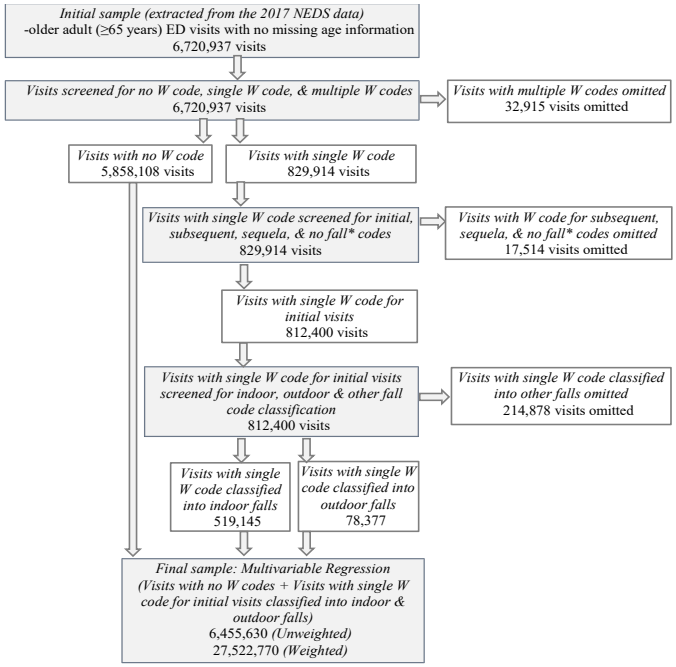

Figure 1. Sample extraction and selection/exclusion criteria using the Nationwide Emergency Department Sample (NEDS) 2017. Note: Data extraction and statistical analysis were conducted by the study authors.
*No falls = Jumping/diving, and slipping, tripping, stumbling without falling.

a set of individual chronic conditions added to our original regression model.

We considered the set of individual chronic conditions identified in the computation of the Charlson Comorbidity Index (CCI).[19] The CCI is a weighted index that takes into account the seriousness of a set of specific comorbid conditions to predict risk of death following hospitalization.[20] The CCI is generated based on weights assigned to 17 chronic conditions. The cumulative weights are then grouped into a three-category [0,1,2] Grouped Charlson Comorbidity Index (GRPCI). The concepts of the CCI and GRPCI are used widely to estimate comorbid burden in health services research using large secondary hospital datasets. A list of these comorbid conditions is indicated in Table 1.

Lastly, we also considered the following covariates in our analyses: insurance; and location (rurality/urbanity) and income of patient's ZIP code. These personal (insurance) and community-level (income and care availability by rurality/urbanity) factors are "enabling resources" that typically influence utilization of health services, including ED services.[21] Additional details on these explanatory factors (predictors) and the outcome variable are in Table 1.

Data Analysis

We computed national estimates for all fall categories from which we calculated the rates (per 100,000 older- adult population) of ED fall-related visits across the three age groups: 65-74 years; 75-84 years; and 85 years and above. The population estimates for those 65 years and older for the calculation of these rates were obtained from the US Census Bureau.[22] We also computed descriptive statistics to summarize the characteristics of fall-related visits by fall locations (indoor and outdoor) across all predictor variables. We conducted both bivariate (chi-square) and multivariable (multinomial logistic regression) analyses to examine heterogeneity, if any, of predictors by fall location of older adult ED visits in the US. We performed all statistical analyses using Stata 15 (StataCorp, College Station, TX). All estimates are weighted unless specified otherwise. We report national estimates and statistically significant findings at $P \leq 0.05$ unless otherwise noted.

RESULTS

National Estimates

We estimated the total volume of ED visits among older adults (≥ 65 years) in 2017 to be about 29 million (28,988,938). Based on 812,400 (unweighted) falls treated in the ED, we estimated about 12.18% (3,529,861 visits) of the total older adult ED visits were fall related. The annual ED charges for these fall visits were $17.3 billion, with an average charge of $5,765 per visit. The average charge for an indoor fall was the highest ($5,820), followed by outdoor falls ($5,730), and "other" falls ($5,511).

Descriptive Statistics and Rates by Fall Categories

When compared across the type of fall setting, 64% were indoor (2,247,417), 10% were outdoor (349,632), and the remaining 26% (932,812) were in the "other" setting. Figure 2 depicts the rates of indoor, outdoor, and "other" falls by gender and age categories. Rates for both indoor and outdoor, as well as "other" fall visits, increased sharply across the three age categories for women as well as men. However, this increase for both genders was the starkest for the indoor category (blue bars) with the largest rate increase recorded among the 85 years and older group. When compared across the type of falls, among both men and women, the rate of indoor falls increased almost fivefold among those 85 years and older compared to the 65-74 years group. On the other hand, for outdoor fall-related ED visits, the difference by age groups was less than twice in men and women. Furthermore, for any given age category (except outdoor falls for 85 years and older), the rate of fall-related ED visits was higher in women than men for indoor and outdoor falls. These trends were consistent for the rates of "other" falls.

Bivariate Analysis

In Table 2, we list descriptive statistics summarizing total ED visits, and total fall-related ED vists, as well as indoor and outdoor falls by fall predictors of the elderly. The ED visits among older adults were highest in women (56.95%), 65-74 year olds (45.31%), Medicare beneficiaries (87.26%), those

Table 1. List of variables included in the bivariate (chi-square) and multivariable (logistic regression) analyses.

Variable	Indicator	Description
Outcome variable:		
Fall event of older adults (≥ 65 years)	Bivariate analysis: Fall-related visits disaggregated by fall location: indoor, outdoor, and other (N = 6,670,508)	Indoors/outdoors falls definition in Kelsey et al (2010) applied to ED visits with ICD-10-CM diagnoses codes (W codes) for those 65 years and older (additional details with the list of W codes as indicated below).
		ICD-10-CM W codes (W00-W19) for Falls
	Multivariable analysis: Fall-related visits aggregated for indoor and outdoor fall locations (N = 6,455,630)	Indoor: W010XXA, W0110XA, W01110A, W01111A, W01118A, W01119A, W01190A, W01198A, W03XXXA, W04XXXA, W050XXA, W06XXXA, W07XXXA, W08XXXA, W16211A, W16212A, W16221A, W16222A, W1811XA, W1812XA, W182XXA, W1830XA, W1831XA, W1839XA Outdoor: W000XXA, W001XXA, W002XXA, W009XXA, W051XXA, W052XXA, W090XXA, W091XXA, W092XXA, W098XXA, W100XXA, W101XXA, W102XXA, W108XXA, W109XXA, W11XXXA, W12XXXA, W130XXA, W131XXA, W132XXA, W133XXA, W134XXA, W138XXA, W139XXA, W14XXXA, W15XXXA, W16011A, W16012A, W16021A, W16022A, W16031A, W16032A, W16111A, W16112A, W16121A, W16122A, W16131A, W16132A Other: W1800XA, W1801XA, W1802XA, W1809XA, W19XXXA
Predictor variables		
Patient characteristics (intrinsic/personal)		
Gender[1]	(Female/Male)	Binary categorical variable.
Age	Age groups	Categorical variable with three levels: 65-74 years; 75-84 years; 85 years and above.
Health	Individual chronic conditions	Chronic conditions identified in the computation of the Charlson Comorbidity Index and Grouped Charlson Comorbidity Index and as listed below. Myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic obstructive pulmonary disease, ulcer, liver disease, diabetes, diabetes with complications, rheumatoid disease, moderate to severe liver disease, hemiplegia, renal disease, cancer, metastatic cancer, and acquired immunodeficiency syndrome.
Personal- and community-level enabling resources		
Insurance	Primary payer	Categorical variable with four levels: Medicare; Medicaid and other payor; private insurance; uninsured (including self-pay and no charge).
Location	Rurality/urbanity of patients' ZIP codes	Categorical variable with four levels: large metropolitan areas; small metropolitan areas; micropolitan areas; non-core areas (rural), using classification provided in NEDS.
Income	Median household income of patients' ZIP codes	Categorical variable with four levels: less than 40,000; 40,000-50,999; 51,000-65,999; 66,000 and above.

[1]The gender variable corresponds to the NEDS data element "Female," which is an indicator of gender.17 It therefore includes the binary male/female categories instead of the non-binary gender identity categories.
N, weighted observations; *ICD-10-CM,* International Classification of Diseases, 10th Revision, Clinical Modification; *NEDS,* Nationwide Emergency Department Sample.

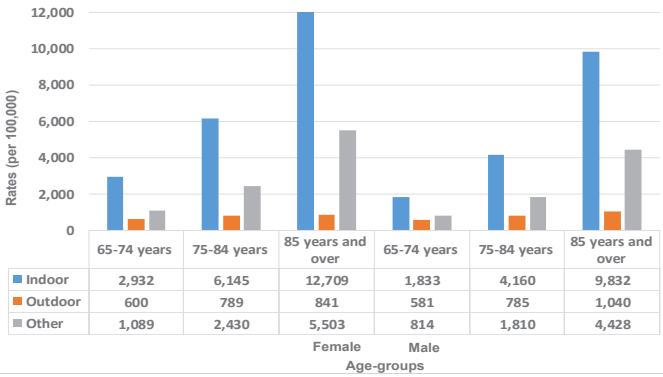

Figure 2. Indoor, outdoor, and other falls stratified by gender and age, NEDS* 2017.
Rates of indoor, outdoor and "other" falls by gender and by age categories demonstrating a higher incidence of falls among women, advancing with age (for both gender).
Note: We calculated the rate for each fall type by dividing the total number of falls in each age/gender category with the total number of population in that age/gender category.
*NEDS, Nationwide Emergency Department Sample.

living in metro areas (81.0%), and among those in ZIP codes with incomes below $51,000 (55.1%). Similarly, a majority of the falls seen in the EDs were among women (65.20%), older adults 75 and over (66.70%), Medicare beneficiaries (89.5%), in large metro areas (48.91%), and among income groups below $51,000 (51.45%).

The bivariate analysis indicated that the type of falls varied significantly across gender, age group, location, payer, income, and GRPCI (P <0.05). Among females, indoor falls made up a larger share of the total falls when compared to males (females: 65.31%; males: 60.6%). In contrast, the share of outdoor falls in men (12.57%) was higher than falls among women (8.48%). While indoor falls progressively increased with age, they represented the highest share of falls among the oldest of the old (85 years and over: 65.96%); outdoor falls were most represented among the 65-74 year olds (14.90%).

Compared to micropolitan and rural areas, indoor falls made up a higher share of total falls in metro areas (large: 64.1%; small: 65.24%). In contrast, the percentage of outdoor falls was slightly higher in micropolitan and rural areas (more than 11%) than that in metro areas (less than 10%). While 63.95% of the total falls paid by Medicare were indoor, 9.44% were outdoor. Private insurance, on the other hand, paid for 61.08% of indoor falls, and 13.98% of outdoor falls. Those living in ZIP codes with an income above $51,000 had a slightly higher share of indoor (approximately 64%) and outdoor (over 10%) falls compared to those living in ZIP codes below $40,000 (63.11%, and 8.89%). Outdoor falls were represented the most among those with a score of "0 = no chronic conditions" on the GRPCI (12.60%), while the least among those with a score of "2 = multiple chronic conditions" (6.26%).

Multivariable Analysis

We present the results from our multivariable analysis (multinomial logistic regression) in Table 3. In Model 1, we present the results for indoor and outdoor fall outcomes, and in Model 2 we substitute the GRPCI with the 17 chronic conditions as predictor variables in the analysis. Females (relative risk [RR] = 1.43, 95%, confidence interval [CI], 1.42-1.44), and older adults over 85 years and above (RR = 2.35, 95%, CI, 2.33-2.37) had a higher likelihood of belonging in the indoor fall visit category as opposed to the no-fall visit category. Next, older adult residence in non-core rural areas (RR = 1.25, 95%, CI, 1.22-1.29) increased the likelihood of reporting an outdoor fall as opposed to no falls. In comparison, residence in higher income (≥ $66,000) ZIP codes increased the likelihood of belonging to an indoor (RR = 1.20, 95%, CI, 1.19-1.21) as well as an outdoor fall visit (RR = 1.65, 95% CI, 1.61-1.68).

In Model 2, we controlled for the 17 chronic conditions identified in the CCI. Both the GRPCI (Model 1) and the individual chronic conditions (Model 2) did not indicate a higher likehood of older adults belonging to any of the fall (indoor/outdoor) categories compared to the elderly reporting no falls. Nevertheless, for all 17 chronic conditions, the probabilities associated with an indoor fall in the presence of a chronic condition were consistently much higher when compared to an outdoor fall. In Figure 3, we provide the probabilities associated with an indoor fall (blue bar) in the presence (compared to an absence) of the 17 conditions. The orange bars indicate the same statistic for an outdoor fall. For instance, the probability of an indoor fall (9.22%) in the presence of dementia was followed by that of rheumatoid arthritis (6.82%) among older adults visiting the ED. In contrast these probabilities for an outdoor fall respectively were 0.67% (dementia) and 0.86% (rheumatoid arthritis).

