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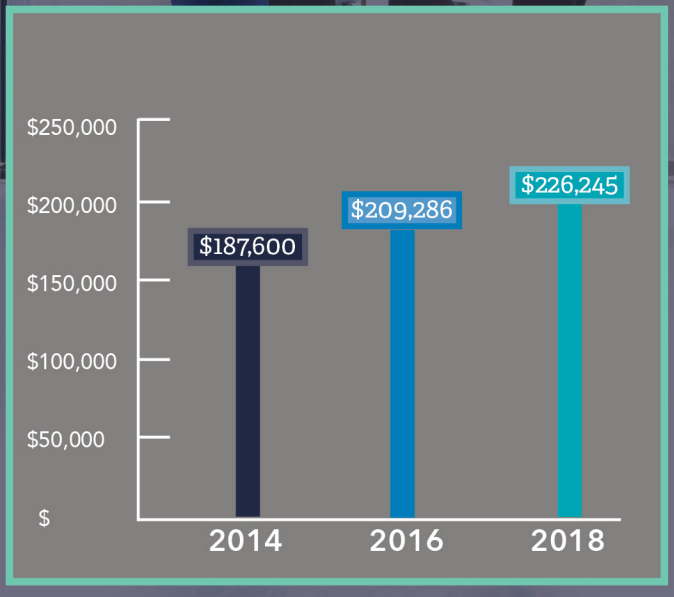

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EDITORIAL

LETTERS TO THE EDITOR

Prospective Randomized Evaluation of Preoperative Angiotensin-Converting Enzyme Inhibition (PREOP-ACEI)

Jason F. Shiffermiller, MD, MPH[1]*, Benjamin J. Monson, MD[2], Chad W. Vokoun, MD[1], Micah W. Beachy, DO[1], Michael P. Smith, MD[1], James N. Sullivan, MD[3], Andrew J. Vasey, MD[4], Purnima Guda, PhD[2], Elizabeth R. Lyden, MS[5], Sheila J. Ellis, MD[3], Huiling Pang, MD PhD[3], Rachel E. Thompson, MD, MPH[1]

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BACKGROUND: Intraoperative hypotension is associated with an increased risk of end organ damage and death. The transient preoperative interruption of angiotensin-converting enzyme inhibitor (ACEI) therapy prior to cardiac and vascular surgeries decreases the occurrence of intraoperative hypotension.

OBJECTIVE: We sought to compare the effect of two protocols for preoperative ACEI management on the risk of intraoperative hypotension among patients undergoing noncardiac, nonvascular surgeries.

DESIGN: Prospective, randomized study.

SETTING: Midwestern urban 489-bed academic medical center.

PATIENTS: Patients taking an ACEI for at least six weeks preoperatively were considered for inclusion.

INTERVENTIONS: Randomization of the final preoperative ACEI dose to omission (n = 137) or continuation (n = 138).

MEASUREMENTS: The primary outcome was intraoperative hypotension, which was defined as any systolic blood pressure (SBP) < 80 mm Hg. Postoperative hypotensive (SBP < 90 mm Hg) and hypertensive (SBP > 180 mm Hg) episodes were also recorded. Outcomes were compared using Fisher's exact test.

RESULTS: Intraoperative hypotension occurred less frequently in the omission group (76 of 137 [55%]) than in the continuation group (95 of 138 [69%]) (RR: 0.81, 95% CI: 0.67 to 0.97, P = .03, NNH 7.5). Postoperative hypotensive events were also less frequent in the ACEI omission group (RR: 0.49, 95% CI: 0.28 to 0.86, P = .02) than in the continuation group. However, postoperative hypertensive events were more frequent in the omission group than in the continuation group (RR: 1.95, 95%: CI: 1.14 to 3.34, P = .01).

CONCLUSION: The transient preoperative interruption of ACEI therapy is associated with a decreased risk of intraoperative hypotension.

REGISTRATION: ClinicalTrials.gov: NCT01669434. *Journal of Hospital Medicine* 2018;13:661-667. Published online first July 25, 2018. © 2018 Society of Hospital Medicine

Over seven million surgeries are performed in hospitals in the United States each year. Among these surgeries, approximately 85% are noncardiac, nonvascular (NCNV) procedures.[1,2] Although the preoperative use of an angiotensin-converting enzyme inhibitor (ACEI) can be expected in as many as 13% of these surgeries,[3] the optimal preoperative ACEI management strategy for patients undergoing NCNV surgeries is poorly understood.

High-quality evidence suggests that renin–angiotensin–aldosterone system (RAAS) inhibitors are associated with intraoperative hypotension among patients undergoing cardiac or vascular surgeries.[4-6] Intraoperative hypotension increases the risk of 30-day mortality,[7] and the duration of intraoperative hypotension increases the risk of end organ damage.[8,9] This body of evidence suggests that withholding ACEIs prior to cardiac and vascular surgeries is safer than continuing ACEIs without interruption.

The evidence concerning perioperative management of ACEIs is inconclusive for patients undergoing NCNV procedures. Some studies comparing patients taking or not taking a RAAS inhibitor preoperatively describe negligible differences in the frequency of intraoperative hypotensive episodes or complications.[3,10] Others have found an increased risk of intraoperative hypotension and associated postoperative adverse events in patients continuing RAAS inhibitors preoperatively.[11,12] Current guideline discrepancies reflect the uncertainty of the evidence. The guidelines set by the American College of Cardiology and American Heart Association (ACC/AHA) suggest the uninterrupted perioperative continuation of RAAS inhibitors.[13] The guidelines provided by the European Society of Cardiology and European Society of Anaesthesiology also suggest the continuation of RAAS inhibitors throughout the perioperative period

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for patients with systolic heart failure but recommend transient discontinuation for patients with hypertension.[14]

This randomized study aimed to compare the effect of two practical strategies for preoperative ACEI management on the perioperative blood pressure of patients undergoing NCNV surgery. The two strategies studied were the omission of the final preoperative ACEI dose and the uninterrupted continuation of ACEI therapy. We hypothesized that patients randomized to ACEI omission would experience intraoperative hypotensive episodes less frequently than those randomized to ACEI continuation.

METHODS

Study Design and Setting

We performed a prospective randomized controlled trial (ClinicalTrials.gov: NCT01669434). The study was carried out in a preoperative evaluation clinic and its affiliated 489-bed academic medical center. Anesthesiologists and internal medicine physicians work collaboratively in the clinic to assess more than 5,000 patients annually (one-third of the institution's elective surgeries). Patients were randomized 1:1 in block sizes of five and 10 and stratified by age < 65 and ≥ 65 years to the omission or continuation of the final preoperative ACEI dose (whether that dose was scheduled for the morning of surgery or the night prior). Preoperative clinicians enrolled patients and subsequently assigned them to intervention groups on the basis of a sequentially numbered list. Patients and healthcare providers were not blinded to allocation status. Intraoperative and postoperative management was provided in accordance with usual care as decided by treatment team.

Participants

Patients who presented to the preoperative evaluation clinic between May 2015 and November 2016 and who had been taking an ACEI for at least six weeks were eligible for inclusion. Patients taking angiotensin receptor blockers were excluded. Enrollment was limited to patients planning NCNV surgery. Patients planning intrathoracic, major vascular, organ transplant, and oncologic surgery were excluded. Patients undergoing outpatient procedures not requiring an overnight stay in the hospital were also excluded. Patients with preoperative clinic systolic blood pressure (SBP) <90 or ≥160 or diastolic blood pressure (DBP) <60 or ≥ 95 were excluded. Patients with moderate to severe or clinically decompensated heart failure (left ventricular ejection fraction < 40% or New York Heart Association class III or IV) and those with end-stage renal disease requiring dialysis were also excluded. Patients presenting more than once during the accrual period were eligible for the initial surgery only. All participating patients provided written informed consent. This project was approved by the University of Nebraska Medical Center Institutional Review Board.

Data Collection

Baseline characteristics were recorded by study personnel at the time of enrollment. We measured serum creatinine level at the preoperative visit and on postoperative day one. An automated anesthesia information management system was used to measure intraoperative blood pressures every three minutes. Postoperative blood pressures through discharge were measured by hospital staff per usual care. During postoperative hospitalization, we queried patients about preoperative adherence to allocation. The digital abstraction of data from the electronic medical record was supplemented by chart review when necessary.

Outcomes

The primary outcome was intraoperative hypotension defined as any SBP < 80 mm Hg occurring from the administration of the first induction agent through transfer to the postanesthesia care unit (PACU). We also examined hypotension during anesthesia induction, which we defined as the 20-minute period following the administration of the first anesthesia induction agent. Episodes of SBP < 80 were defined as being associated with vasopressor administration when any vasopressor was administered during or within 10 minutes of the episode.

Secondary analyses included postoperative acute kidney injury (AKI), postoperative hypotensive and hypertensive episodes, cardiac events, and mortality. When comparing postoperative day one creatinine levels to preoperative creatinine levels, we used the Acute Kidney Injury Network definition of AKI as an increase in creatinine of 0.3 mg/dl or 50%.[15] Postoperative hypotension was defined as any SBP < 90 mm Hg and postoperative hypertension as any SBP > 180 mm Hg occurring after arrival in the PACU. Major adverse cardiac events (MACE) were defined as a composite of acute coronary syndrome, acute heart failure, or new-onset arrhythmia. Discharge from the hospital served as the study endpoint for each patient.

Analysis

Fisher's exact test was used to compare categorical outcomes between groups. The independent sample *t*-test or Wilcoxon rank–sum test, as appropriate, was used to compare continuous measures. We selected Fisher's exact test over χ^2-test to produce conservative estimates. Patients were maintained in their allocated group as randomized for analytical purposes regardless of adherence to allocation. We performed all analyses using SAS version 9.4 for Windows (SAS institute, Cary, North Carolina).