DISCUSSION

Using the 2017 NEDS dataset, we estimated a total of 3.5 million fall-related visits among older adults in the United States in 2017. Overall, indoor fall-related ED visits were six times higher than outdoor fall visits. We examined various factors affecting fall-related ED visits to identify and compare-contrast factors associated with indoor vs outdoor fall visits since fall prevention and mitigation strategies would be different for each type of fall. In connection, we present results to highlight implications from three perspectives – from a population health standoint for EDs working with their primary care and community care colleagues, from an ED administrative angle, and from an individual emergency clinician's point of view.

Consistent with prior studies,[12-15] our analysis found the role of intrinsic (personal) factors – gender- and age-based

Table 2*. Key sociodemographic characteristics of older adults (≥ 65 years) reporting falls in the ED, NEDS 2017.[a]

Variables[b]	Total older adult ED visits % (SE) [CI] (n=6,670,508) (N=28,988,938)	Falls, % (SE) [CI]		
		Total falls[c] (n=812,400) (N=3,529,861)	Indoor falls (n=519,145) (N=2,247,417)	Outdoor falls (n=78,377) (N=349,632)
	Predictor categories add up to 100% column-wise	Predictor categories add up to 100% column-wise	Row-wise (Indoor + Outdoor + Other [not shown in the table]) adds up to 100%	
Total				
Gender	6,670,129†	812,370†		0.00††
Male	43.05 (0.02) [43.01, 43.08]	34.80 (0.05) [34.70,34.91]	60.60 (0.09) [60.41, 60.78]	12.57 (0.06) [12.44, 12.70]
Female	56.95 (0.02) [56.92, 56.99]	65.20 (0.05) [65.09,65.30]	65.31 (0.07) [65.18, 65.44]	8.48 (0.04) [8.41, 8.56]
Age group	6,670,508†	812,400†		0.00††
65-74 years	45.31 (0.02) [45.27, 45.35]	33.30 (0.05) [33.19,33.40]	60.91 (0.096) [60.72, 61.1]	14.90 (0.07) [14.76, 15.04]
75-84 years	33.46 (0.02) [33.43, 33.5]	34.22 (0.05) [34.12, 34.33]	64.18 (0.093) [64.0, 64.36]	9.57 (0.06) [9.46, 9.68]
85 years and over	21.23 (0.02) [21.19, 21.26]	32.48 (0.05) [32.37, 32.58]	65.96 (0.095) [65.77, 66.14]	5.14 (0.04) [5.05, 5.23]
Payer	6,656,643†	810,595†		0.00††
Medicare	87.26 (0.01) [87.23, 87.28]	89.50 (0.03) [89.43, 89.57]	63.95 (0.06) [63.84, 64.07]	9.44 (0.035) [9.37, 9.51]
Medicaid and other	3.30 (0.007) [3.29, 3.31]	2.70 (0.02) [2.66, 2.74]	61.77 (0.34) [61.10, 62.43]	13.16 (0.24) [12.70, 13.64]
Private insurance	8.14 (0.01) [8.12, 8.17]	6.83 (0.03) [6.78, 6.89]	61.08 (0.21) [60.67, 61.50]	13.98 (0.15) [13.69, 14.29]
Self-pay/No pay	1.30 (0.004) [1.29, 1.31]	0.97 (0.01) [0.95, 0.99]	61.54 (0.56) [60.44, 62.63]	13.18 (0.39) [12.43, 13.97]
Location	6,651,198†	810,272†		0.00††
Large metro areas	48.5 (0.008) [48.48, 48.51]	48.91 (0.02) [48.86, 48.96]	64.10 (0.08) [63.95, 64.25]	9.60 (0.05) [9.51, 9.70]
Small metro areas	32.5 (0.01) [32.48, 32.52]	33.27 (0.03) [33.22, 33.32]	65.24 (0.09) [65.06, 65.43]	9.54 (0.06) [9.43, 9.66]
Micropolitan areas	10.95 (0.008) [10.93, 10.97]	10.20 (0.02) [10.16, 10.25]	60.88 (0.18) [60.52, 61.23]	11.18 (0.12) [10.95, 11.41]
Non-core areas	8.05 (0.007) [8.04, 8.07]	7.62 (0.02) [7.58, 7.66]	57.80 (0.21) [57.38, 58.22]	11.66 (0.14) [11.39, 11.93]
Income Level	6,559,393†	799,987†		0.00††
$1-$39,000	28.09 (0.02) [28.06, 28.12]	24.79 (0.05) [24.70, 24.88]	63.11 (0.11) [62.89, 63.33]	8.89 (0.07) [8.76, 9.02]

*The instructions provided by the Agency for Healthcare Research and Quality: Healthcare Cost and Utilization Project (HCUP) directed the statistical procedure we used to generate the national estimates and descriptive statistics (confidence intervals and standard errors) for falls by each falls category as well as by predictor variables.

[a]We used the sampling weights provided by the HCUP NEDS dataset to generalize the estimates to the US civilian, noninstitutionalized adult population.

[b]Missing value for predictors variables: The maximum was 1.5% for income.

[c]Total unweighted fall-related visits (N = 812,400) include three fall location categories: i) indoor (519,145); ii) outdoor (78,377); and iii) other (N = 214,878).

†Unweighted observations (n with no missing values) for each predictor variables;†† $\chi 2$ P values.

SE, standard error; *CI,* confidence interval; *n,* unweighted observations with no missing values, *N,* weighted observations, *NEDS,* Nationwide Emergency Department Sample.

Table 2. Continued.

Variables[b]	Total older adult ED visits % (SE) [CI] (n=6,670,508) (N=28,988,938)	Falls, % (SE) [CI]		
		Total falls[c] (n=812,400) (N=3,529,861)	Indoor falls (n=519,145) (N=2,247,417)	Outdoor falls (n=78,377) (N=349,632)
	Predictor categories add up to 100% column-wise	Predictor categories add up to 100% column-wise	Row-wise (Indoor + Outdoor + Other [not shown in the table]) adds up to 100%	
$40,000-$50,999	27.01 (0.02) [26.97, 27.04]	26.66 (0.05) [26.56, 26.76]	63.59 (0.11) [63.38, 63.8]	9.86 (0.07) [9.73, 10.0]
$51,000-$65,999	23.96 (0.02) [23.93, 24.0]	25.03 (0.05) [24.94, 25.13]	64.23 (0.11) [64.01, 64.44]	10.26 (0.07) [10.12, 10.40]
$66,000 or more	20.94 (0.01) [20.91, 20.97]	23.52 (0.04) [23.44, 23.61]	63.81 (0.11) [63.59, 64.03]	10.55 (0.07) [10.40, 10.69]
Grouped Charlson Comorbidity Index (GRPCI)	6,670,508†	812,400†		0.00††
0	40.19 (0.02) [40.16, 40.23]	48.75 (0.06) [48.64, 48.86]	63.93 (0.08) [63.78, 64.09]	12.60 (0.05) [12.49, 12.70]
1	23.73 (0.02) [23.69, 23.76]	25.02 (0.05) [24.92, 25.11]	63.81 (0.11) [63.59, 64.02]	8.48 (0.06) [8.36, 8.61]
2	36.08 (0.02) [36.04, 36.12]	26.23 (0.05) [26.14, 26.33]	63.04 (0.11) [62.83, 63.25	6.26 (0.05) [6.15, 6.37]

*The instructions provided by the Agency for Healthcare Research and Quality: Healthcare Cost and Utilization Project (HCUP) directed the statistical procedure we used to generate the national estimates and descriptive statistics (confidence intervals and standard errors) for falls by each falls category as well as by predictor variables.

[a]We used the sampling weights provided by the HCUP NEDS dataset to generalize the estimates to the US civilian, noninstitutionalized adult population.

[b]Missing value for predictors variables: The maximum was 1.5% for income.

[c]Total unweighted fall-related visits (N = 812,400) include three fall location categories: i) indoor (519,145); ii) outdoor (78,377); and iii) other (N = 214,878).

†Unweighted observations (n with no missing values) for each predictor variables;†† $\chi 2$ P values.

SE, standard error; *CI,* confidence interval; *n,* unweighted observations with no missing values, *N,* weighted observations, *NEDS,* Nationwide Emergency Department Sample.

variations in the incidence of fall-related ED visits. Age was a significant predictor of indoor falls with the frequency of ED visits increasing more than sixfold with age across both genders. On the other hand, although an increase was seen in the frequency of ED visits with age for outdoor falls, that increase was less than twofold. Similarly, our multivariable analysis indicated that with age, the likelihood of a patient visiting the ED with an indoor fall (RR 2.35 for age>85) increased, but the same was not true for an outdoor fall. Increasing age is therefore a strong predictor of indoor fall visits. Emergency clinicians should refer older patients (>85 years) more aggressively to community resources for indoor-fall prevention programs while providing general resources for all ages for outdoor fall prevention. Furthermore, to address the needs of patients presenting with fall-related visits, ED medical directors need to account for the fact that the majority of their outdoor fall cases will be in the younger age group (Table 3) and that indoor fall cases, in all likelihood, will be evenly distributed (Table 2). This trend will be of importance when arranging services for post-fall visit discharge from the ED. At the population level, greater resources need to be dedicated for indoor-fall prevention programs for those above age 85 for the highest return on investment.

With respect to gender, women had a higher incidence of fall-related ED visits in the outdoor and indoor fall categories across all ages (except outdoor for 85 years and older). Female gender increased the probability of an indoor fall-related ED visit (as opposed to no falls) by one and a half times when compared to men, but this difference was minimal in the case of outdoor fall visits. Out of a 100 falls seen in the ED, females accounted for two thirds of the indoor fall visits. This significant gender disparity needs to be addressed when arranging for primary preventive services as well as arranging care for older adults who present to the ED with falls. Females will need greater attention in all fall prevention and mitigation programs at the individual as well as the population level. On

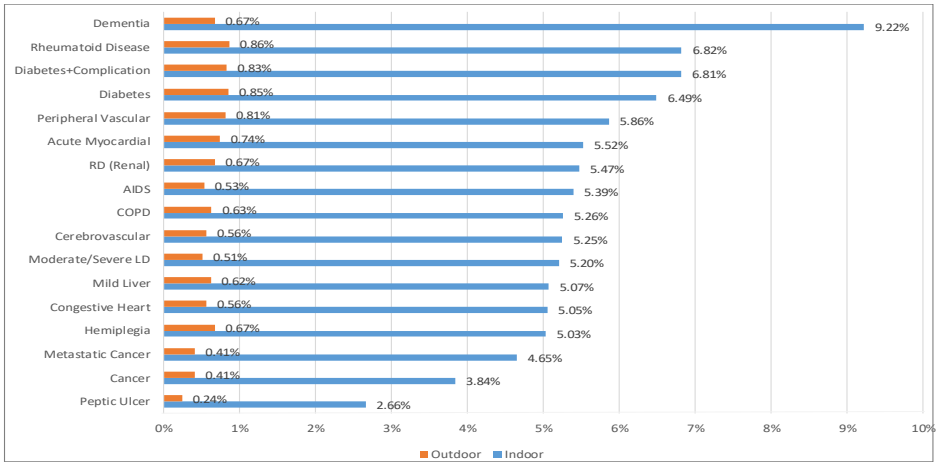

Figure 3. Probabilities of an indoor and outdoor fall in the presence of a chronic condition, NEDS 2017.
Note: The complement of the probabilities for each chronic condition is the probability associated with no fall in the presence of the respective chronic condition.

the administrative side, greater fall-prevention resources will need to be allocated for female patients.

Additionally, compared to an outdoor fall, the probabilities of an indoor fall were higher in the presence of all 17 chronic conditions that we considered in our analysis (Figure 3). This difference was far higher for each of these chronic health conditions than the sixfold gap between the incidences of indoor and outdoor fall-related ED visits. While previous studies have primarily examined the relation between risk of falling and the presence of a particular chronic condition,[8] our study finds robust evidence of a higher likelihood of falling in an indoor setting in the presence of this group of 17 chronic conditions. The prevalence of multiple chronic conditions among older adults in the US is not only high but is also increasing over time,[23] rendering effective indoor falls prevention a public health priority. Thus, emergency clinicians may be able to use the presence of these particular chronic conditions to identify patients at risk of indoor falling. Use of fall precautions in patients being admitted to the hospital from the ED or being discharged home from the ED should be based on the presence/absence of these chronic health conditions.