We estimated that a sample size of 300 patients would achieve 80% power to detect a difference of 0.17 between the group proportions of 0.33 and 0.50 at a significance level (α) of 0.05 by using a two-sided *z*-test with continuity correction, assuming 15% loss to follow-up. This estimate allowed for one interim analysis using the O'Brien-Fleming spending function truncated at three standard deviations to determine the test boundaries. The monitoring boundary *P* values associated with the interim analysis were .003, and the threshold *P* value for the final analysis was .049.

RESULTS

Study Flow

A total of 453 patients were screened for eligibility. Among these patients, 162 were excluded, and the remaining 291 patients were randomized (Figure 1). Surgery was cancelled in six

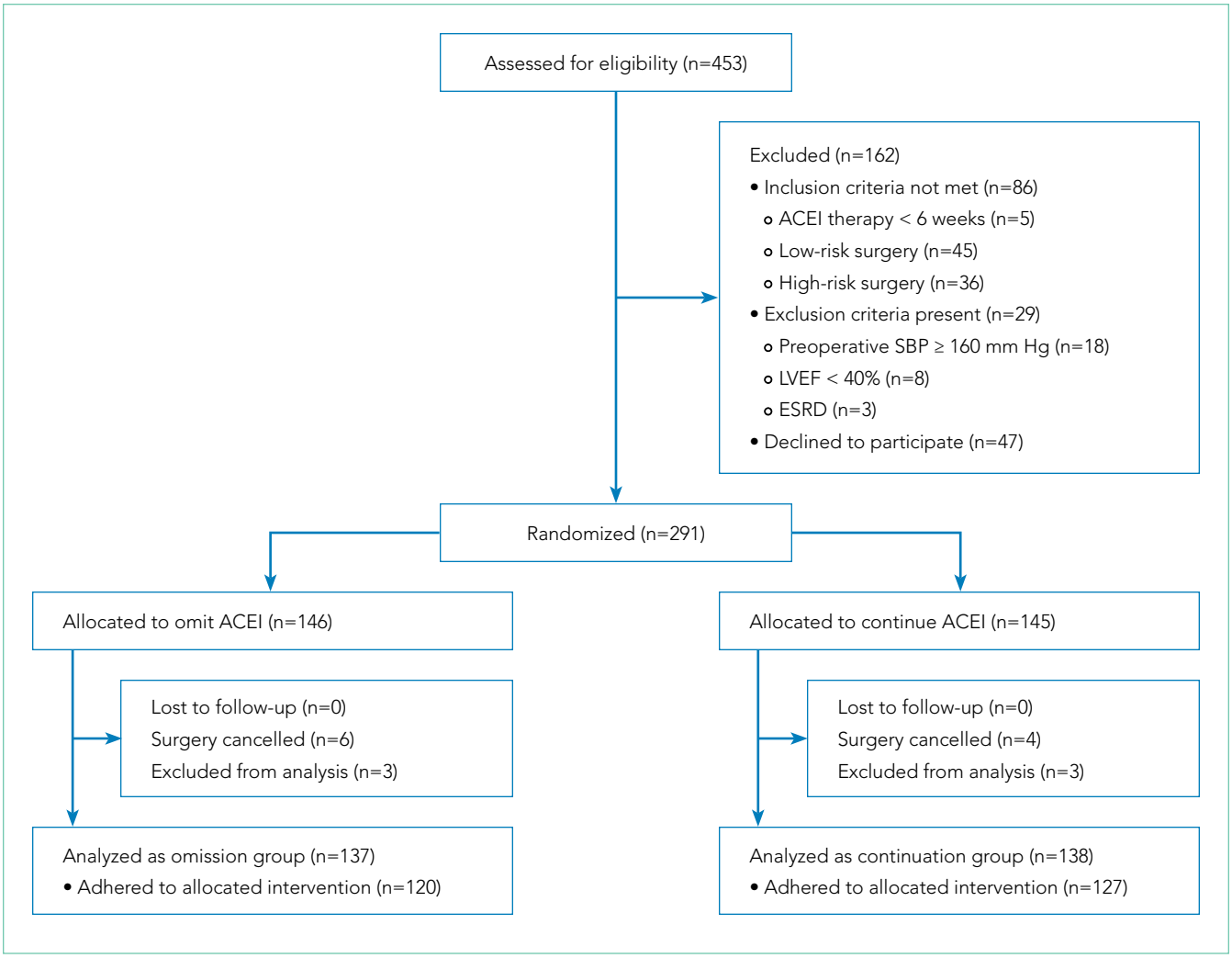

FIG 1. CONSORT diagram.
Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ESRD, end-stage renal disease; LVEF, left ventricular ejection fraction; SBP, systolic blood pressure.

patients allocated to omission and in four patients allocated to continuation arms, respectively. Moreover, three patients in the omission arm were excluded from the analysis following randomization. Specifically, one was excluded because of early discharge without overnight stay, one was excluded because of withdrawal of consent, and one was excluded because of missing primary outcome data. In addition, three cases in the continuation arm were excluded following randomization because of the preoperative (permanent) discontinuation of ACEI therapy in two cases and discharge without an overnight stay in one case. Finally, 275 patients were included in the analysis: 137 in the ACEI omission group and 138 in the ACEI continuation group. Adherence to allocation was 88% and 92% in the omission and continuation groups, respectively.

Baseline Characteristics

The demographic data of patients allocated to ACEI omission and those allocated to ACEI continuation were similar (Table 1). A large majority of patients in both groups took the ACEI lisinopril. Overall, 187 of 275 (68%) patients were taking at least one antihypertensive agent, most commonly a diuretic, in addition to an ACEI. SBP measured during the preoperative clinic visit averaged 136.5 mm Hg and did not differ significantly between groups ($P = .84$).

Surgical Variables

General anesthesia was the most commonly utilized technique, although spinal and regional anesthesia were also represented (Table 1). The majority of cases in both groups were planning for orthopedic and spinal surgery. The method of anesthesia or type of surgery between patients allocated to ACEI omission and those allocated to continuation did not differ ($P = .61$ and $P = .45$ respectively).

Episodes of Intraoperative Hypotension

Intraoperative SBPs are displayed in Figure 2, and hemodynamic outcomes are summarized in Table 2. Episodes of SBP < 80 mm Hg during anesthesia induction were numerically less frequent in the omission group than in the continuation group; the difference between groups, however, was not statistically

TABLE 1. **Patient and Surgical Characteristics by Study Arm**

	ACEI Omission (n = 137)	ACEI Continuation (n = 138)
Patient characteristics		
Male sex	65 (47%)	68 (49%)
Age (years)	64.0 (11.0)	63.7 (10.9)
BMI	34.4 (6.4)	35.0 (8.4)
Caucasian race	115 (84%)	125 (91%)
Smoking status		
Never	63 (46%)	54 (39%)
Former	60 (44%)	59 (43%)
Current	14 (10%)	25 (18%)
ASA classification	3 (1-4)	3 (2-4)
Revised cardiac risk index	0 (0-3)	0 (0-3)
Comorbidity		
Hypertension	116 (85%)	112 (81%)
Hyperlipidemia	78 (57%)	79 (57%)
Coronary artery disease	18 (13%)	19 (14%)
Diabetes on insulin	16 (12%)	19 (14%)
COPD	9 (7%)	16 (12%)
Atrial fibrillation	10 (7%)	10 (7%)
Congestive heart failure	7 (5%)	9 (7%)
Preoperative creatinine > 2	1 (1%)	1 (1%)
CVA/TIA	0	0
ACEI		
Lisinopril	113 (82%)	109 (79%)
Benazepril	10 (7%)	11 (8%)
Enalapril	7 (5%)	7 (5%)
Other	7 (5%)	11 (8%)
Additional antihypertensive	92 (67%)	95 (69%)
Diuretic	55 (40%)	58 (42%)
Beta-blocker	43 (31%)	51 (37%)
Other	42 (31%)	34 (25%)
NSAID use	53 (39%)	71 (51%)
Preoperative* systolic BP (mmHg)	136.6 (16.0)	136.3 (14.7)
Surgical Characteristics		
Anesthesia technique		
General	74 (54%)	67 (49%)
Spinal	30 (22%)	36 (26%)
Regional	33 (24%)	35 (25%)
Type of surgery		
Orthopedic	78 (57%)	88 (64%)
Spine	29 (21%)	26 (19%)
Bariatric	7 (5%)	7 (5%)
Otolaryngologic	5 (4%)	6 (4%)
Other	18 (13%)	11 (8%)

Categorical variables expressed as number (%); Continuous variables expressed as mean (SD) when normally distributed and median (range) when not normally distributed. *Preoperative–during preoperative clinic visit.

Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; ASA, American Society of Anesthesiologists; BMI, Body Mass Index; BP, blood pressure; COPD, chronic obstructive pulmonary disease; CVA/TIA, history of cerebrovascular accident or transient ischemic attack.

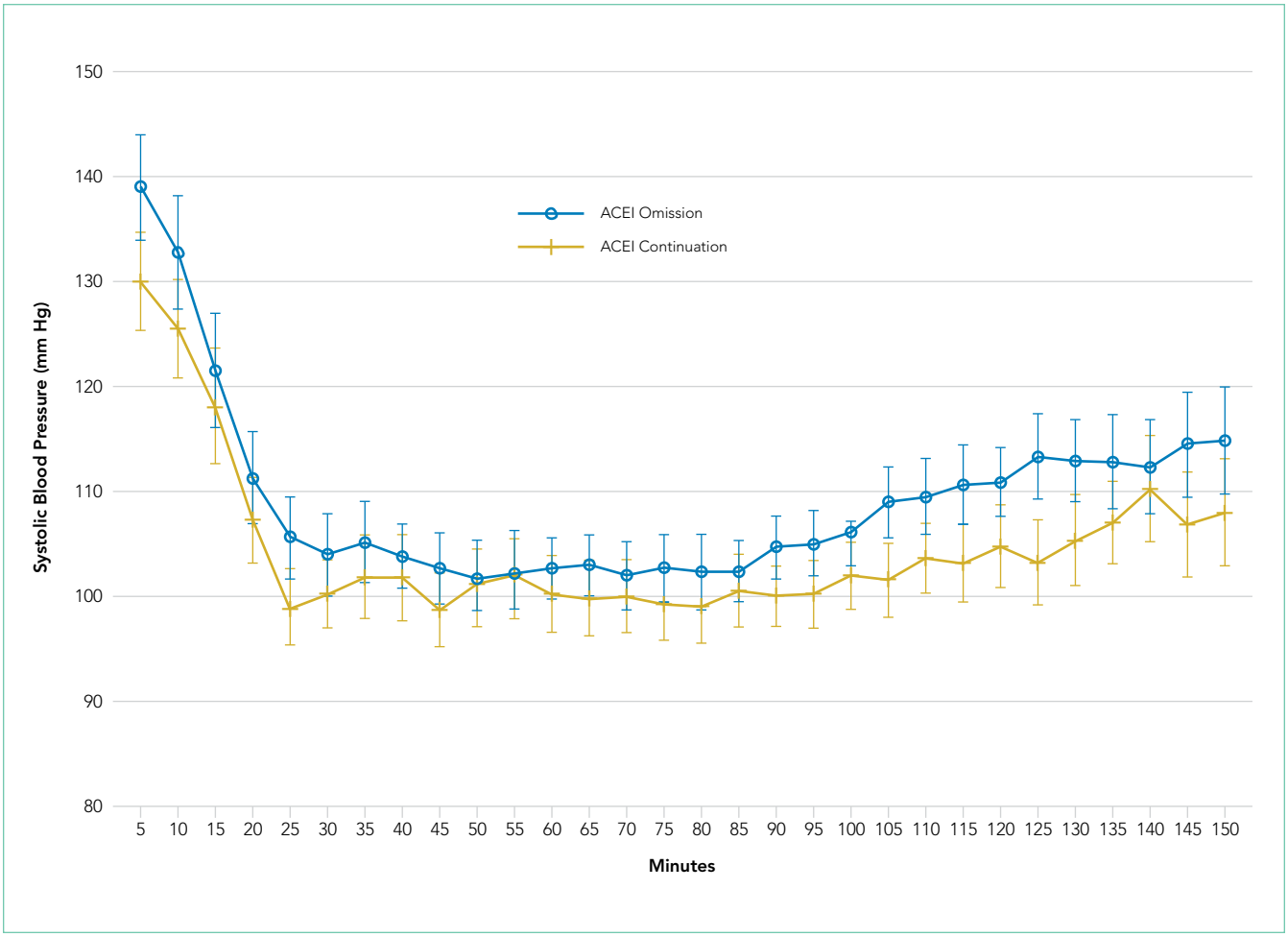

FIG 2. Intraoperative blood pressure. Systolic blood pressures expressed as 5 min averages. Time 0 = arrival in operating room. Error bars represent 95% confidence intervals. Abbreviations: ACEI, angiotensin-converting enzyme inhibitor.

significant (24 of 137 [18%] vs 38 of 138 [28%], RR: 0.64, 95% CI: 0.40 to 1.00, $P = .06$). The primary outcome, episodes of intraoperative SBP < 80 mm Hg, occurred less often in patients allocated to the ACEI omission group than in those allocated to the ACEI continuation group (76 of 137 [55%] vs 95 of 138 [69%], RR: 0.81, 95% CI: 0.67 to 0.97, $P = .03$). A per-protocol sensitivity analysis of the primary outcome did not substantially alter results (RR: 0.75, 95% CI: 0.61 to 0.91, $P = .003$). Among the patients, one was excluded from the sensitivity analysis because of missing data on adherence to allocation. Of the 171 episodes of intraoperative SBP < 80 mm Hg, 149 were associated with vasopressor administration (61 of 76 [80%] omission vs 88 of 95 continuation [93%], RR: 0.87, 95% CI: 0.76 to 0.98, $P = .02$). Episodes of intraoperative SBP < 80 associated with vasopressor administration occurred less frequently in patients allocated to the omission group than in those allocated to the continuation group (61/137 [45%] vs 88/138 [64%], RR: 0.70, 95% CI: 0.56-0.87, $P < .01$). Few patients in either group developed severe intraoperative hypotension, which was defined as SBP < 60 mm Hg (6 of 137 [4%] omission vs 7 of 138 [5%] continuation, RR: 0.86, 95% CI: 0.30 to 25.0, $P = 1.0$). The number of patients needing to continue ACEI therapy preoperatively to cause one additional episode of harm in the form of intraoperative SBP < 80 mm Hg was 7.5 (NNH 7.5).

Duration of Intraoperative Hypotension

The median cumulative duration of intraoperative SBP < 80 was two minutes (range 0-41) in patients allocated to the ACEI omission group compared with seven minutes (range 0-214) in those allocated to the continuation group ($P < .01$). The median cumulative duration of mean arterial pressure < 55 mm Hg was also shorter in the omission group (median 0 minutes [range 0-39] vs 3 minutes [range 0-122], $P < .01$) than in the continuation group. The duration of surgery did not differ between groups (median 141 minutes [range 77-554] vs 142 minutes [range 57-665], $P = .97$).

Postoperative Outcomes

RAAS inhibitor therapy was resumed within 48 h after surgery in 122 of 137 (89%) patients allocated to the omission group and in 128 of 138 (93%) patients allocated to the continuation group (RR: 0.96, 95% CI: 0.89-1.03, $P = .30$).

Patients allocated to the omission group were significantly less likely to experience postoperative hypotension (15 of 137

TABLE 2. **Intraoperative Hemodynamics by Study Arm**

	ACEI Omission (n = 137)	ACEI Continuation (n = 138)	*P* Value
Episodes of SBP < 80 mm Hg	76 (55%)	95 (69%)	.03
Episodes of SBP < 80 mm Hg treated with vasopressor	61 (45%)	88 (64%)	<.01
Episodes of SBP < 60 mm Hg	6 (4%)	7 (5%)	1.00
Duration of SBP < 80 mm Hg (min)	2 (0–41)	7 (0–214)	<.01
Duration of MAP < 55 mm Hg (min)	0 (0–39)	3 (0–122)	< .01

Categorical variables expressed as number (percent); Continuous variables expressed as median (range).
Abbreviations: ACEI, angiotensin-converting enzyme inhibitor; MAP, mean arterial pressure; SBP, systolic blood pressure. .

[11%] vs 31 of 138 [22%], RR: 0.49, 95% CI: 0.28 to 0.86, *P* = .02) and significantly more likely to experience severe postoperative hypertension (33 of 137 [24%] vs 17 of 138 [12%], RR: 1.95, 95% CI: 1.14 to 3.34, *P* = .01) than those allocated to the continuation group. The occurrences of postoperative AKI (RR: 0.60, 95% CI: 0.23 to 1.60, *P* = .44) or MACE (RR: 4.03, 95% CI: 0.46 to 35.59, *P* = .21) in the omission group did not differ from the continuation group. The two groups exhibited similar PACU recovery time (mean 97.2 min) and overall hospital length of stay (mean 3.0 days) (*P* = .49 and *P* = .56). No episodes of inpatient mortality in either group were observed.

DISCUSSION

The omission of the final preoperative ACEI dose was associated with a significant reduction in the risk of intraoperative hypotension in patients undergoing NCNV surgery. This result confirmed our hypothesis. Coupled with the knowledge that intraoperative hypotension is associated with an increased risk of complications and mortality,[7-9,16] this study favors the omission of the final preoperative ACEI dose prior to NCNV surgeries.

Our findings are in agreement with those of previous randomized studies that explored this question[4,5] and help extend results from cardiac and vascular surgeries to NCNV surgeries. Previous studies on the use of RAAS inhibitors in NCNV surgeries did not employ randomization and yielded mixed results.[3,10-12,17] A large single-institution study (n = 18,056) noted no difference in intraoperative blood pressure between patients taking ACEIs and a matched group of non-ACEI users.[3] More recently, a subgroup analysis of the international VISION study showed that omitting RAAS inhibitors on the day of surgery reduced the risk of intraoperative hypotension.[11] In that analysis, however, only a small amount of the variability in preoperative RAAS inhibitor management was explainable by modeling known factors, thus allowing for the possibility of unmeasured confounding. Our study, which minimized confounding through randomization, is the first to prospectively compare protocols for patients undergoing NCNV surgery. In contrast to previous studies, the present study was able to report the lack of difference in postoperative RAAS inhibitor administration between study groups. Postoperative RAAS inhibitor management affects complications and mortality.[18,19]

Our present finding that preoperative ACEI management affects postoperative hypotensive and hypertensive events conflicts with some previous findings.[11,20] However, recent evidence has revealed that postoperative hypotensive episodes are associated with vascular events and mortality.[11,21] In the context of that evidence, our study lends further support to the omission of the final preoperative ACEI dose. However, we did not detect any decrease in AKI, MACE, or mortality in the ACEI omission group.