Our results also revealed that the the cost of care for an indoor fall visit was greater than for an outdoor fall. We estimated the total charges associated with falls seen in EDs in the US were over $17 billion in 2017. Of this total, a disproportionate 34% was borne by Medicare to reimburse fall visits in the ED for older adults 85 years and over. Out of every 100 falls seen in the ED almost 90 are paid by Medicare. This was true for indoor as well as outdoor location of falls. In 2017, the estimated population of adults aged 85 and over was over six million,[22] of which over two-thirds were women. The 85 years and over population is projected to reach 19 million in 2050.[24] With this increase, the number of indoor and outdoor falls, and associated costs are expected to rise. Consequently, the need for effective falls prevention, especially indoor falls among women, is urgent.

In addition to the intrinsic factors, our results also identified personal- and community-level factors for fall-related ED visits. With respect to patient residence across communities (metropolitan, micropolitan, non-core), living in a metropolitan area increased the likelihood of an older adult reporting an indoor fall compared to a higher likelihood of an outdoor fall in non-core rural areas. While emergency clinicians should take note of this trend, population health and ED administrative startegic planning may similarly need appropriate tailoring in urban vs rural areas. Results from the multinomial logistic regression analyses (Table 3) also indicated a higher likelihood of indoor and outdoor fall-related visits among those in high-income ZIP codes. This finding, in all likelihood, highlights the disparity in access to resources for patients residing in low- income areas. At the population level, all in the healthcare system need to address economic disparities in access to care, specifically access to ED care for those in low-income areas. Additionally, individual emergency clinicians need to remain aware that all patients, including those from a higher income bracket, will need referal to fall prevention and mitigation care upon discharge from the ED.

In conjunction to the above, we also highlight the role of the multidisciplinary ED team comprised of emergency physicians, nurses, social workers, case managers, and counselors to help mitigate the effects of these personal (intrinsic) and socioeconomic (extrinsic) factors that may be contributing to the increasing volume of fall-related indoor/outdoor visits among our elderly. With fall-related ED visits on the rise, analysts[2] have highlighted the potential role that EDs could play in falls-prevention, and in conjunction the need for research on types of programs administrable in EDs. The EDs are in a unique position to engage and educate the older adults about future falls prevention. In 2014, the American College of Emergency Physicians, American Geriatric Society, Emergency Nurses Association, and Society for Academic Emergency Medicine released geriatric

Table 3. Multivariable multinomial logistic regression analysis (N = 27,522,770 (weighted)): Predictors of indoor falls (0 = no falls; 1 = indoor; 2 = outdoor) of older adults (≥ 65 years), NEDS 2017.

Population >=65 years	MODEL 1 RR, [CI] [Base category: no falls]	P-value	MODEL 2 RR, [CI] [Base category: no falls]	P-value
Indoor falls				
Gender				
Male	Ref		Ref	
Female	1.46 [1.45-1.46]	0.000	1.43 [1.42-1.44]	0.000
Age group				
65-74 years	Ref		Ref	
75-84 years	1.55 [1.54-1.56]	0.000	1.51 [1.49-1.52]	0.000
85 years and over	2.53 [2.51-2.55]	0.000	2.35 [2.33-2.37]	0.000
Location				
Large metro areas	Ref		Ref	
Small metro areas	1.06 [1.05-1.06]	0.000	1.06 [1.06-1.07]	0.000
Micropolitan areas	0.90 [0.88-0.91]	0.000	0.91 [0.90-0.92]	0.000
Non-core areas	0.87 [0.86-0.88]	0.000	0.88 [0.87-0.89]	0.000
Payer				
Medicare	Ref		Ref	
Medicaid and other	0.91 [0.89-0.93]	0.000	0.91 [0.89-0.92]	0.000
Private insurance	0.87 [0.85-0.88]	0.000	0.86 [0.85-0.87]	0.000
Self-pay/No pay	0.73 [0.71-0.76]	0.000	0.72 [0.70-0.75]	0.000
Income level				
$1-$39,000	Ref		Ref	
$40,000-$50,999	1.09 [1.08-1.10]	0.000	1.10 [1.09-1.10]	0.000
$51,000-$65,999	1.13 [1.12-1.14]	0.000	1.14 [1.13-1.15]	0.000
$66,000 or more	1.20 [1.19-1.21]	0.000	1.20 [1.19-1.21]	0.000
Grouped Charlson Comorbidity Index (GRPCI)				
0	Ref			
1	0.81 [0.80-0.81]	0.000	-	-
2	0.52 [0.51-0.52]	0.000	-	-
Outdoor falls				
Gender				
Male	Ref		Ref	
Female	0.96 [0.95-0.97]	0.000	0.96 [0.94-0.97]	0.000
Age group				
65-74 years	Ref		Ref	
75-84 years	1.00 [0.98-1.01]	0.709	1.00 [0.99-1.02]	0.709
85 years and over	0.89 [0.87-0.91]	0.000	0.90 [0.88-0.92]	0.000
Location				
Large metro areas	Ref		Ref	
Small metro areas	1.07 [1.05-1.08]	0.000	1.07 [1.05-1.09]	0.000
Micropolitan areas	1.16 [1.13-1.19]	0.000	1.17 [1.14-1.20]	0.000
Non-core areas	1.25 [1.21-1.28]	0.000	1.25 [1.22-1.29]	0.000

*Missing values were about 3% of the sample.
RR, relative risk ratio; *CI,* confidence interval; *N,* observations; *NEDS,* Nationwide Emergency Department Sample.

Table 3. Continued.

Population >=65 years	MODEL 1 RR, [CI] [Base category: no falls]	P-value	MODEL 2 RR, [CI] [Base category: no falls]	P-value
Payer				
Medicare	Ref		Ref	
Medicaid and other	1.07 [1.03-1.12]	0.002	1.06 [1.02-1.11]	0.002
Private insurance	1.04 [1.02-1.07]	0.004	1.04 [1.01-1.06]	0.004
Self-pay/no pay	0.86 [0.81-0.92]	0.000	0.85 [0.80-0.91]	0.000
Income level				
$1-$39,000	Ref		Ref	
$40,000-$50,999	1.24 [1.21-1.26]	0.000	1.24 [1.21-1.27]	0.000
$51,000-$65,999	1.43 [1.39-1.46]	0.000	1.43 [1.40-1.47]	0.000
$66,000 or more	1.63 [1.59-1.66]	0.000	1.65 [1.61-1.68]	0.000
17 Chronic conditions controlled	No		Yes	

*Missing values were about 3% of the sample.
RR, relative risk ratio; *CI,* confidence interval; *N,* observations; *NEDS,* Nationwide Emergency Department Sample.

guidelines specific for EDs that recommend screening for fall risk in EDs.[25] Indeed, a collective assessment that includes evaluation of current level of knowledge in addition to patient's balance, history of falls, and home evaluations is essential,[4] especially for those 85 years and older, female, or with chronic conditions. In fact, EDs incorporating a clinical support tool, such as the Stopping Elderly Accidents, Deaths, and Injuries, in conjunction with primary care providers saw a subsequent decrease in fall-related hospitalizations[26] and were successful in delivering high-quality care.[1] In addition, a geriatric-friendly protocol[27] that facilitates community service providers and/or geriatricians to collaborate with EDs for fall prevention could be beneficial.

LIMITATIONS

While our study is the first national-level study to report evidence of heterogeneity of risk factors by fall locations of older adults across the US, this finding is subject to a few limitations. First, the NEDS dataset collects visits-level information without designating any unique identifiers to patients. Thus, we could not determine instances of multiple records for the same patient. Despite this shortcoming, NEDS is the one exception that provides robust national estimates of hospital-based ED visit characteristics using the ICD-10-CM classification as opposed to self-reported data on falls. Second, while we controlled for patient's location as a proxy indicator for indoor/outdoor exposure, variation in fall types due to indoor and outdoor environments is an important future research direction.

Finally, while some of the ICD-10-CM codes (for example, W06-fall from bed, W14-fall from tree) were easily and clearly classifiable into an indoor (or outdoor) fall type, for others, we had to rely on evidence from the prior literature. For example, prior research[28-33] indicated elderly falls on the same level from slipping, tripping and stumbling (W01) to occur predominantly at home and so we categorized this ICD-10-CM code as an indoor fall. With this method, we acknowledge that we may have misclassified any portion of the same-level geriatric falls that occurred outside.

CONCLUSION

Older adult falls are complex, resulting from intrinsic conditions (such as chronic disease, frailty), extrinsic (environmental) factors, and/or situational activity. Emergency department encounters specific to older adult falls are associated with substantial costs, particularly to the Medicare program. Using the nationally representative 2017 NEDS dataset, we estimated a total of 3.52 million falls among older adults seen in the ED and found that risk factors of these falls varied by fall indoor/outdoor locations. When compared to older adult reporting no falls, women, those over 85 years, those with chronic conditions, and those from metropolitan areas had a higher likelihood of reporting indoor falls in the ED. In conjunction, we highlighted implications from three perspectives: a population health standoint for EDs working with their primary care and community care colleagues, from an ED administrative vantage point; and from an individual emergency clinician's point of view. Findings of our study are of salience in interpreting falls in EDs across the US. Indeed, reducing fall-related ED visits and, in turn, ED-based falls prevention programs are a public health priority.

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Emergency Absentee Voting for Hospitalized Patients and Voting During COVID-19: A 50-State Study

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Introduction: Voters facing illness or disability are disproportionately under-represented in terms of voter turnout. Earlier research has indicated that enfranchisement of these populations may reinforce the implementation of policies improving health outcomes and equity. Due to the confluence of the coronavirus 2019 (COVID-19) pandemic and the 2020 election, we aimed to assess emergency absentee voting processes, which allow voters hospitalized after regular absentee deadlines to still obtain an absentee ballot, and election changes due to COVID-19 in all 50 states.

Methods: We performed a cross-sectional study collecting 34 variables pertaining to emergency voting processes and COVID-19-related election changes, including deadlines, methods of submission for applications and ballots, and specialized services for patients. Data were obtained from, in order of priority, state boards of elections websites, poll worker manuals, application forms, and state legislation. We verified all data through direct correspondence with state boards of elections.

Results: Emergency absentee voting processes are in place in 39 states, with the remaining states having universal vote-by-mail (n = 5) or extended regular absentee voting deadlines (n = 6). The emergency absentee period most commonly began within 24 hours following the normal absentee application deadline, which was often seven days before an election (n = 11). Unique aspects of emergency voting processes included patients designating an "authorized agent" to deliver their applications and ballots (n = 38), electronic ballot delivery (n = 5), and in-person teams that deliver ballots directly to patients (n = 18). Documented barriers in these processes nationwide include unavailable online information (n = 11), restrictions mandating agents to be family members (n = 7), physician affidavits or signatures (n = 9), and notary or witness signature requirements (n = 15). For the November 2020 presidential election, 12 states expanded absentee eligibility to allow COVID-19 as a reason to request an absentee ballot, and 18 states mailed absentee ballot applications or absentee ballots to all registered voters.

Conclusion: While 39 states operate emergency absentee voting processes for hospitalized voters, there are considerable areas for improvement and heterogeneity in guidelines for these protocols. For future election cycles, information on emergency voting and broader election reforms due to COVID-19 may be useful for emergency providers and patients alike to improve the democratic participation of voters experiencing illness. [West J Emerg Med. 2021;22(4)1000–1009.]

INTRODUCTION

Earlier research indicates that Americans with significant health conditions or belonging to marginalized populations are disproportionately under-represented in terms of voter turnout.[1-6] Healthcare institutions have the potential to improve democratic participation,[2,7,8] and one method to achieve this is emergency absentee voting. The emergency absentee voting process allows voters to obtain and submit an absentee ballot if they experience a medical emergency or are hospitalized after their state's regular absentee deadline, which usually falls days or weeks before election day. However, guidelines and restrictions vary greatly between states.

For elections in 2020, existing disparities in voting accessibility were challenged further by the ongoing coronavirus disease 2019 (COVID-19) pandemic. Infections caused by the severe acute respiratory syndrome coronavirus 2 have been diagnosed in over 28 million cases in the United States (US), with over 500,000 deaths thus far.[9] Moreover, leading up to the election, an estimated 5,000-10,000 new hospitalizations daily occurred due to COVID-19.[10] Significant disparities in disease impact and mortality have been documented not only in older populations and those with comorbidities, but also across racial and socioeconomic lines.[11,12] This rise in hospitalizations may have increased the utilization and value of emergency absentee processes for patients unable to attend the polls in-person. The current pandemic also created challenges for all voters in general.