This study should be considered in light of its limitations. The pragmatic nature of the study allowed for certain potential biases. Although adherence to allocation was high, the specific ACEI agent taken and the exact timing of the final dose in relation to surgery were not controlled. Anesthetic and postoperative management decisions were made by the treatment team and may have systematically varied given that the treatment team was not blinded to allocation. Furthermore, all outcome data were collected as part of routine care and may not have captured events with great fidelity. Generalizability is limited by the execution of the study at a single academic institution, the preponderance of orthopedic and spine surgeries, and by the negligible representation of ethnicities other than Caucasian. Additionally, recruitment from the preoperative evaluation clinic likely resulted in a patient group with greater comorbidity than the overall population of patients undergoing NCNV surgery. This study was powered for intraoperative hypotension and not postoperative outcomes. Our primary outcome, intraoperative hypotension, is an intermediate measure but one that has well-established associations with adverse outcomes, including mortality. One study showed that sustaining an intraoperative SBP below 70 mm Hg for longer than five minutes increased the risk of mortality from less than 1% to nearly 6%.[16] A large study detected an increase in mortality associated with SBP sustained below 80 mm Hg for 10 minutes or longer.[7] Intraoperative hypotension has also been associated with postoperative AKI and myocardial injury.[8,9,12]

Many of the limitations of the current study could be addressed by a large randomized controlled trial of ACEI management prior to NCNV surgeries that examines clinically important endpoints beyond intraoperative hypotension. Several specific aspects of perioperative RAAS inhibitor management

also deserve further investigation. Our findings may not be generalizable to patients taking ARBs or to patients with congestive heart failure. The preoperative management of ARBs and the preoperative management of RAAS inhibitors in those with congestive heart failure are important areas of focus for future research. Lastly, our finding that preoperative ACEI management decisions can affect postoperative hypotensive and hypertensive events should be substantiated by future research, and any negative consequences of those events should be further explored.

Nonetheless, our study is the largest randomized study of preoperative RAAS inhibition published to date. More than twice as many patients were randomized in this study than in all previous randomized studies combined.[4-6] To the best of our knowledge, this is also the first randomized study evaluating NCNV surgeries. Finally, our use of a practical ACEI omission protocol based on known pharmacokinetics allows for direct application to clinical practice.

CONCLUSION

Hypertension is among the most common chronic conditions encountered in patients planning surgery, and ACEIs are among the most frequently prescribed antihypertensive medications. This study showed that ACEI continuation is associated with an increased frequency and cumulative duration of intraoperative hypotension. These findings, while at odds with current ACC/AHA guidelines, align with the findings of a meta-analysis on this subject and with recent literature.[3,11-13,22]

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Focused Ethnography of Diagnosis in Academic Medical Centers

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BACKGROUND: Approaches of trainees to diagnosis in teaching hospitals are poorly understood. Identifying cognitive and system-based barriers and facilitators to diagnosis may improve diagnosis in these settings.

METHODS: We conducted a focused ethnography of trainees at 2 academic medical centers to understand the barriers and facilitators to diagnosis. Field notes regarding the diagnostic process (eg, information gathering, integration and interpretation, working diagnosis) and the work system (eg, team members, organization, technology and tools, physical environment, tasks) were recorded. Following observations, focus groups and interviews were conducted to understand the viewpoints, problems, and solutions to improve diagnosis.

RESULTS: Between January 2016 and May 2016, four teaching teams (4 attendings, 4 senior residents, 9 interns, and 12 medical students) were observed for 168 hours. Observations of diagnosis during care led to identification of the following four key themes: (1) diagnosis is a social phenomenon, (2) data necessary to make diagnoses are fragmented, (3) distractions interfere with the diagnostic process, and (4) time pressures impede diagnostic decision-making. These themes suggest that specific interventions tailored to the academic setting such as team-based discussions of diagnostic workups, scheduling diagnostic time-outs during the day, and strategies to "protect" learners from interruptions might prove to be useful in improving the process of diagnosis. Future studies that implement these ideas (either alone or within a multimodal intervention) appear to be necessary.

CONCLUSION: Diagnosis in teaching hospitals is a unique process that requires improvement. Contextual insights gained from this ethnography may be used to inform future interventions. *Journal of Hospital Medicine* 2018;13:668-672. Published online first April 25, 2018. © 2018 Society of Hospital Medicine

Diagnostic error – defined as a failure to establish an accurate and timely explanation of the patient's health problem – is an important source of patient harm.[1] Data suggest that all patients will experience at least one diagnostic error in their lifetime.[2-4] Not surprisingly, diagnostic errors are among the leading categories of paid malpractice claims in the United States.[5]

Despite diagnostic errors being morbid and sometimes deadly in the hospital,[6,7] little is known about how residents and learners approach diagnostic decision making. Errors in diagnosis are believed to stem from cognitive or system failures,[8] with errors in cognition believed to occur due to rapid, reflexive thinking operating in the absence of a more analytical, deliberate process. System-based problems (eg, lack of expert availability, technology barriers, and access to data) have also been cited as contributors.[9] However, whether and how these apply to trainees is not known.

Therefore, we conducted a focused ethnography of inpatient medicine teams (ie, attendings, residents, interns, and medical students) in two affiliated teaching hospitals, aiming to (1) observe the process of diagnosis by trainees and (2) identify methods to improve the diagnostic process and prevent errors.

METHODS

We designed a multimethod, focused ethnographic study to examine diagnostic decision making in hospital settings.[10,11] In contrast to anthropologic ethnographies that study entire fields using open-ended questions, our study was designed to examine the process of diagnosis from the perspective of clinicians engaged in this activity.[11] This approach allowed us to capture diagnostic decisions and cognitive and system-based factors in a manner currently lacking in the literature.[12]

Setting and Participants

Between January 2016 and May 2016, we observed the members of four inpatient internal medicine teaching teams at two

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affiliated teaching hospitals. We purposefully selected teaching teams for observation because they are the primary model of care in academic settings and we have expertise in carrying out similar studies.[13,14] Teaching teams typically consisted of a medical attending (senior-level physician), one senior resident (a second- or third-year postgraduate trainee), two interns (a trainee in their first postgraduate year), and two to four medical students. Teams were selected at random using existing schedules and followed Monday to Friday so as to permit observation of work on call and noncall days. Owing to manpower limitations, weekend and night shifts were not observed. However, overnight events were captured during morning rounds.

Most of the teams began rounds at 8:30 AM. Typically, rounds lasted for 90–120 minutes and concluded with a recap (ie, "running the list") with a review of explicit plans for patients after they had been evaluated by the attending. This discussion often occurred in the team rooms, with the attending leading the discussion with the trainees.

Data Collection

A multidisciplinary team, including clinicians (eg, physicians, nurses), nonclinicians (eg, qualitative researchers, social scientists), and healthcare engineers, conducted the observations. We observed preround activities of interns and residents before arrival of the attending (7:00 AM-8:30 AM), followed by morning rounds with the entire team, and afternoon work that included senior residents, interns, and students.

To capture multiple aspects of the diagnostic process, we collected data using field notes modeled on components of the National Academy of Science model for diagnosis (Appendix).[1,15] This model encompasses phases of the diagnostic process (eg, data gathering, integration, formulation of a working diagnosis, treatment delivery, and outcomes) and the work system (team members, organization, technology and tools, physical environment, tasks).

Focus Groups and Interviews

At the end of weekly observations, we conducted focus groups with the residents and 1-on-1 interviews with the attendings. Focus groups with the residents were conducted to encourage a group discussion about the diagnostic process. Separate interviews with the attendings were performed to ensure that power differentials did not influence discussions. During focus groups, we specifically asked about challenges and possible solutions to improve diagnosis. Experienced qualitative methodologists (J.F., M.H., M.Q.) used semistructured interview guides for discussions (Appendix).

Data Analysis

After aggregating and reading the data, three reviewers (V.C., S.K, S.S.) began inductive analysis by handwriting notes and initial reflective thoughts to create preliminary codes. Multiple team members then reread the original field notes and the focus group/interview data to refine the preliminary codes and develop additional codes. Next, relationships between codes were identified and used to develop key themes. Triangulation of data collected from observations and interview/focus group sessions was carried out to compare data that we surmised with data that were verbalized by the team. The developed themes were discussed as a group to ensure consistency of major findings.

Ethical and Regulatory Oversight

This study was reviewed and approved by the Institutional Review Boards at the University of Michigan Health System (HUM-00106657) and the VA Ann Arbor Healthcare System (1-2016-010040).

RESULTS

Four teaching teams (4 attendings, 4 senior residents, 9 interns, and 14 medical students) were observed over 33 distinct shifts and 168 hours. Observations included morning rounds (96 hours), postround call days (52 hours), and postround noncall days (20 hours). Morning rounds lasted an average of 127 minutes (range: 48-232 minutes) and included an average of nine patients (range: 4-16 patients).

Themes Regarding the Diagnostic Process

We identified the following four primary themes related to the diagnostic process in teaching hospitals: (1) diagnosis is a social phenomenon, (2) data necessary to make diagnoses are fragmented, (3) distractions undermine the diagnostic process, and (4) time pressures interfere with diagnostic decision-making (Appendix Table 1).

(1) Diagnosis is a Social Phenomenon.

Team members viewed the process of diagnosis as a social exchange of facts, findings, and strategies within a defined structure. The opportunity to discuss impressions with others was valued as a means to share, test, and process assumptions.

> *"Rounds are the most important part of the process. That is where we make most decisions in a collective, collaborative way with the attending present. We bounce ideas off each other." (Intern)*

Typical of social processes, variations based on time of day and schedule were observed. For instance, during call days, learners gathered data and formed working diagnosis and treatment plans with minimal attending interaction. This separation of roles and responsibilities introduced a hierarchy within diagnosis as follows:

> *"The interns would not call me first; they would talk to the senior resident and then if the senior thought he should chat with me, then they would call. But for the most part, they gather information and come up with the plan." (Attending).*

The work system was suited to facilitate social interactions. For instance, designated rooms (with team members informally assigned to a computer) provided physical proximity of the resident to interns and medical students. In this space, numerous informal discussions between team members (eg, "What do

you think about this test?" "I'm not sure what to do about this finding." "Should I call a [consult] on this patient?") were observed. Although proximity to each other was viewed as beneficial, dangers to the social nature of diagnosis in the form of anchoring (ie, a cognitive bias where emphasis is placed on the first piece of data)[16] were also mentioned. Similarly, the paradox associated with social proof (ie, the pressure to assume conformity within a group) was also observed as disagreement between team members and attendings rarely occurred during observations.

> *"I mean, they're the attending, right? It's hard to argue with them when they want a test or something done. When I do push back, it's rare that others will support me–so it's usually me and the attending." (Resident)*

> *"I would push back if I think it's really bad for the patient or could cause harm–but the truth is, it doesn't happen much." (Intern)*

(2) Data Necessary to Make Diagnoses are Fragmented

Team members universally cited fragmentation in data delivery, retrieval, and processing as a barrier to diagnosis. Team members indicated that test results might not be looked at or acted upon in a timely manner, and participants pointed to the electronic medical record as a source of this challenge.

> *"Before I knew about [the app for Epic], I would literally sit on the computer to get all the information we would need on rounds. Its key to making decisions. We often say we will do something, only to find the test result doesn't support it–and then we're back to square 1." (Intern)*

Information used by teams came from myriad sources (eg, patients, family members, electronic records) and from various settings (eg, emergency department, patient rooms, discussions with consultants). Additionally, test results often appeared without warning. Thus, availability of information was poorly aligned with clinical duties.

> *"They (the lab) will call us when a blood culture is positive or something is off. That is very helpful but it often comes later in the day, when we're done with rounds." (Resident)*

The work system was highlighted as a key contributor to data fragmentation. Peculiarities of our electronic medical record (EMR) and how data were collected, stored, or presented were described as "*frustrating*," and "*unsafe*," by team members. Correspondingly, we frequently observed interns asking for assistance for tasks such as ordering tests or finding information despite being "trained" to use the EMR.

> *"People have to learn how to filter, how to recognize the most important points and link data streams together in terms of causality. But we assume they know where to find that information. It's actually a very hard thing to do, for both the house staff and me." (Attending)*

(3) Distractions Undermine the Diagnostic Process

Distractions often created cognitive difficulties. For example, ambient noise and interruptions from neighbors working on other teams were cited as barriers to diagnosis. In addition, we observed several team members using headphones to drown out ambient noise while working on the computer.

> *"I know I shouldn't do it (wear headphones), but I have no other way of turning down the noise so I can concentrate." (Intern)*

Similarly, the unpredictable nature and the volume of pages often interrupted thinking about diagnosis.

> *"Sometimes the pager just goes off all the time and (after making sure its not an urgent issue), I will just ignore it for a bit, especially if I am in the middle of something. It would be great if I could finish my thought process knowing I would not be interrupted." (Resident)*

To mitigate this problem, one attending described how he would proactively seek out nurses caring for his patients to "head off" questions (eg, "I will renew the restraints and medications this morning," and "Is there anything you need in terms of orders for this patient that I can take care of now?") that might lead to pages. Another resident described his approach as follows:

> *"I make it a point to tell the nurses where I will be hanging out and where they can find me if they have any questions. I tell them to come talk to me rather than page me since that will be less distracting." (Resident).*

Most of the interns described documentation work such as writing admission and progress notes in negative terms ("an academic exercise," "part of the billing activity"). However, in the context of interruptions, some described this as helpful.

> *"The most valuable part of the thinking process was writing the assessment and plan because that's actually my schema for all problems. It literally is the only time where I can sit and collect my thoughts to formulate a diagnosis and plan." (Intern)*

(4) Time Pressures Interfere With Diagnostic Decision-Making

All team members spoke about the challenge of finding time for diagnosis during the workday. Often, they had to skip learning sessions for this purpose.

> *"They tell us we should go to morning report or noon conference but when I'm running around trying to get things done. I hate having to choose between my education and doing what's best for the patient–but that's often what it comes down to." (Intern)*

When specifically asked whether setting aside dedicated time to specifically review and formulate diagnoses would be valuable, respondents were uniformly enthusiastic. Team members described attentional conflicts as being the worst when "cross

covering" other teams on call days, as their patient load effectively doubled during this time. Of note, cross-covering occurred when teams were also on call—and thus took them away from important diagnostic activities such as data gathering or synthesis for patients they were admitting.

> *"If you were to ever design a system where errors were likely–this is how you would design it: take a team with little supervision, double their patient load, keep them busy with new challenging cases and then ask questions about patients they know little about." (Resident)*

DISCUSSION

Although diagnostic errors have been called "the next frontier for patient safety,"[17] little is known about the process, barriers, and facilitators to diagnosis in teaching hospitals. In this focused ethnography conducted at two academic medical centers, we identified multiple cognitive and system-level challenges and potential strategies to improve diagnosis from trainees engaged in this activity. Key themes identified by those we observed included the social nature of diagnosis, fragmented information delivery, constant distractions and interruptions, and time pressures. In turn, these insights allow us to generate strategies that can be applied to improve the diagnostic process in teaching hospitals.

Our study underscores the importance of social interactions in diagnosis. In contrast, most of the interventions to prevent diagnostic errors target individual providers through practices such as metacognition and "thinking about thinking."[18-20] These interventions are based on Daniel Kahnemann's work on dual thought process. Type 1 thought processes are fast, subconscious, reflexive, largely intuitive, and more vulnerable to error. In contrast, Type two processes are slower, deliberate, analytic, and less prone to error.[21] Although an individual's Type two thought capacity is limited, a major goal of cognitive interventions is to encourage Type 2 over Type 1 thinking, an approach termed "de-biasing."[22-24] Unfortunately, cognitive interventions testing such approaches have suffered mixed results–perhaps because of lack of focus on collective wisdom or group thinking, which may be key to diagnosis from our findings.[9,25] In this sense, morning rounds were a social gathering used to strategize and develop care plans, but with limited time to think about diagnosis.[26] Introduction of defined periods for individuals to engage in diagnostic activities such as de-biasing (ie, asking "what else could this be)[27] before or after rounds may provide an opportunity for reflection and improving diagnosis. In addition, embedding tools such as diagnosis expanders and checklists within these defined time slots[28,29] may prove to be useful in reflecting on diagnosis and preventing diagnostic errors.

An unexpected yet important finding from this study were the challenges posed by distractions and the physical environment. Potentially maladaptive workarounds to these interruptions included use of headphones; more productive strategies included updating nurses with plans to avert pages and creating a list of activities to ensure that key tasks were not forgotten.[30,31] Applying lessons from aviation, a focused effort to limit distractions during key portions of the day, might be worth considering for diagnostic safety.[32] Similarly, improving the environment in which diagnosis occurs—including creating spaces that are quiet, orderly, and optimized for thinking—may be valuable.[33]

Our study has limitations. First, our findings are limited to direct observations; we are thus unable to comment on how unobserved aspects of care (eg, cognitive processes) might have influenced our findings. Our observations of clinical care might also have introduced a Hawthorne effect. However, because we were closely integrated with teams and conducted focus groups to corroborate our assessments, we believe that this was not the case. Second, we did not identify diagnostic errors or link processes we observed to errors. Third, our approach is limited to two teaching centers, thereby limiting the generalizability of findings. Relatedly, we were only able to conduct observations during weekdays; differences in weekend and night resources might affect our insights.

The cognitive and system-based barriers faced by clinicians in teaching hospitals suggest that new methods to improve diagnosis are needed. Future interventions such as defined "time-outs" for diagnosis, strategies focused on limiting distractions, and methods to improve communication between team members are novel and have parallels in other industries. As challenges to quantify diagnostic errors abound,[34] improving cognitive- and system-based factors via reflection through communication, concentration, and organization is necessary to improve medical decision making in academic medical centers.

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Characterizing Hospitalizations for Pediatric Concussion and Trends in Care

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BACKGROUND: Children hospitalized for concussion may be at a higher risk for persistent symptoms, but little is known about this subset of children.

OBJECTIVE: Delineate a cohort of children admitted for concussion, describe care practices received, examine factors associated with prolonged length of stay (LOS) or emergency department (ED) readmission, and investigate changes in care over time.

DESIGN/SETTING: Retrospective analysis of data submitted by 40 pediatric hospitals to the Pediatric Health Information System.

PATIENTS: Children 0 to 17 years old admitted with a primary diagnosis of concussion from 2007 to 2014.

MEASUREMENTS: Descriptive statistics characterized this cohort and care practices delivered, logistic regression identified factors associated with a LOS of ≥2 days and ED readmission, and trend analyses assessed changes in care over time.

RESULTS: Of the 10,729 children admitted for concussion, 68.7% received intravenous pain or antiemetic medications. Female sex, adolescent age, and having government insurance were all associated ($P \leq .02$) with increased odds of LOS ≥ 2 days and ED revisit. Proportions of children receiving intravenous ondansetron (slope = 1.56, $P = .001$) and ketorolac (slope = 0.61, $P < .001$) increased over time, and use of neuroimaging (slope = −1.75, $P < .001$) decreased.

CONCLUSIONS: Although concussions are usually self-limited, hospitalized children often receive intravenous therapies despite an unclear benefit. Factors associated with prolonged LOS and ED revisit were similar to predictors of postconcussive syndrome. Since there has been an increased use of specific therapeutics, prospective evaluation of their relationship with concussion recovery could lay the groundwork for evidenced-based admission criteria and optimize recovery. *Journal of Hospital Medicine* 2018;13:673-680. Published online first April 25, 2018. © 2018 Society of Hospital Medicine

Approximately 14% of children who sustain a concussion are admitted to the hospital,[1] although admission rates reportedly vary substantially among pediatric hospitals.[2] Children hospitalized for concussion may be at a higher risk for persistent postconcussive symptoms,[3,4] yet little is known about this subset of children and how they are managed while in the hospital. Characterizing children hospitalized for concussion and describing the inpatient care they received will promote hypothesis generation for further inquiry into indications for admission, as well as the relationship between inpatient management and concussion recovery.