Among several studies documenting "superspreading" events due to large public gatherings,[13-15] some studies have suggested that elections may also be linked to increased viral transmission[16,17]; however, evidence on these surges has been mixed.[18] Nevertheless, in 2020 state governments implemented election delays and varying changes to voting processes for statewide and national elections, such as mailing ballots or ballot applications to voters and temporarily switching to universal mail-in voting. The confluence of the November 2020 election and COVID-19 emphasized the importance for patient and provider awareness of remote voting mechanisms that may both ensure access to voting for hospitalized voters and ameliorate the viral transmission risks by providing an alternative to in-person voting. However, to the best of our knowledge, there has been no nationwide assessment of emergency absentee voting processes or election changes nationwide due to COVID-19. Consequently, in the present study we aimed to a) profile state-by-state details and national trends in "emergency absentee processes" available to hospitalized voters and b) summarize changes in all 50 states' overall voting processes in light of COVID-19.

Population Health Research Capsule

What do we already know about this issue?
United States' citizens with health conditions have significantly lower voter turnout. In several states, emergency absentee voting enables hospitalized patients to vote.

What was the research question?
What statewide processes are available for unexpectedly hospitalized patients to access an absentee ballot?

What was the major finding of the study?
A total of 39 states have emergency absentee voting processes, with varying deadlines, features, and barriers to access.

How does this improve population health?
Emergency absentee voting may improve democratic participation among voters facing significant health conditions and promote more equitable policymaking.

METHODS

We collected 34 variables related to emergency absentee voting processes and election changes implemented due to COVID-19 for all 50 states from July15–November 3, 2020. Collected variables were determined using both deductive and inductive approaches.[19] Two authors (OYT and KEW) collated an initial set of variables from a first review of elections websites for all 50 states. This variable list was iteratively expanded through the the process of the study's data collectors convening weekly during data collection to discuss emergent themes across statewide protocols, representing new variables to record, until thematic saturation was reached. In order of priority we obtained data for these variables from each state's board of elections website, poll worker manuals, application forms, and state legislation. Variables related to election process changes implemented due to COVID-19 were re-collected weekly, due to the evolving nature of these changes. We verified collected data through correspondences with the boards of elections of all 50 states. Washington, DC, was not included for analysis due to nonresponse from the District of Columbia Board of Elections. This study was exempt from institutional review board approval, due to the publicly available nature of these data.

We report details for each state's emergency absentee voting process representing important information for physicians and patients to be aware of, including deadlines, methods of submission for applications and ballots, and specialized services such as in-person, ballot delivery teams. We used descriptive statistics and color-coded maps to summarize shared characteristics across states. All analyses were performed using Stata 15 (StataCorp, College Station, TX).

RESULTS

National Overview of Absentee and Emergency Absentee Voting

Twenty-nine states have no-excuse absentee voting systems, wherein no excuse or condition is required to obtain an absentee ballot (Figure 1A). Of the remaining 21 states, five conduct universal vote-by-mail elections, whereas 16 require specific conditions, such as physical disability or hospitalization to apply for an absentee ballot. However, because the deadline to apply for an absentee ballot is often days or weeks before election day, 39 states have "emergency" absentee voting processes for voters experiencing a medical emergency or hospitalization after this deadline (Figure 1B). The remaining six non-universal, vote-by-mail states did not have legislation on emergency absentee voting but were classified as having "extended regular absentee processes," due to having deadlines falling within 24 hours of election day or not having any specific application deadline. While emergency absentee processes primarily serve hospitalized voters, 23 states also had legislation extending emergency absentee voting privileges to family members of hospitalized patients, and 17 states had such legislation for healthcare workers unable to vote due to occupational duties (Figures 1C-D).

Steps of Emergency Absentee Voting Process and Interstate Differences

The normal absentee application deadline was most commonly seven days before an election (11 states), but this deadline ranged from 21 days (Rhode Island) to one day (four states) before an election. (Supplementary Figures A-B

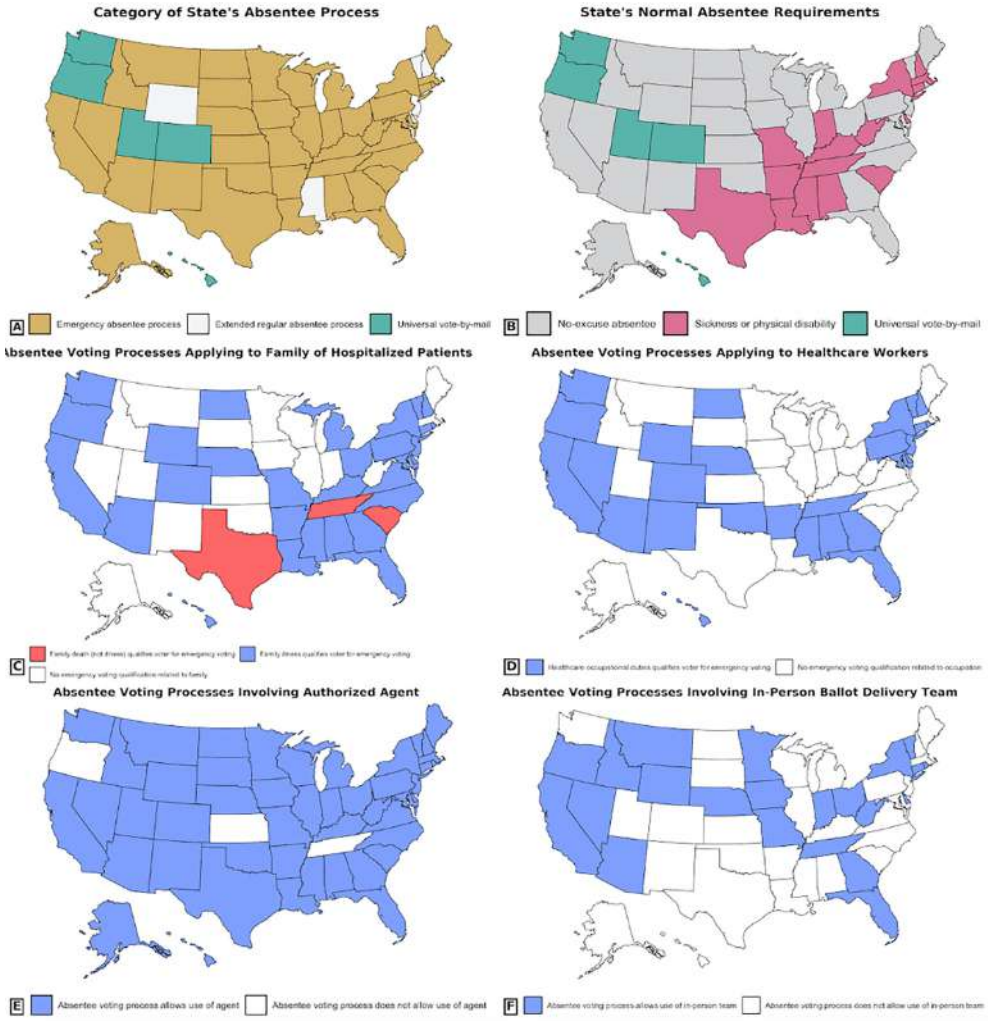

Figure 1. Nationwide map of state absentee voting practices. A. Nationwide distribution of absentee voting categories (universal vote-by-mail, no-excuse absentee voting, or absentee voting requiring an excuse). B. States with emergency absentee voting processes. C. States with absentee voting processes also applying to family members of hospitalized patients. D. States with absentee voting processes also applying to healthcare workers. E. States incorporating the use of an authorized agent for the voter. F. States using in-person ballot delivery teams.

and Supplementary Table 1). For the 39 emergency absentee voting processes nationwide, the emergency absentee period most commonly began within 24 hours following the normal absentee application deadline. Only 28 states had publicly available information on their board of elections website outlining the state's specific protocol.

The procedure for obtaining and voting through an emergency absentee ballot entails three steps. First, a hospitalized voter must fill out an initial emergency absentee application. Twenty-five states allow applications to be directly downloaded from the board of elections website, but the remaining states necessitate contacting a local election official to obtain an application. Moreover, nine states mandate a physician signature or affidavit on the application, attesting to the voter's hospitalization (Supplementary Table 2). The voter must subsequently return their filled-out application to their local election official (Table). The most common submission method is through an authorized agent (38 states), wherein the voter appoints an "agent," a representative designated for delivering the application in person (Figure 1E). Seven states mandate that a voter's agent must be a family member, but anyone, such as a healthcare worker, may serve as an agent in the remaining 31 (Figure. 2A). Additionally, 29 states do not limit the maximum number of applications a single agent can process (Figure 2B). Twenty-five states alternatively allow for applications to be submitted by mail, and 21 states have electronic submission methods such as email, fax, or phone requests. Applications must be returned by a specific deadline, which may fall 24-48 hours earlier than the eventual ballot return deadline (Supplementary Figure A).

Second, the voter must obtain their emergency absentee ballot. Thirty states allow for the voter's agent to pick up and return the ballot, following the processing of the emergency

Table. Methods for submitting application, obtaining ballot, and returning ballot.

	Methods to submit application			Methods to obtain ballot				Methods to submit ballot	
State	Agent	Mail	Electr.	Agent	Mail	Electr.	IPT	Agent	Mail
Alabama	X	X		X				X	
Alaska	X			X				X	
Arizona	X	X	X				X		
Arkansas	X	X	X	X	X			X	X
California	X			X			X[d]	X	
Connecticut	X	X		X	X		X	X	X
DC	X			X				X	
Florida	X		X[a]	X			X[d]	X	X
Georgia	X[a]	X	X	X[a]	X	X	X[d]	X[a]	X
Idaho	X	X	X		X		X[d]		X
Illinois	X			X				X	
Indiana	X	X	X				X		
Iowa	X[b]	X[b]	X[b]		X[b]		X[b,d]	X	X
Kansas		X	X		X				X
Kentucky	X	X	X	X	X			X	X
Louisiana	X	X	X	X	X	X		X	X
Maine	X			X				X	X
Maryland	X			X		X[c]		X	X

Breakdown of possible methods for submitting the emergency absentee application, obtaining the ballot, and returning the filled-out ballot for all 40 emergency absentee voting processes nationwide. "X" denotes that this is a viable method within the state.
a This method may not be universally available across all counties within the state and the patient should clarify with their county election office whether this method is allowed.
b Iowa's emergency absentee voting process has several phases. A voter hospitalized before 10/24 5 PM can submit an application by mail or agent to obtain an absentee ballot by mail. A voter hospitalized after this time but before 10/30 5 PM may follow the same submission methods to obtain an absentee ballot through an in-person team. Finally, voter hospitalized on 10/31 or after may contact their county auditor directly, such as by phone or email, to obtain an absentee ballot through an in-person team.
c Electronic delivery of emergency absentee ballots in Maryland is possible but decided on a case-by-case basis.
d In-person ballot delivery teams are only available based on certain geographic or institutional requirements, which are detailed in Supplementary Table 3.
DC, District of Columbia; *Electr.,* electronic; *IPT,* in-person team.

Table. Continued.

State	Methods to submit application			Methods to obtain ballot				Methods to submit ballot	
	Agent	Mail	Electr.	Agent	Mail	Electr.	IPT	Agent	Mail
Massachusetts	X	X	X	X	X			X	X
Michigan	X			X				X	
Minnesota	X	X	X	X	X		X[d]	X	X
Missouri	X	X	X	X	X		X[d]	X	X
Montana	X		X	X			X	X	
Nebraska	X	X	X	X	X	X	X	X	X
Nevada	X	X	X	X			X	X	X
New Mexico	X	X	X		X	X		X	X
New York	X			X			X[d]	X	
North Carolina	X			X				X	X
North Dakota	X	X	X	X	X			X	X
Ohio	X	X		X	X		X[d]	X	
Oklahoma	X	X	X	X	X			X	X
Pennsylvania	X	X		X	X			X	X
Rhode Island	X	X					X		
South Carolina	X			X				X	
South Dakota	X	X		X				X	X
Tennessee	X	X	X				X		
Texas	X			X				X	
Virginia	X			X				X	
West Virginia	X	X	X				X		
Wisconsin	X			X				X	

Breakdown of possible methods for submitting the emergency absentee application, obtaining the ballot, and returning the filled-out ballot for all 40 emergency absentee voting processes nationwide. "X" denotes that this is a viable method within the state.
c Electronic delivery of emergency absentee ballots in Maryland is possible but decided on a case-by-case basis.
d In-person ballot delivery teams are only available based on certain geographic or institutional requirements, which are detailed in Supplementary Table 3.
DC, District of Columbia; *Electr.,* electronic; *IPT,* in-person team.

application. Alternatively, 17 states can mail the ballot to a voter's hospital, and five states can electronically deliver a ballot such as through an online voter portal. Finally, 18 states may send bipartisan, in-person teams to deliver ballots directly to hospitalized voters (Figure 1F). These teams automatically return a voter's ballot to be counted after it has been filled out. However, in 10 of these states, the accessibility of in-person teams varies depending on where the voter is hospitalized (Supplementary Table 3).