We described a cohort of children admitted to 40 pediatric hospitals primarily for concussion and detailed care delivered during hospitalization. We explored individual-level factors and their association with prolonged length of stay (LOS) and emergency department (ED) readmission. Finally, we evaluated if there had been changes in inpatient care over the eight-year study period.

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PATIENTS AND METHODS

Study Design

The Institutional Review Board determined that this retrospective cohort study was exempt from review.

Data Source

The Children's Hospital Association's Pediatric Health Information System (PHIS) is an administrative database from pediatric hospitals located within 17 major metropolitan areas in the United States. Data include: service dates, patient demographics, payer type, diagnosis codes, resource utilization information (eg, medications), and hospital characteristics.[1,5] De-identified data undergo reliability and validity checks prior to inclusion.[1,5] We analyzed data from 40 of 43 hospitals that contributed inpatient data during our study period. Two hospitals were excluded due to inconsistent data submission, and one removed their data.

Study Population

Data were extracted for children 0 to 17 years old who were admitted to an inpatient or observational unit between January 1, 2007 and December 31, 2014 for traumatic brain injury

(TBI). Children were identified using International Classification of Diseases, Clinical Modification, Ninth Revision (ICD-9-CM) diagnosis codes that denote TBI per the Centers for Disease Control (CDC): 800.0-801.9, 803.0-804.9, 850-854.1, and 959.01.[6-8] To examine inpatient care for concussion, we only retained children with a primary (ie, first) concussion-related diagnosis code (850.0-850.9[9]) for analyses. For patients with multiple visits during our study period, only the index admission was analyzed. We refined our cohort using two injury scores calculated from ICD-9-CM diagnosis codes using validated ICDMAP-90 injury coding software.[6,10–12] The Abbreviated Injury Scale (AIS) ranges from one (minor injury) to six (not survivable). The total Injury Severity Score (ISS) is based on six body regions (head/neck, face, chest, abdomen, extremity, and external) and calculated by summing the squares of the three-worst AIS scores.[13] A concussion receives a head AIS score of two if there is an associated loss of consciousness or a score of 1 if there is not; therefore, children were excluded if the head AIS score was >2. We also excluded children with the following features, as they may be indicative of more severe injuries that were likely the cause of admission: ISS > 6, secondary diagnosis code of skull fracture or intracranial injury, intensive care unit (ICU) or operating room (OR) charges, or a LOS > 7 days. Because some children are hospitalized for potentially abusive minor head trauma pending a safe discharge plan, we excluded children 0 to 4 years of age with child abuse, which was determined using a specific set of diagnosis codes (E960-E96820, 995.54, and 995.55) similar to previous research.[14]

Data Elements and Outcomes

Outcomes

Based on previous reports,[1,15] a LOS ≥ 2 days distinguished a typical hospitalization from a prolonged one. ED revisit was identified when a child had a visit with a TBI-related primary diagnosis code at a PHIS hospital within 30 days of initial admission and was discharged home. We limited analyses to children discharged, as children readmitted may have had an initially missed intracranial injury.

Patient Characteristics

We examined the following patient variables: age, race, sex, presence of chronic medical condition, payer type, household income, area of residence (eg, rural versus urban), and mechanism of injury. Age was categorized to represent early childhood (0 to 4 years), school age (5 to 12 years), and adolescence (12 to 17 years). Race was grouped as white, black, or other (Asian, Pacific Islander, American Indian, and "other" per PHIS). Ethnicity was described as Hispanic/Latino or not Hispanic/Latino. Children with medical conditions lasting at least 12 months and comorbidities that may impact TBI recovery were identified using a subgrouping of ICD-9-CM codes for children with "complex chronic conditions".[16] Payer type was categorized as government, private, and self-pay. We extracted a PHIS variable representing the 2010 median household income for the child's home zip code and categorized it into quartiles based on the Federal Poverty Level for a family of 4.[17,18] Area of residence was defined using a Rural–Urban Commuting Area (RUCA) classification system[19] and grouped into large urban core, suburban area, large rural town, or small rural town/isolated rural area.[17] Mechanism of injury was determined using E-codes and categorized using the CDC injury framework,[20] with sports-related injuries identified using a previously described set of E-codes.[1] Mechanisms of injury included fall, motor vehicle collision, other motorized transport (eg, all-terrain vehicles), sports-related, struck by or against (ie, objects), and all others (eg, cyclists).

Hospital Characteristics

Hospitals were characterized by region (Northeast, Central, South, and West) and size (small <200, medium 200-400, and large >400 beds). The trauma-level accreditation was identified with Level 1 reflecting the highest possible trauma resources.

Medical Care Variables

Care variables included medications, neuroimaging, and cost of stay. Medication classes included oral non-narcotic analgesics [acetaminophen, ibuprofen, and others (aspirin, tramadol, and naproxen)], oral narcotics (codeine, oxycodone, and narcotic–non-narcotic combinations), intravenous (IV) non-narcotics (ketorolac), IV narcotics (morphine, fentanyl, and hydromorphone), antiemetics [ondansetron, metoclopramide, and phenothiazines (prochlorperazine, chlorpromazine, and promethazine)], maintenance IV fluids (dextrose with electrolytes or 0.45% sodium chloride), and resuscitation IV fluids (0.9% sodium chloride or lactated Ringer's solution). Receipt of neuroimaging was determined if head computed tomography (CT) had been conducted at the admitting hospital. Adjusted cost of stay was calculated using a hospital-specific cost-to-charge ratio with additional adjustments using the Center for Medicare & Medicaid's Wage Index.

Statistical Analyses

Descriptive statistics were calculated for individual, injury, and hospital, and care data elements, LOS, and ED readmissions. The number of children admitted with TBI was used as the denominator to assess the proportion of pediatric TBI admissions that were due to concussions. To identify factors associated with prolonged LOS (ie, ≥2 days) and ED readmission, we employed a mixed models approach that accounted for clustering of observations within hospitals. Independent variables included age, sex, race, ethnicity, payer type, household income, RUCA code, chronic medical condition, and injury mechanism. Models were adjusted for hospital location, size, and trauma-level accreditation. The binary distribution was specified along with a logit link function. A two-phase process determined factors associated with each outcome. First, bivariable models were developed, followed by multivariable models that included independent variables with P values < .25 in the bivariable analysis. Backward step-wise elimination was performed, deleting variables with the highest P value one at a time. After each deletion, the percentage change in odds ratios was examined; if variable removal resulted in >10%

TABLE 1. **Characteristics of Concussion Admissions to 40 PHIS Hospitals from 2007-2014 (N = 10,729)**

Characteristic	Category	n (% of N)[a]
Age	0 ≤ 4 years	2,392 (22.3)
	5 ≤ 12 years	4,400 (41.0)
	>12 years	3,937 (36.7)
Race	White	6,738 (62.8)
	Black	2,460 (22.9)
	Other	1,529 (14.3)
Sex	Male	7,153 (66.7)
	Female	3,539 (33.0)
Chronic Medical Condition	Present	519 (4.8)
	Absent	10,210 (95.2)
Median Household Income in 2010[b]	≤150% of the FPL	2,920 (27.2)
	151% to 199% of the FPL	3,188 (29.7)
	200% to 299% of the FPL	3,114 (29.0)
	≥300% of the FPL	1,240 (11.6)
Payer Type	Government	4,565 (42.6)
	Private Insurance	4,591 (42.8)
	Self-pay	1,162 (10.8)
Rural–Urban Commuting Area	Large Urban Core	8,114 (75.6)
	Suburban Area	1,055 (9.8)
	Large Rural Town	692 (6.5)
	Small/Isolated Rural Area	601 (5.6)
Mechanism of Injury	Fall	3,719 (34.7)
	Motor Vehicle Collision	1,705 (15.9)
	Other Motorized Transport	532 (5.0)
	Sports	1,589 (14.8)
	Struck by, Against	1,006 (9.4)
	Other	1,083 (10.0)

[a]Data were missing for the following variables: Race (n = 2), Income (n = 267), Payer type (n = 411), Rural–Urban (n = 267), Mechanism of injury (n = 1,095)

[b]As previously described, this variable was categorized into quartiles based on the Federal Poverty Level for a family of 4 per the US Department of Health and Human Services: ≤150% of the FPL (≤$33,525), 151% to 199% of the FPL ($33,526–$44,700), 200% to 299% of the FPL ($44,701–$67,050), and ≥300% of the FPL (≥$67,051)

Abbreviations: FPL, Federal Poverty Line; PHIS, Pediatric Health Information System.

change, the variable was retained as a potential confounder. This process was repeated until all remaining variables were significant ($P < .05$) with the exception of potential confounders. Finally, we examined the proportion of children receiving selected care practices annually. Descriptive and trend analyses were used to analyze adjusted median cost of stay. Analyses were performed using SAS software (Version 9.3, SAS Institute Inc., Cary, North Carolina).

RESULTS

Over 8 years, 88,526 children were admitted to 40 PHIS hospitals with a TBI-related diagnosis, among whom 13,708 had a primary diagnosis of concussion. We excluded 2,973 children with 1 or more of the following characteristics: a secondary diagnosis of intracranial injury (n = 58), head AIS score > 2 (n = 218), LOS > 7 days (n = 50), OR charges (n = 132), ICU charges (n = 1947), and ISS > 6 (n = 568). Six additional children aging 0 to 4 years were excluded due to child abuse. The remaining 10,729 children, averaging 1,300 hospitalizations annually, were identified as being hospitalized primarily for concussion.