Third, and finally, the voter must fill out and return their ballot. Fifteen states normally require a notary or witness to sign the absentee ballot before it can be counted, with a notary being the only option in four states (Supplementary Table 4). Voters may return their ballot through their agent (32 states), the mail (23 states), or an in-person ballot delivery team (18 states). Across all 39 states, the ballot return deadline falls after 12 PM on election day (Supplementary Figure A).

Accommodations for Hospitalized Voters in States Without Emergency Processes

The six states with extended regular absentee processes have absentee applications deadlines within 24 hours of election day (Supplementary Figure B). Despite not having formal emergency absentee processes these states often had components of these procedures, such as allowing voters to use authorized agents and using electronic and in-person team delivery of ballots (Supplementary Table 5). Additionally, the five states with universal vote-by-mail that mail ballots to all registered voters have processes for voters to re-obtain a ballot if they are separated from their original ballot due to a situation such as hospitalization.

Election Changes Made Due to COVID-19

In response to COVID-19, 20 states delayed state-level elections in 2020, such as congressional primaries. In the 16

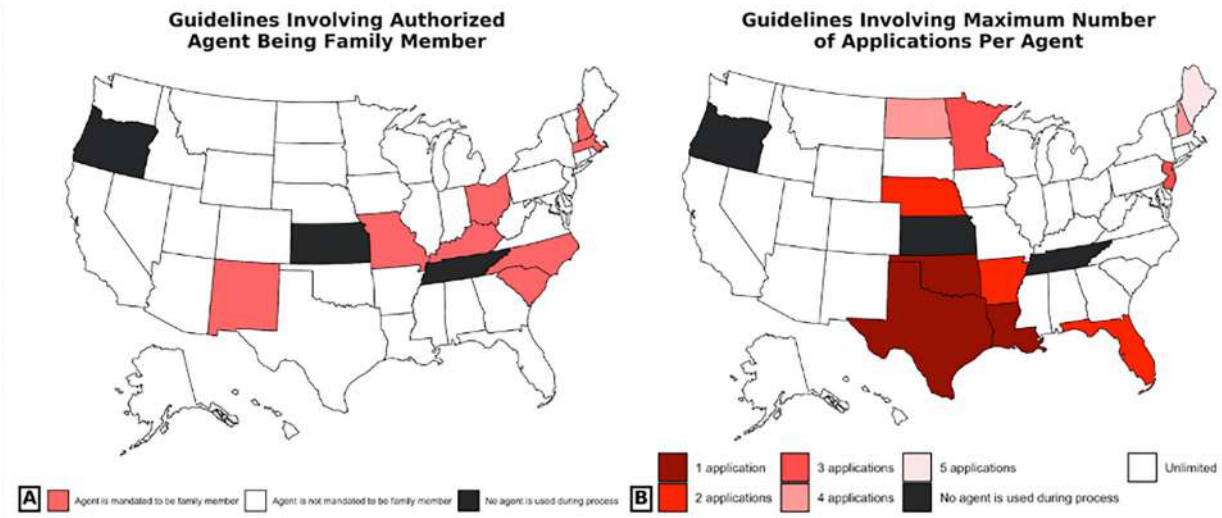

Figure 2. Statewide rules for voter's authorized agent.
A. Rules concerning whether a voter's authorized agent is mandated to be a family member. B. Rules concerning the maximum number of applications or ballots that a single agent can handle during an election.
[a]This regulation may vary county by county within the state.
[b]In Florida, the maximum limit of two applications per agent does not include immediate family members of the agent.

states requiring specific conditions to apply for an absentee ballot, 13 states expanded absentee eligibility to allow social distancing or concerns over COVID-19 as a legitimate excuse to obtain an absentee ballot (Figure 3A). Among the 45 states without universal vote-by-mail, 15 mailed absentee ballot applications and eight mailed absentee ballots to all registered voters (Figure 3B). Finally, of the 15 states with notary- or witness-signature requirements, eight loosened these regulations due to COVID-19, while seven did not make any changes (Supplementary Table 4).

Only a fraction of these changes applied to the November 2020 general election. Only 12 states continued to expand absentee eligibility requirements due to COVID-19 (Figure 3C). Thirteen states and five states mailed absentee ballot applications or absentee ballots, respectively, for the general election (Figure 3D). Six states extended the receipt deadline for receiving mail-in ballot deadlines (Supplementary Table 2), but similar efforts in Michigan and Wisconsin were overturned by federal courts.

Finally, COVID-19 also impacted emergency absentee processes within certain states. For example, the state of Maryland temporarily canceled in-person ballot requests, due to local election offices being closed to the public. Additionally, in light of infection control-related restrictions to hospital visitor regulations, election officials in six states reported the cancellation or decreased use of in-person ballot delivery teams (Arizona, Iowa, New York, Rhode Island) or in-hospital election workers to assist patients with ballots (Alaska and Minnesota) for 2020 state-level elections. However, four states (Arizona, Rhode Island, Tennessee, and Texas) reported adapting to these restrictions by swearing in or involving healthcare workers in ballot delivery teams.

DISCUSSION

In the setting of evidence that voters facing illness or disability are under-represented at the ballot box,[1-6] a potential way to improve democratic participation among this population is emergency absentee voting. These protocols allow hospitalized or ailing individuals to obtain ballots after the regular absentee deadline. Over three-quarters of states have an emergency absentee process, while the remaining have comparatively later regular absentee ballot deadlines or, in the case of universal mail-in ballot states, have last-minute replacement ballot options. The current study's summary of emergency absentee ballot procedures demonstrated a canonical process across states: patients must first submit an application; secondly, obtain their ballot; and, finally, return their filled-out ballot.

We found considerable heterogeneity between states in the sum of options, instructional clarity, and level of nuance for emergency absentee voting. A notable accommodation within emergency absentee processes is the use of a designated agent to carry out each step of the process. In particular, the majority of states do not require a voter's agent to be a family member or limit the maximum number of applications an agent can handle, allowing healthcare or social workers to potentially facilitate this process for patients. Moreover, 18 states employ in-person teams to deliver ballots directly to patients and eventually return them. Electronic means for application submission and ballot delivery may also expedite emergency voting processes,

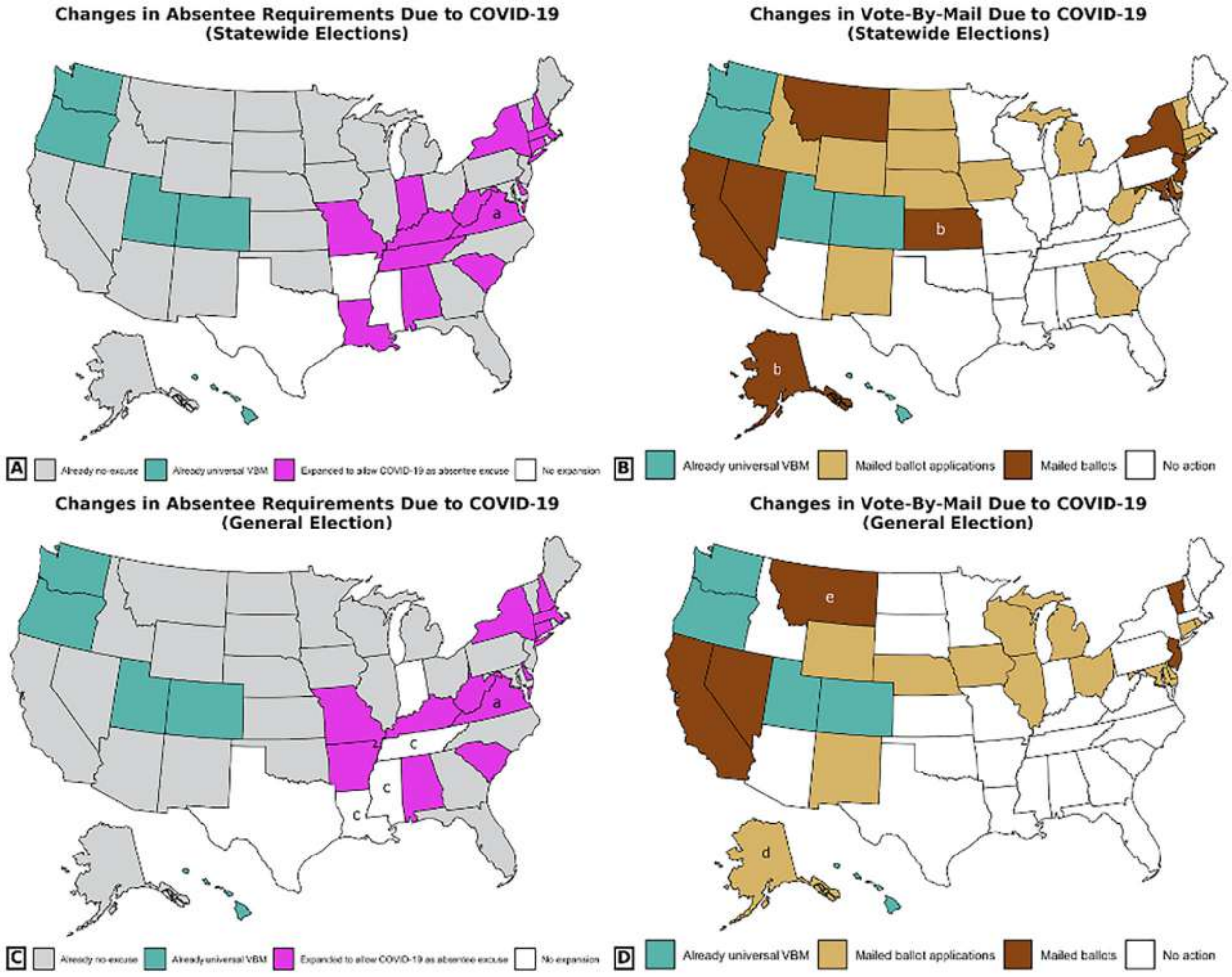

Figure 3. Nationwide map of election process changes due to COVID-19.
A. Expansion of absentee voting eligibility during state-level elections before November 2020. B. Expansion of mail-in ballots and application during state-level elections before November. C: Expansion of absentee voting eligibility for the November general election. D: Expansion of mail-in ballots and applications for the November general election.
a Virginia was already deliberating legislation to make absentee voting no-excuse before the COVID-19 pandemic, with an anticipated start date of July 1, 2020, but the state implemented this change earlier for its May municipal elections.
b These changes only applied to a presidential primary for a specific party and were not made by the state government.
c While absentee voting was not expanded to no-excuse in Louisiana, Tennessee, and Mississippi, these three states introduced absentee eligibility for voters under quarantine, serving as caretakers for others under quarantine, or belonging to a high-risk group for COVID-19.
d Absentee ballot applications were only mailed to voters above the age of 65.
e Montana allowed individual counties to make the choice to mail voters absentee ballots.
VBM, vote-by-mail.

but the extremely limited use of these methods indicates substantial room for expansion. Nevertheless, the present analysis also highlights notable areas of improvement for emergency voting processes, with the first being lack of access to public information.

Eleven states with emergency processes do not have this information on their board of elections websites, and 14 states do not have emergency ballot applications readily available for download. These processes also have substantial geographic variability. For example, over half of states with an in-person team delivery option have geographic restrictions determining whether a team can be sent to a voter. Requirements of designating family members as agents (seven states) also impede emergency voting for patients without readily available family. Administrative obstacles exist as well; several states have a notary and/or witness requirement for emergency absentee voting, and many also require a physician affidavit. In the most onerous case, Arkansas does not accept physician validation and requires a signature from a hospital's

administrative head. Conversely, in North Carolina it is a felony for hospital employees to assist patients with absentee voting.[20]

Limited studies have analyzed the issue of voting while hospitalized, and earlier research has primarily focused on assessing competency for certain hospitalized populations, such as patients with dementia, and the under-representation of patients in the voting population.[8,21,22] A common finding from the literature is that ill patients may have different voting priorities than the general population, especially on matters related to healthcare.[4,23] An under-representation of these voters may impact policy decisions pertaining to medical care and population health, and some studies have accordingly called for healthcare workers to address barriers to voting faced by patients.[2,7,8,24-27] Importantly, several studies have indicated that enfranchising marginalized populations is associated with improved health outcomes, due to these voters disproportionately supporting policies focused on equity, including healthcare and education.[1,23,28]

There are several ways that healthcare workers and institutions may act on this study's findings. First, healthcare workers may strive to educate themselves on the specific absentee and hospitalized voting procedures for their state — such as absentee ballot requirements and deadlines as well as methods of ballot and application delivery, especially given substantial interstate heterogeneity — and counsel interested patients accordingly, particularly those expressing concerns about missing an election due to their hospitalization. Healthcare workers should navigate the topic of voting with their patients akin to obtaining informed consent for a procedure, and they should respect a patient's decision to abstain from voting. Hospitals may also seek to expand patient knowledge by distributing informational flyers and codifying discussions of emergency voting into care encounters, such as social work consultations.