Table 1 summarizes the individual characteristics for this cohort. The average (standard deviation) age was 9.5 (5.1) years. Ethnicity was missing for 25.3% and therefore excluded from the multivariable models. Almost all children had a head AIS score of two (99.2%), and the majority had a total ISS ≤ 4 (73.4%). The majority of admissions were admitted to Level 1 trauma-accredited hospitals (78.7%) and medium-sized hospitals (63.9%).

The most commonly delivered medication classes were non-narcotic oral analgesics (53.7%), dextrose-containing IV fluids (45.0%), and antiemetic medications (34.1%). IV and oral narcotic use occurred in 19.7% and 10.2% of the children, respectively. Among our cohort, 16.7% received none of these medication classes. Of the 8,940 receiving medication, 32.6% received a single medication class, 29.5% received two classes, 20.5% three classes, 11.9% four classes, and 5.5% received five or more medication classes. Approximately 15% (n = 1,597) received only oral medications, among whom 91.2% (n = 1,457) received only non-narcotic analgesics and 3.9% (n = 63) received only oral narcotic analgesics. The majority (69.5%)

TABLE 2. **Characteristics Associated with an Inpatient Length of Stay of Two or More Days in Children Admitted for Concussion**

Characteristic	Bivariable Analysis[a]		Multivariable Analysis[a]	
	Odds Ratio (95% CL)	*P* Value	Odds Ratio (95% CL)	*P* Value
Age		<.0001		<.001
>12 years	1.45 (1.25, 1.69)		1.41 (1.21, 1.65)	
0 ≤ 4 years	1.05 (0.87, 1.26)		1.09 (0.89, 1.32)	
5 ≤ 12 years	REFERENCE		REFERENCE	
Sex		<.0001		<.0001
Female	1.5 (1.30, 1.72)		1.53 (1.33, 1.77)	
Male	REFERENCE		REFERENCE	
Race		.04		–
Black	1.17 (0.98, 1.39)		–	
Other	1.26 (1.03, 1.54)		–	
White	REFERENCE		–	
Payer Type		<.01		<.01
Self-pay	1.24 (0.99, 1.56)		1.17 (0.93, 1.47)	
Government	1.27 (1.10, 1.48)		1.30 (1.12, 1.51)	
Private Insurance	REFERENCE		REFERENCE	
Median Household Income in 2010		.08		–
<150% of the FPL	1.38 (1.07, 1.79)		–	
151% to 199% of the FPL	1.36 (1.04, 1.73)		–	
200% to 299% of the FPL	1.23 (0.96, 1.59)		–	
≥300% of the FPL	REFERENCE		–	
Rural–Urban Commuting Area		.50		–
Suburban Area	1.08 (0.86, 1.36)		–	
Large rural town	1.22 (0.92, 1.61)		–	
Small/isolated rural area	1.11 (0.82, 1.50)		–	
Large urban core	REFERENCE		–	
Chronic Medical Condition		<.0001		<.0001
Present	2.12 (1.65, 2.72)		2.22 (1.73, 2.86)	
Absent	REFERENCE		REFERENCE	
Mechanism of Injury		<.0001		<.0001
Fall	0.80 (0.65, 0.97)		0.78 (0.62, 0.98)	
Motor vehicle collision	1.38 (1.11, 1.72)		1.29 (1.03, 1.62)	
Other motorized transport	1.14 (0.83, 1.55)		1.10 (0.80, 1.52)	
Struck by, against	0.90 (0.69, 1.17)		0.87 (0.66, 1.14)	
Other	1.10 (0.86, 1.41)		1.12 (0.87, 1.45)	
Sports	REFERENCE		REFERENCE	

[a]All models included covariates that were adjusted for the hospital's size based on the number of inpatient beds, trauma-level accreditation, and geographic region of the county. The multivariable model was constructed including all independent variables with *P* values < .25 in the bivariable analysis. Backward step-wise elimination was performed by deleting variables with the highest *P* value one at a time, and if the removal of a variable resulted in a greater than 10% change in odds ratios, it was left in the model as a potential confounder.

Abbreviation: FPL, Federal Poverty Line.

received a head CT.

The median (interquartile range) LOS was one (1) day with 11.3% (n = 1,209) of the children being hospitalized ≥2 days. ED revisits with a primary TBI-related diagnoses were infrequent at 3.8% (n = 411). As summarized in Table 2, children with protracted LOS were more likely to be female, >12 years of age, and publicly insured. Children injured in a motor vehicle collision (relative to sports-related injuries) and with chronic medical conditions were also more likely to have prolonged LOS. Children >12 years old, female, and publicly insured were significantly more likely to incur ED revisits (Table 3).

Table 4 summarizes medication administration trends over time. Oral non-narcotic administration increased significantly (slope = 0.99, $P < .01$) with the most pronounced change occurring in ibuprofen use (slope = 1.11, $P < .001$). Use of the IV non-narcotic ketorolac (slope = 0.61, $P < .001$) also increased significantly, as did the proportion of children receiving antiemetics (slope = 1.59, $P = .001$), with a substantial increase in ondansetron use (slope = 1.56, $P = .001$). The proportion of children receiving head CTs decreased linearly over time

TABLE 3. **Characteristics Associated with Emergency Department Revisits within 30 Days of Inpatient Admission for Concussion**

Characteristic	Bivariable Analysis[a]		Multivariable Analysis[a]	
	Odds Ratio (95% CL)	*P* Value	Odds Ratio (95% CL)	*P* Value
Age		.01		.01
>12 years	1.46 (1.12, 1.89)		1.49 (1.15, 1.93)	
0 ≤ 4 years	1.38 (1.03, 1.86)		1.27 (0.94, 1.93)	
5 ≤ 12 years	REFERENCE		REFERENCE	
Sex		.01		<.01
Female	1.34 (1.07, 1.69)		1.37 (1.09, 1.73)	
Male	REFERENCE		REFERENCE	
Race		<.01		–
Black	1.45 (1.11, 1.89)		–	
Other	0.81 (0.55, 1.19)		–	
White	REFERENCE		–	
Payer Type		<.01		.02
Self-pay	0.87 (0.56, 1.36)		0.84 (0.53, 1.31)	
Government	1.45 (1.14, 1.83)		1.35 (1.1, 1.75)	
Private insurance	REFERENCE		REFERENCE	
Median Household Income in 2010		.08		.04
<150% of the FPL	1.37 (0.92, 2.05)		1.42 (0.93, 2.18)	
151% to 199% of the FPL	1.05 (0.70, 1.57)		1.05 (0.69, 1.59)	
200% to 299% of the FPL	0.97 (0.64, 1.45)		0.92 (0.61, 1.39)	
≥300% of the FPL	REFERENCE		REFERENCE	
Rural–Urban Commuting Area		<.01		<.001
Suburban area	0.91 (0.62, 1.31)		0.98 (0.64, 1.44)	
Large rural town	0.5 (0.28, 0.9)		0.46 (0.26, 0.83)	
Small/isolated rural area	0.2 (0.08, 0.5)		0.18 (0.07, 0.44)	
Large Urban Core	REFERENCE		REFERENCE	
Chronic Medical Condition		.61		–
Present	0.87 (0.50, 1.50)		–	
Absent	REFERENCE		–	
Mechanism of Injury		.08		–
Fall	1.11 (0.79, 1.55)		–	
Motor vehicle collision	1.43 (0.99, 2.07)		–	
Other motorized transport	0.76 (0.41, 1.41)		–	
Struck by, against	1.27 (0.83, 1.94)		–	
Other	0.82 (0.51, 1.32)		–	
Sports	REFERENCE		–	

[a]All models included covariates that were adjusted for the hospital's size based on the number of inpatient beds, trauma-level accreditation, and geographic region of the county. The multivariable model was constructed including all independent variables with *P* values < .25 in the bivariable analysis. Backward step-wise elimination was performed by deleting variables with the highest *P* value one at a time, and if the removal of a variable resulted in a greater than 10% change in odds ratios, it was left in the model as a potential confounder.

Abbreviation: FPL, Federal Poverty Line.

(slope= −1.75, $P < .001$), from 76.1% in 2007 to 63.7% in 2014. Median cost, adjusted for inflation, increased during our study period ($P < .001$) by approximately $353 each year, reaching $11,249 by 2014.

DISCUSSION

From 2007 to 2014, approximately 15% of children admitted to PHIS hospitals for TBI were admitted primarily for concussion. Since almost all children had a head AIS score of two and an ISS ≤ 4, our data suggest that most children had an associated loss of consciousness and that concussion was the only injury sustained, respectively. This study identified important subgroups that necessitated inpatient care but are rarely the focus of concussion research (eg, toddlers and those injured due to a motor vehicle collision). Most children (83.3%) received medications to treat common postconcussive symptoms (eg, pain and nausea), with almost half receiving three or more medication classes. Factors associated with the development of postconcussive syndrome (eg, female sex and adolescent age)[4,21] were significantly associated with hospitalization of two

TABLE 4. **Trends in Medication Administration to Children Admitted for Concussion from 2007-2014 (N=10,729)**