Second, hospital personnel may aim to improve the convenience of the documentation necessary for emergency voting, through measures such as printing out readily available ballot applications, coordinating mailing services, and arranging notary services for states with these requirements. Third, in states where it is allowed, healthcare workers may serve as agents for voters without any available designee, such as by delivering a patient's absentee application or assisting a ballot delivery team looking for the patient. Hospitals may also target volunteer recruitment toward this specific purpose. Fourth, hospitals may seek to partner directly with their local election body to establish a formalized process for patients to undertake absentee voting, a communication line for any troubleshooting or process updates, and institutional experience across election cycles. These recommendations may be especially important for emergency physicians, who are most commonly the first-line providers for unexpectedly hospitalized patients. Increasing public awareness of and access to emergency voting processes may improve representation of hospitalized voters.

Additionally, COVID-19 drove several states to make notable changes to overall election processes during 2020, including switching to entirely universal vote-by-mail elections, mailing absentee ballot applications or ballots to all registered voters, expanding absentee ballot eligibility to include concerns over COVID-19, and reducing notary/witness requirements; however, the carryover of these changes from statewide elections to the November 2020 general election was more limited. The pandemic also limited the operation of emergency absentee voting in several states. For example, to mitigate risk six states canceled the use of in-person teams but two (Arizona and Rhode Island) reported implementing teams using sworn-in healthcare workers to deliver ballots. It is conceivable that increases in hospitalizations due to COVID-19 increased the utilization of emergency absentee voting processes, but limited data in emergency ballot counts for most states limited analysis of this. However, in our anecdotal experience coordinating a nonpartisan emergency absentee voting organization called Patient Voting,[29] over 50% of patient inquiries nationwide were related to COVID-19 hospitalizations.

The COVID-19 pandemic presented several public health implications for the November 2020 election. Among several studies elucidating a potential link between elections and rises in viral transmission,[16,17] long-distance absentee voting options, which have been empirically demonstrated to have no impact on partisan turnout and minimal risk for fraud,[30,31] were increasingly used. An estimated 65 million mail-in ballots were cast in the 2020 election, compared to 33.5 million in 2016, which may have contributed to the historic turnout rate of over 65%.[32,33] The evolving election changes and the variable availability of voting-related information documented in this study emphasize the importance of state boards of elections clearly communicating voting processes to the public well in advance of elections.

Nevertheless, states faced additional infrastructure challenges for sufficiently handling an influx of mail-in ballots, which may continue to hold importance for future elections. Online portals for voters to request and track absentee ballots warrant expansion, such as incorporating notification of potential marking issues. Additionally, given research demonstrating that limited in-person voting options may disproportionately disenfranchise marginalized populations,[34] states still need to maintain in-person elections in some capacity for populations such as voters without internet access or requiring assistance due to disability. For 2020, this required investment into increased poll worker hiring, personal protective equipment for voters and workers, and sanitization resources for voting facilities and machines. While quantifying the nationwide costs of these

2020 election resilience measures is the subject of future study, one report projected that these reforms may have cost approximately $2 billion dollars.[35]

LIMITATIONS

The present study has several potential limitations. First, nearly every state did not track the number of emergency absentee ballots cast in elections, as these counts were often aggregated with general absentee voting turnout. Consequently, we were unable to assess variables associated with statewide differences in emergency absentee voting turnout or longitudinal trends in emergency absentee voting. Nevertheless, certain states such as Pennsylvania anecdotally reported increases in emergency absentee turnout following legislation simplifying requirements such as application submission methods. To facilitate future research on emergency absentee processes, such as characteristics that may influence turnout, states should record this outcome.

Second, the constant evolution of voting procedures due to COVID-19 complicated the process of collecting these variables, as states' disparate legal landscapes and state government decision-making produced varying levels of expansion, including some measures being reversed. Nevertheless, the data presented represents the information available at the time of the 2020 general election being conducted and may serve to guide public health dialogue on these measures. Third, because state emergency voting policies are actively evolving, some of the information in this study may not apply to future election cycles. Due to COVID-19 impacting even permanent election policy for some states, such as motivating Virginia's decision to expedite its transition to no-excuse absentee voting, it is conceivable that some changes made in 2020 due to the pandemic may be permanently extended into future elections by legislation. We believe our findings are significant in that they a) explain the archetypal process of emergency absentee voting for patients; b) summarize the current state of emergency absentee voting nationwide; and c) elucidate barriers to voting that future legislation may aim to alleviate.

CONCLUSION

This study reports information on emergency absentee voting for physicians and patients and summarizes information on 2020 election changes driven by the COVID-19 pandemic. We report nationwide data on election processes for physicians to mitigate the impact on marginalized and under-represented populations disproportionately affected by healthcare disparities. The COVID-19 pandemic has proven the necessity of voting systems structured to assist patients burdened by illness and disability. Understanding emergency voting procedures for sick or hospitalized voters is an important step.

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An Automated Tobacco Cessation Intervention for Emergency Department Discharged Patients

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Introduction: Nearly 14% of US adults currently smoke cigarettes. Cigarette smoking causes more than 480,000 deaths each year in the United States. Emergency department (ED) patients are frequently asked for their use of tobacco. Manual selection of pre-formed discharge instructions is the norm for most ED. Providing tobacco cessation discharge instructions to ED patients presents another avenue to combat the tobacco use epidemic we face. The objective of the study is to evaluate the effectiveness of an automated discharge instruction system in increasing the frequency of discharging current tobacco users with instructions for tobacco cessation.

Methods: The study was done at an urban academic tertiary care center. A before and after study was used to test the hypothesis that use of an automated discharged instruction system would increase the frequency that patients who use tobacco were discharged with tobacco cessation instructions. Patients that were admitted, left against medical advice, eloped or left without being seen were excluded. The before phase was from 09/21/14-10/21/14 and the after phase was from the same dates one year later, 09/21/15-10/21/15. This was done to account for confounding by time of year, ED volume and other factors. A Fisher's Exact Test was calculated to compare these two groups.

Results: Tobacco cessation DC instructions were received 2/486 (0.4%) of tobacco users in the pre-implementation period compared to 357/371 (96%) in the post-implementation period ($p < 0.05$).

Conclusions: The automated discharge instructions system increases the proportion of tobacco users who receive cessation instructions. Given the public health ramifications of tobacco use, this could prove to be a significant piece in decreasing tobacco use in patients who go to the emergency department. [West J Emerg Med. 2021;22(4)1010–1013.]

INTRODUCTION

Nearly 14 of every 100 U.S. adults aged 18 years or older (14.0%) currently smoke cigarettes. Cigarette smoking causes more than 480,000 deaths each year in the United States.[1,2] Patients are usually asked about tobacco use by nursing in the emergency department (ED) as part of a set of standardized questions during the initial triage process[3] However, this information is rarely addressed by the physician unless the tobacco use is relevant to the presenting complaint, such as with acute respiratory illness.[4,5] Patients frequently leave the ED, with the emergency physician aware of their patient's tobacco use however with only a small minority stating that they provided any intervention to help the patients quite tobacco use.[4] ED patients often times are interested in quitting smoking however lack the resources to do it.[6] Prior studies have shown only 27% of emergency physicians routinely asked patients to

quit smoking.[7]

Perceived barriers by physicians to addressing tobacco use in the ED include lack of training, resources, and time as ED volumes continues to climb.[7,8] This presents a challenge for emergency physicians as the high volume of patients make it challenging to address non-emergent issues such as tobacco use. However, with electronic health records (EHR) becoming ubiquitous, studies have shown improvement of smoking cessation practices through automated reminders.[9] Printed self-help materials help more people to stop smoking than no intervention.[10] Therefore, providing tobacco cessation discharge instructions to ED patients presents another avenue to combat the tobacco use epidemic we face.

The aim of our study is to evaluate the effectiveness of an automated discharge instruction system in increasing the frequency of discharging current ED tobacco users with instructions for tobacco cessation.

MATERIALS AND METHODS

Study Design and Setting

The study was granted Institutional Review Board exemption status. The setting of the study is an urban academic tertiary care center with an affiliated three-year emergency medicine residency. The hospital uses a homegrown EHR and does not use a proprietary vendor. The automated discharge instructions system was specifically designed for this EHR, which the hospital continues to use at the time of publication.

A before and after study was used to test the hypothesis that use of an automated discharge instruction system (which automatically detects for tobacco use) would increase the frequency of tobacco cessation discharge instructions usage. All patients who were discharged from the ED during the study period were enrolled. The hospital does not routinely see patients under the age of 18, however any pediatric patients that were seen and discharged in the ED were included in the study. Patients that were not properly discharged were excluded including admitted, left against medical advice, eloped, expired, transferred, or left without being seen. Sample size calculations were performed with an alpha of 0.05 and a power of .80 to detect a 5% increase in the inclusion of tobacco cessation discharge instructions in the post implementation group. A convenience sample of patients was collected during two, 31-day time periods. The intervention was deployed on November 20, 2014. The before group data were collected from September 21, 2014 to October 21, 2014, thirty days prior to intervention. Patients from the exact time frame one year later comprised the after group, September 21, 2015 to October 21, 2015.

Methods of Measurement

As part of the normal triage screening process, patients are asked a brief social history by the triage nurse, including the use of tobacco, alcohol or other illicit drugs. For tobacco use specifically, patients are specifically asked by the triage nurse, "Do you currently use tobacco products?" The responses are captured in dichotomous structured data elements with the option of further detail in free text comment box. This did not change pre- or post-intervention. These patients in their discharge instructions had a standard discharge instructions attachment automatically included in their discharge paperwork. Patients who had tobacco screening questions asked after discharge paperwork initiated would not have the tobacco cessation instructions automatically included. Patients were considered to be tobacco users if on review of their completed chart, the patient responded affirmatively to either anyone on the care team (e.g., nursing, attending physician, resident physician, supervising senior resident) asking them about tobacco use.

Outcome Measures

The primary outcome measure in this study is the inclusion of tobacco cessation discharge instructions in patients discharged from the ED.

Primary Data Analysis

In order to ensure that the before and after study populations did not statistically demonstrate any differences, baseline characteristics between the two groups were tested for significant different. Age collected in years was treated as a normal distribution and a two-sample t-test with unequal variances was used. Gender (male/female), race (white/non-white), language (English/non-English) and tobacco (use or no use) were dichotomous variables and a Fisher's exact test was used. Emergency Severity Index (ESI) is an ordinal variable and a Pearson's chi-squared test was used. Length of stay (in minutes) was found to be not normally distributed and a Wilcoxon rank-sum test was used. Lastly, inclusion of the standard tobacco cessation instructions into the discharge paperwork was dichotomous so Fisher's exact test was used.

RESULTS

Characteristics of Study Subjects

A total of 2824 patients were discharged from the ED during the before phase compared to 2818 in the after phase. The before and after group did not demonstrate any significant differences in various characteristics based on testing. Table 1 shows these

Table 1. Characteristic comparison between the before and after implementation of the automated discharge instructions module.

	Before group	After group	P-value
Age (years)	47.3	46.9	0.53
Gender (% female)	59.8	56.8	0.94
ESI (1-5)	2.86	2.82	0.89
Race (% white)	54.8	52.9	0.79
Language (% English)	90.4	89.4	0.47
LOS (minutes)	299	320	0.58
Tobacco (% use)	17.2	13.2	0.24

LOS, length of stay; *ESI,* emergency severity index.

attributes in the before and after populations as well as the statistical testing results.

Main Results

Tobacco cessation discharge instructions were received in 2 out of the 486 (0.4%) of tobacco users in the pre-implementation period compared to 357 out of the 371 (96%) in the post-implementation period. The Fisher's Exact test was significant with a p-value of <0.001.

DISCUSSION

The automated discharge instruction system significantly increased the number of tobacco-using patients who were subsequently discharged with tobacco cessation counseling instructions. Given the public health ramifications of tobacco use, this could prove to be a significant piece in decreasing tobacco use in tobacco using patients who are discharged from the ED.

Prior to implementation of the automated process, providers manually selected tobacco cessation discharge instructions in appropriate situations in less that 1% of patient encounters, a similar rate to prior studies.[3] With a simple automated intervention this rate increased to over 95% adherence, thereby circumventing the prior barriers emergency providers encountered. Fourteen patients in the after group who did use tobacco did not end up getting the cessation instructions because they not properly triaged due to. acuity thereby bypassing triage, language barrier, and nursing oversight. Tobacco users were based off of chart review of a combination of triage, physician and nursing documentation so additional patients were captured that use tobacco that were not initially picked up at triage.

Tobacco cessation is merely one of many non-emergent health care issues that emergency physicians encounter on a daily basis with greater adoption of EHRs, there is ample opportunity to easily identify non-emergent but important patient issues (such as hypertension, hyperglycemia, alcohol abuse) and automate a structured response in an effort to deliver better care.

LIMITATIONS

One limitation of the study is that this is a before-after study and therefore subject to potential confounders. Thus, the study periods were chosen exactly 1 year apart as this would try to account for some confounding. Some of the more common populations characteristics were compared in our study to ensure two similar study populations. No significant operational or staffing changes were made between the two study periods.

Other limitations include whether the outcome measure of increasing the rate of tobacco users presenting to the ED who are subsequently discharged with tobacco cessation instructions is clinically relevant. By automating detection and inclusion of discharge materials for patient education, this offloads this simple but easily forgotten task to the EHR thereby vastly increasing the likelihood of attaching instructions to help the patient cease tobacco use. The use of a custom homegrown EHR is another limitation, as most hospitals have shifted to a commercial vendor. However, the concept and programming implementation for this intervention should be easily reproducible with minimal cost and effort.

Future studies include long term follow up of those who received tobacco cessation discharge instructions compared to those that did not and observing for decrease in tobacco use. Other areas of research include using similar automated discharge instructions for other common, overlooked chronic conditions in ED discharge patients such as hypertension and blood sugar management.

CONCLUSIONS

Using an automated discharge instruction system can help emergency physicians increase the frequency of providing written instructions on tobacco cessation to users, which has previously been shown to help more people to stop smoking than no intervention. Tools such as automated discharge instructions provide a means of addressing incidental, chronic issues that busy emergency physicians might otherwise overlook.

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Severe Vitamin K-dependent Coagulopathy from Rodenticide-contaminated Synthetic Cannabinoids: Emergency Department Presentations

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Introduction: Synthetic cannabinoids are a rapidly expanding subset of designer drugs widely available in the United States since 2008. In Illinois during the spring of 2018, over 160 documented cases of bleeding and prolonged coagulopathy occurred secondary to contaminated synthetic cannabinoids.

Methods: We conducted a retrospective cohort study consisting of 38 patients to describe the initial emergency department (ED) presentation, diagnosis, and treatment.

Results: Through serum testing we found that three long-acting anticoagulant rodenticides (LAAR) were detected in patients who had inhaled these tainted products: brodifacoum, difenacoum, and bromodialone.

Discussion: This study encompasses the largest ED presentation of LAAR poisoning via the inhalational route known to date.

Conclusion: The emergency physician should be aware of the potential for tainted coingestants as the cause of undifferentiated coagulopathy. [West J Emerg Med. 2021;22(4)1014–1019.]

INTRODUCTION

Synthetic cannabinoids have become a widely used type of designer drug in the global drug market.[1] Synthetic cannabinoids first made their appearance in the United States in 2008 and are sold under numerous names including "K2," "Spice," and "Black Magic." These drugs have long evaded law enforcement due to the drug manufacturers' ability to quickly alter chemical formulas and generate novel products that have yet to be made illegal under the Controlled Substances Act. In addition, most of these are packaged and sold as herbal products and labeled as "not for human consumption" to further circumvent drug laws.[2]

After being dissolved in solvent, synthetic cannabinoids are typically formulated and sprayed onto an herbal product that is then smoked and inhaled.[3] A wide array of symptoms has been associated with ingestion from these compounds. While some users report similar euphoric effects to that of marijuana, there have been other significant adverse reactions reported. Most common adverse symptoms reported include paranoid delusions, psychosis, supraventricular tachycardia, seizures, and altered sensorium.[4] Additionally, there are many reports describing associations of synthetic cannabinoids with acute medical conditions including ischemic and hemorrhagic strokes, thrombotic microangiopathy, disseminated intravascular coagulation, immune thrombocytopenic purpura, rhabdomyolysis, and death.[5-9]

Illicit drugs are often adulterated with other products to increase profits and/or to enhance or alter the drugs' effects on the body. Several substances including both legal and illegal compounds have been used to achieve these effects.[10] Interestingly, there are numerous case reports surrounding the use of warfarin as an adulterant "lacing compound."[11-15] The addition of warfarin or long-acting anticoagulant rodenticides (LAAR) may alter CYP P450 metabolism of the psychoactive compound and act to enhance the high. We surmise drug manufacturers and distributors have exploited this pharmacological interaction in the past based on several other reported cases.

During the spring of 2018, a large influx of patients presented to area hospitals in Illinois with unfounded coagulopathy and bleeding. The outbreak began in mid-March 2018 with over 160 reported cases in Illinois across 15 counties through June 2018.[16] Through July 2018 the number of cases increased to 255 with eight reported deaths.[17] By the end of July, over 55% of the documented cases had occurred in Peoria, Tazewell, and surrounding counties in Illinois. Due to symptoms of significant, prolonged bleeding and lack of known exposure to vitamin K_1 antagonists there was concern that these patients had been inadvertently exposed to a long-acting anticoagulant. A large, interdisciplinary task force composed of members of the US Centers for Disease Control and Prevention, Illinois Poison Center, Illinois Department of Public Health, law enforcement agencies, and health departments was convened to elucidate the cause of this unexplained coagulopathy. It was promptly discovered that poisoned patients had been exposed to tainted synthetic cannabinoids that largely tested positive for brodifacoum, a LAAR.[18]

Other researchers have described a similar population at a single Illinois academic center.[19,20] While those studies concentrated on the inpatient population, treatment and long-term therapy, our focus is to address the emergency department (ED) presentation, diagnosis, and treatment. While the populations are similar, we feel the difference in focus is substantive as the emergency physician is tasked with diagnosis, stabilization, and treatment initiation prior to the patient's hospital stay. Our goal is to help readers recognize and diagnose patients suffering from bleeding diathesis in the ED as well as to identify potential resuscitative treatment strategies via descriptive data from a recent LAAR outbreak.

Population Health Research Capsule

What do we already know about this issue?
An outbreak of bleeding diathesis in Illinois in spring 2018 was linked to exposure to synthetic cannabinoids contaminated with long-acting anticoagulant rodenticides.

What was the research question?
To elucidate management therapies we investigated patients who presented to our ED with concerns for exposure to anticoagulants.

What was the major finding of the study?
Many of our patients required active reversal of anticoagulant effects with Vitamin K and/or fresh frozen plasma, and a high number were admitted to the intensive care unit.

How does this improve population health?
The emergency physician must be prepared for and aware of the possibility of future outbreak linked to tainted synthetic cannabinoids.

METHODS

Study Design

We conducted a retrospective cohort study to describe the initial ED presentation, diagnosis, and treatment of inhaled LAAR-induced coagulopathy.

Population

This study was conducted at two Illinois academic urban EDs with annual patient visits of approximately 85,000 and 120,000, respectively. We performed chart review of all patients with suspected brodifacoum-related coagulopathy from contaminated synthetic cannabinoids presenting to the ED. Patients with reported exposure who presented to either of these ED between March 29–April 23, 2018 were included in this study. Patients were identified from internal and public health registries, from patients themselves self-identifying as having an exposure, or who were identified by hospital providers as having an exposure. Using defined variables, we abstracted ED and hospital charts, and all data was deidentified prior to analysis. The institutional review boards (IRB) of the University of Illinois College of Medicine at Peoria and Oregon State University reviewed

and approved this study prior to initiation. All data remained deidentified throughout.

Samples

Serum samples were obtained from 38 patients from Illinois academic urban EDs. Initial blood samples were obtained for clinical care of these patients. Leftover serum from clinical draws was then placed in vacutainers and stored at –80°C until analysis. Samples were sent to and analyzed at the Linus Pauling Institute, Corvallis, OR. Ultra performance liquid chromatography - tandem mass spectrometry (UHPLC-MS/MS) analysis was used to quantify plasma concentrations of brodifacoum, difenacoum and bromadiolone, three structurally distinct LAARs.

Statistics

We used descriptive statistics to describe the population, define common symptomatology, and identify successful treatment regimens. Unadjusted linear regression analysis was used to describe relationships between plasma LAAR levels and international normalized ratio (INR) values. We used Pearson coefficients to investigate the correlation between variables.

RESULTS

A total of 38 patients met criteria for inclusion in this study. Of the patients included, 24 males (68%) and 14 females (36%) were identified as being exposed to tainted synthetic cannabinoids. Ages ranged between 23-65 years with a mean age of 37 years at time of presentation. Of these patients, 76% (n = 24) were identified as White. This cohort experienced high admission rates to the hospital with 92% of patients (n = 35) being admitted. The three patients not admitted to the hospital left the ED against medical advice (AMA). Mean length of stay for those admitted was 4.1 days, with a range of 1-11 days. Readmission rates were also very high for this group as 30% of patients (n = 12) were readmitted within 30 days of their initial presentation. Among the wide variety of presenting symptoms the most common presenting complaint was back and or flank pain and the most common site of bleeding was from the urinary tract (Figure 1).

On average, patients had significantly elevated INR values at time of presentation. The INRs ranged from 1 to >20. (The maximum upper limit of on-site laboratory testing is an INR level of >20.) The mean INR at presentation was 14.5. At time of discharge from the hospital, the mean INR was 2.5.

Reversal of LAAR-related coagulopathy was at the treating physician's discretion. Several therapeutic decisions were made in consultation with Illinois Poison Control. Patients were treated with a combination of oral vitamin K_1, intravenous (IV) vitamin K_1, and fresh frozen plasma (FFP). Two patients left AMA before being treated. Of those treated, 25% (n = 9) received 10 milligrams (mg) IV vitamin K_1; 41% (n = 16) received 50 mg oral vitamin K_1 as monotherapy, and 34% (n = 13) received a combination of 50 mg oral vitamin K_1 and 10 mg

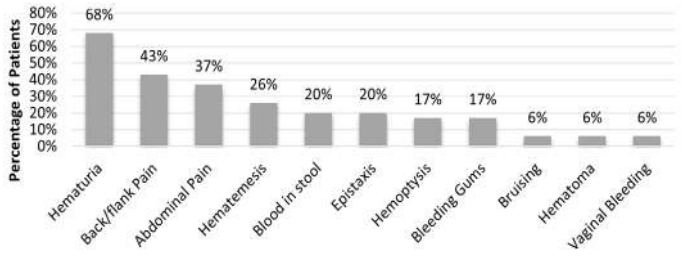

Figure 1. Thirty-eight patients with identified exposure to super warfarin-tainted synthetic cannabinoids.

IV vitamin K_1. In addition to vitamin K_1, 48% of patients (n = 18) also received FFP with a dose range of 1-4 units while in the ED (Figure 2). There were no patients treated solely with FFP, which was always used in conjunction with vitamin K_1 therapy. Brodifacoum, difenacoum, and bromodialone were detected in serum samples. Brodifacoum and difenacoum were detected in 37/38 samples (97%), and bromadiolone was detected in 24/38 samples (63%). Brodifacoum was the predominant LAAR detected; however, it appears that given the high prevalence of difenacoum and its strong correlation to brodifacoum levels (Figure 3) that difenacoum was a co-contaminant of the synthetic cannabinoids, or possibly a minor breakdown product of brodifacoum. In contrast, bromadiolone was detected in few samples overall and had a weaker correlation with brodifacoum levels (Figure 3). This may suggest that only some batches of synthetic cannabinoids were co-contaminated with bromadiolone, or it could reflect the contaminant's more rapid metabolism compared to the other LAARs.

Levels of LAAR and serum INR correlated in a weakly linear fashion (Figure 4). These LAARs have significant distribution into tissues and sequester in the liver; therefore, serum levels of LAAR do not fully represent total body accumulation and may account for at least part of the significant variability of brodifacoum levels and INR.[21]

DISCUSSION

In the largest cohort of inhalational LAAR coagulopathy to date, many of the patients were quickly recognized and

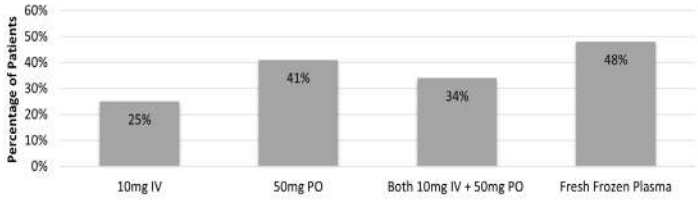

Figure 2. Thirty-eight patients presented and were identified as being exposed to tainted synthetic cannabinoids. Initial emergency department treatment included oral vitamin K1, IV vitamin K1, and fresh frozen plasma.
IV, intravenous; *PO,* by mouth; *mg,* milligram.

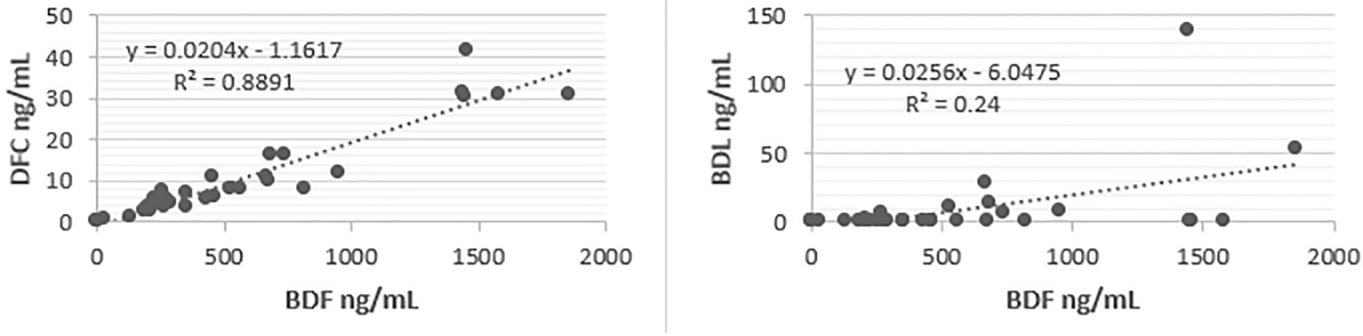

Figure 3. Left: Serum brodifacoum levels plotted on X axis; serum difenacoum levels plotted on Y axis. Linear relationship indicates likely co-contaminant. Right: Serum brodifacoum levels plotted on X axis; serum bromadiolone levels plotted on Y axis. Bromadiolone levels were around 4% of brodifacoum levels, suggesting this is a minor metabolite or a minor co-contaminant.
ng, nanogram; *mL,* milliliter.

triaged in the ED. The initial treatments in the ED focused on recognition and stabilization as well as reversal of their coagulopathy. The most prominent presenting symptoms included complaints of back and/or flank pain and abdominal pain. Physical manifestations of coagulopathy, including hematuria, bloody stools, and epistaxis and mucosal bleeding, were also observed. Although the exact reasons for combining, or tainting, synthetic cannabis with LAAR is unknown, it is hypothesized that potentiation of cannabinoid effects may have been the desired outcome.[22-25] Regardless of intent, recognizing the potential of contamination of street drugs is extremely salient to the emergency physician. Since the Illinois outbreak that occurred between March-May 2018, there have been further outbreaks of tainted synthetic cannabinoid coagulopathy throughout the East Coast.[26] As this would suggest, the outbreak in Illinois does not appear to be an isolated incident, and continued vigilance and awareness of this ongoing problem by emergency care providers is necessary.

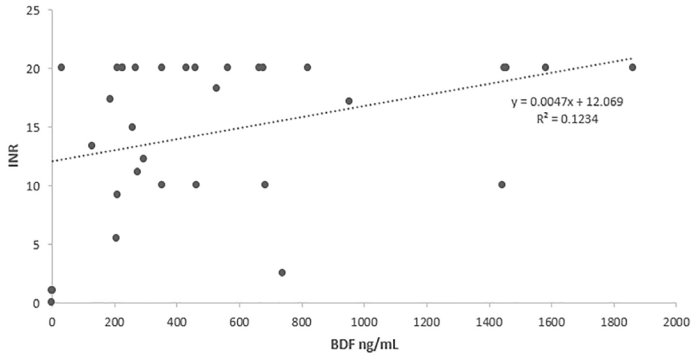

Figure 4. Serum brodifacoum levels plotted on X axis, INR plotted on Y axis. There is a linear correlation with respect to increasing serum brodifacoum levels and elevated INR. This likely is in part due to the volume of distribution into tissues.
BDF, brodifacoum; *INR,* international normalized ratio; *ng,* nanogram; *mL,* milliliter.

This cohort of patients was largely treated with vitamin K_1 in both oral and IV formulations while in the ED. Early involvement of Illinois Poison Control allowed for additional treatment recommendations and appropriate surveillance of the outbreak. Most patients were given either 50 mg oral vitamin K_1 and/or 10 mg IV vitamin K_1. However, in those with more significant bleeding, FFP in doses between 1 to 4 units was also used. More advanced products such as Kcentra and factor eight inhibitor bypassing activity (FEIBA) were not used. These products have been shown in several studies to rapidly reverse LAAR-induced coagulopathy and are recommended for those with life-threatening bleeding.[27-28]

Treatment for LAAR-induced coagulopathy outside the initial ED stay has proven to be difficult. Many of these patients have experienced repeat ED visits with 30% readmitted in the first 30 days. Many patients were sent home with high doses of oral vitamin K_1, ranging from 50-150 mg daily. With 15 mg of generic vitamin K_1 estimated to cost around 80 US dollars, this treatment was often cost-prohibitive for many patients. We suspect cost was the reason many patients with coagulopathy went untreated and suffered from recurrent bleeding, comorbidities, and repeat hospitalizations. Additionally, the pharmacokinetics of brodifacoum (which has a half-life up to 40 hours) can cause patients to suffer from coagulopathy for up to 12 months post ingestion. Until this time, many experts recommended using serum INR to guide vitamin K_1 therapy for patients with ingestions. With data from these outbreaks, new proposals suggest that following LAAR levels may be the best way to determine when vitamin K_1 therapy may be stopped.[29,30]

LIMITATIONS

This descriptive study of the largest inhalational LAAR poisoning to date is not without limitations. First is that we conducted a retrospective chart review of patient data. While

this study is limited by the standard biases that retrospective chart reviews suffer, we have addressed some of these aspects. During this outbreak, IRB approval was obtained to allow for a prospective approach to standard documentation; this limited some of the collection discrepancies. In addition, prior to chart review we created a standardized abstraction form allowing for a systematic approach to data retrieval. Secondly, while this is the largest tainted inhalational LAAR cohort to date, inherently the patient population is limited. Although we were able to formulate some correlations given the sample size, results may be more pronounced with a larger cohort.

This is the largest cohort of inhalational LAAR toxicity known to date. Recurrences of smaller outbreaks would suggest that LAAR-contaminated synthetic cannabinoids may not be isolated to synthetic cannabinoids.

CONCLUSION

Working on the frontlines of healthcare, the emergency physician should be aware of the potential for tainted coingestants as the cause of undifferentiated coagulopathy. Long-acting anticoagulant rodenticide poisoning can usually be treated with vitamin K_1, with the majority of these patients needing long-term outpatient treatment. For those with life-threatening bleeding more advanced products including fresh frozen plasma, Kcentra and FEIBA may be indicated. Additionally, the emergency physician should be aware of the high potential for return visits in these patients for recurrent bouts of coagulopathy due to the prolonged course of action of the drug.

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Comment on "Misunderstanding the Match: Do Students Create Rank Lists Based on True Preferences?"

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We would like to thank the authors for exploring students' understanding of the National Residency Match Program (NRMP) algorithm,[1] as it is both complex and potentially confusing. In their paper, the authors make significant value judgments about what should and should not affect an applicant's rank list. They make assumptions about what an optimal match would be for applicants and assert that a program's opinion of an applicant is not a reason to change a preference for one residency over another. An applicant's perceived competitiveness based on program reputation alone should not dissuade them from ranking highly a very competitive program, as the NRMP algorithm prioritizes applicants' preferences over those of programs. However, if an applicant has some evidence that a certain program thinks especially highly of them, we believe that bit of data may suggest how a program views their fit with the residency. Programs should be cautious when alerting applicants about their relative rank list positions as applicants may interpret that as a guarantee. Ranking an applicant highly may not necessarily mean they are guaranteed to match, but rather in a position to match based on data from previous match years.

The benefits of mentorship during training are well described.[2] Even more than mentorship, though, having a champion, one who can support and promote a resident during their training and into their post-GME career, is a rare and invaluable asset to any trainee. Making a connection with program faculty during an interview based on a shared background, professional interests, or personal goals may be the first signs of a future mentor or champion. Of course, each applicant who enters a residency should be supported by the program director (PD), associate and assistant PD, and program staff, but if there is already an indication that there is a special connection or rapport with others, this may be apparent to the applicant and may be worth ranking a particular program higher than another.

We believe the converse is also true. If a program is ranking an applicant low there may be many reasons, including a strong applicant pool, differences in weightings of the written application and interview, or potentially a poor fit based on the interview. The NRMP algorithm does favor the student; so if all other aspects of that residency program are ideal for the applicant, they may still rank a program highly even after hearing they would be ranked low by the program. Acknowledging that it would be an aberrancy for an applicant to know for certain that they will be ranked low, this information may indicate that the residency program feels the fit is not ideal, and there may be programs perceived as less competitive that might be a better fit and, ultimately, a better match for that applicant.

Applicants must assess programs based on many characteristics. Each applicant will determine their own personal algorithm for weighting each of these assessments. Factors that have been important to applicants include location and reputation, but knowing that a program will rank an applicant highly may well shine a light on the "goodness of fit," which is described as the second most important factor in how applicants rank programs.[3] Becoming aware of how a program rates the applicant may provide a sense of that "goodness of fit" and may be a worthwhile criteria to impel a reordering of an applicant's rank list.

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Response to "Misunderstanding the Match: Do Students Create Rank Lists Based on True Preferences?"

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We agree fully that "reciprocal liking" may be an important causal factor behind some of the mismatch between student behavior and theoretically ideal Match behavior. Indeed, it likely explains why programs and applicants go out of their way to communicate liking for one another despite official National Resident Matching Program (NRMP) policy discouraging communications.[1] It is well supported in the social psychology literature that expressing liking for someone increases the tendency for the other individual to like them.[2-4] Additionally, we agree that programs often have a good sense of where they can provide maximal value to applicants for career development, such as mentorship, research infrastructure, or specific clinical experiences such as flight medicine. We would advise applicants against making more than minor changes to their rank lists based on communications from programs regarding these factors, but we agree that it is not necessarily irrational for an applicant to adjust their rank list when a program communicates strong interest.

However, there are several reasons to believe that the findings of this study are not comprehensively explained by students making potentially justifiable adjustments to their rank list. First, when asked directly if perceived competitiveness would impact their rank list, 63% of students responded that it would by at least a moderate amount, suggesting that it is not a sense of liking or a strong value proposition that is causing students to make changes to their list.

Second, to attempt to account for the effect of potential "reciprocal liking," we created one of our case scenarios to depersonalize the rank decision. Specifically, the scenario stated that the applicant was being ranked lower because of a decision to prioritize internal applicants, removing any potential judgment of the applicant by the program. Despite not being "disliked" by the program in this scenario, 22% of respondents still stated that they would move the program lower on their rank list, while 3% would move it higher. We believe this scenario is particularly relevant, as programs may place applicants lower on their rank list for a variety of reasons beyond perceived potential for success, including a desire to create a residency class with diverse backgrounds, interests and aspirations. Sound "reciprocal liking" and "fit"-based decision making also do not explain why students did not change their rank lists when the facts of the scenario suggested that they should have (e.g., a partner's amazing job offer).

Third, we would strongly caution both programs and applicants against over-reliance on a subjective assessment of "fit" to override their otherwise methodologically sound rankings. While "fit" is known to be used heavily by applicants and programs alike, it is also a known proxy for similarity to the status quo and can bias programs and applicants against otherwise strong matches that may enable them to grow and change in unexpected ways.[5]

Some of the nuances of why students do not display consistently logical behavior when making rank lists still remain to be elucidated. It remains possible that subjects misinterpreted the case scenarios, for example. We feel that our overall findings, however, are still most consistent with some level of student misunderstanding of the Match algorithm. We believe that our original recommendation for more specific education for senior students about how the Match functions is well-founded based on the results of this study.

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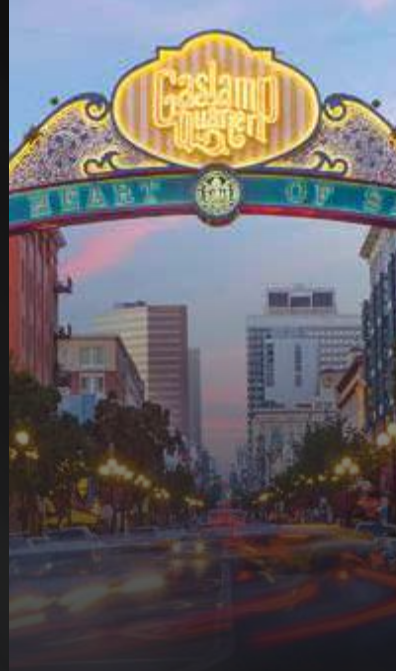

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