	Percent of Concussion Admissions by Year Receiving Medication								Trend Analysis Results	
Medication Classes	2007 (n = 1,192)	2008 (n = 1,237)	2009 (n = 1,288)	2010 (n = 1,343)	2011 (n = 1,337)	2012 (n = 1,494)	2013 (n = 1,517)	2014 (n = 1,321)	Slope (β)	*P* Value
Oral Non-narcotic Analgesics[a]	50.4	50.9	52.8	53.0	55.2	51.5	56.7	58.4	0.99	<.01[b]
Acetaminophen	41.5	42.9	45.3	44.5	43.7	40.2	47.1	47.3	0.54	.18
Ibuprofen	16.4	16.4	17.9	19.3	21.4	21.0	22.1	24.0	1.11	<.001[b]
Other	0.3	0.2	0.1	0.4	0.2	0.7	1.1	0.5	0.09	.09
Oral Narcotics[a]	8.7	9.4	10.0	10.4	8.8	11.4	10.7	11.4	0.33	.03[b]
Codeine	0.4	0.1	0.2	0.1	0.0	0.1	0.0	0.0	-0.04	.03[b]
Oxycodone	1.1	1.2	1.5	1.7	1.9	2.0	2.3	3.6	0.29	.001[b]
Combination	7.3	8.1	8.6	8.9	6.9	9.4	8.6	8.0	0.09	.53
IV Non-narcotic Analgesic										
Ketorolac	4.0	4.9	5.0	6.5	7.1	7.6	8.2	7.8	0.61	<.001[b]
Intravenous Narcotics[a]	18.5	20.7	18.3	19.1	18.4	20.9	20.6	20.7	0.27	.15
Morphine	16.4	18.5	15.9	16.8	16.5	17.2	17.1	16.8	-0.01	.92
Fentanyl	2.7	2.8	3.1	2.8	3.4	4.8	5.0	5.3	0.42	.001[b]
Hydromorphone	0.3	0.7	0.3	0.3	0.2	0.3	0.6	0.1	-0.03	.38
Antiemetics[a]	25.9	31.0	31.4	34.1	35.1	37.4	38.3	37.1	1.59	.001[b]
Ondansetron	25.2	30.2	30.9	33.4	34.6	36.8	37.2	36.1	1.56	.001[b]
Metoclopramide	1.5	1.6	0.9	0.7	0.4	1.3	1.0	1.1	-0.05	.45
Phenothiazines	0.5	0.3	1.3	0.7	0.5	0.7	1.1	0.9	0.06	.32
IV resuscitation fluids	23.2	22.1	19.6	22.3	24.8	22.3	22.5	21.4	-0.01	.98
IV maintenance fluids	53.0	46.5	43.6	43.6	42.3	42.2	44.3	46.0	-0.77	.17

[a]Represents the total percentage of children who received that category of medication; in cases where a child received two or more medications of the same category, the child was counted only once toward the medication category's total number

[b]Denotes a significant ($P < .05$) change in the percentage of children admitted for concussion who received that medication over time

Abbreviation: IV, intravenous.

or more days and ED revisit within 30 days of admission. In the absence of evidenced-based guidelines for inpatient concussion management, we identified significant trends in care, including increased use of specific pain [ie, oral and IV nonsteroidal anti-inflammatory drugs (NSAIDs)] and antiemetic (ie, ondansetron) medications and decreased use of head CT. Given the number of children admitted and receiving treatment for concussion symptomatology, influences on the decision to deliver specific care practices, as well as the impact and benefit of hospitalization, require closer examination.

Our study extends previous reports from the PHIS database by characterizing children admitted for concussion.[1] We found that children admitted for concussion had similar characteristics to the broader population of children who sustain concussion (eg, school-aged children, male, and injured due to a fall or during sports).[1,3,22] However, approximately 20% of the cohort were less than five years old, and less is known regarding appropriate treatment and outcomes of concussion in this age group.[23] Uncertainty regarding optimal management and a young child's inability to articulate symptoms may contribute to a physician's decision to admit for close observation. Similar to Blinman et al., we found that a substantial proportion of children admitted with concussion were injured due to a motor vehicle collision,[3] suggesting that although sports-related injuries are responsible for a significant proportion of pediatric concussions, children injured by other preventable mechanisms may also be incurring significant concussive injuries. Finally, the majority of our cohort was from an urban core, relative to a rural area, which is likely a reflection of the regionalization of trauma care, as well as variations in access to health care.

Although most children recover fully from concussion without specific interventions, 20%-30% may remain symptomatic at 1 month,[3,4,21,24] and children who are hospitalized with concussion may be at higher risk for protracted symptoms. While specific individual or injury-related factors (eg, female sex, adolescent age, and injury due to motor vehicle collision) may contribute to more significant postconcussive symptoms, it is unclear how inpatient management affects recovery trajectory. Frequent sleep disruptions associated with inpatient care[25] contradict current acute concussion management recommendations for physical and cognitive rest[26] and could potentially impair symptom recovery. Additionally, we found widespread use of NSAIDs, although there is evidence suggesting that NSAIDs may potentially worsen concussive symptoms.[26] We identified an increase in medication usage over time despite limited evidence of their effectiveness for pediatric concus-

sion.[27-29] This change may reflect improved symptom screening[4,30] and/or increased awareness of specific medication safety profiles in pediatric trauma patients, especially for NSAIDs and ondansetron. Although we saw an increase in NSAID use, we did not see a proportional decrease in narcotic use. Similarly, while two-thirds of our cohort received IV medications, there is controversy about the need for IV fluids and medications for other pediatric illnesses, with research demonstrating that IV treatment may not reduce recovery time and may contribute to prolonged hospitalization and phlebitis.[31,32] Thus, there is a need to understand the therapeutic effectiveness and benefits of medications and fluids on postconcussion recovery.

Neuroimaging rates for children receiving ED evaluation for concussion have been reported to be up to 60%-70%,[1,22] although a more recent study spanning 2006 to 2011 found a 35%-40% head CT rate in pediatric patients by hospital-based EDs in the United States.[33] Our results appear to support decreasing head CT use over time in pediatric hospitals. Hospitalization for observation is costly[1] but could decrease a child's risk of malignancy from radiation exposure. Further work on balancing cost, risk, and shared decision-making with parents could guide decisions regarding emergent neuroimaging versus admission.

This study has limitations inherent to the use of an administrative dataset, including lack of information regarding why the child was admitted. Since the focus was to describe inpatient care of children with concussion, those discharged home from the ED were not included in this dataset. Consequently, we could not contrast the ED care of those discharged home with those who were admitted or assess trends in admission rates for concussion. Although the overall number of concussion admissions has continued to remain stable over time,[1] due to a lack of prospectively collected clinical information, we are unable to determine whether observed trends in care are secondary to changes in practice or changes in concussion severity. However, there has been no research to date supporting the latter. Ethnicity was excluded due to high levels of missing data. Cost of stay was not extensively analyzed given hospital variation in designation of observational or inpatient status, which subsequently affects billing.[34] Rates of neuroimaging and ED revisit may have been underestimated since children could have received care at a non-PHIS hospital. Similarly, the decrease in the proportion of children receiving neuroimaging over time may have been associated with an increase in children being transferred from a non-PHIS hospital for admission, although with increased regionalization in trauma care, we would not expect transfers of children with only concussion to have significantly increased. Finally, data were limited to the pediatric tertiary care centers participating in PHIS, thereby reducing generalizability and introducing selection bias by only including children who were able to access care at PHIS hospitals. Although the care practices we evaluated (eg, NSAIDs and head CT) are available at all hospitals, our analyses only reflect care delivered within the PHIS.

Concussion accounted for 15% of all pediatric TBI admissions during our study period. Further investigation of potential factors associated with admission and protracted recovery (eg, adolescent females needing treatment for severe symptomatology) could facilitate better understanding of how hospitalization affects recovery. Additionally, research on acute pharmacotherapies (eg, IV therapies and/or inpatient treatment until symptoms resolve) is needed to fully elucidate the acute and long-term benefits of interventions delivered to children.

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Does Patient Experience Predict 30-Day Readmission? A Patient-Level Analysis of HCAHPS Data

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BACKGROUND: Hospital-level studies have found an inverse relationship between patient experience and readmissions. However, based on typical survey response time, it is unclear if patients are able to respond to surveys before they get readmitted and whether being readmitted might be a driver of poor experience scores (reverse causation).

OBJECTIVE: Using patient-level Hospital Consumer Assessment of Healthcare Providers and Systems (HCHAPS) and Press Ganey data to examine the relationship between readmissions and experience scores and to distinguish between patients who responded before or after a subsequent readmission.

DESIGN: Retrospective analysis of 10-year HCAHPS data.

SETTING: Single tertiary care academic hospital.

PARTICIPANTS: Patients readmitted within 30 days of an index hospitalization who received an HCAHPS survey linked to index admission comprised the exposure group. This group was divided into those who responded prior to readmission and those who responded after readmission. Nonreadmitted patients comprised the control group.

ANALYSIS: Multivariable-logistic regression to analyze the association between HCHAPS and Press Ganey scores and 30-readmission status, adjusted for patient factors.

RESULTS: Only 15.8% of the readmitted patients responded to the survey prior to readmission, and their scores were not significantly different from the nonreadmitted patients. The patients who responded after readmission were significantly more dissatisfied with physicians (doctors listened 73.0% versus 79.2%, adjusted odds ratio [aOR] 0.75, $P < .0001$), staff responsiveness, (call button 50.0% vs 59.1%, aOR 0.71, $P < .0001$) pain control, discharge plan, noise, and cleanliness of the hospital.

CONCLUSION: Our findings suggest that poor patient experience, may be due to being readmitted, rather than being predictive of readmission. *Journal of Hospital Medicine* 2018;13:681-687. Published online first July 25, 2018. © 2018 Society of Hospital Medicine

Patient experience and 30-day readmission are important measures of quality of care for hospitalized patients. Performance on both of these measures impact hospitals financially. Performance on the Hospital Consumer Assessment of Healthcare Systems and Providers (HCAHPS) survey is linked to 25% of the incentive payment under Value Based Purchasing (VBP) Program.[1] Starting in 2012, the Centers for Medicare and Medicaid Services (CMS) introduced the Readmission Reduction Program, penalizing hospitals financially for excessive readmissions.[2]

A relationship between patient experience and readmissions has been explored at the hospital level. Studies have mostly found that higher patient experience scores are associated with lower 30-day readmission rates. In a study of the relationship between 30-day risk-standardized readmission rates for three medical conditions (acute myocardial infarction, heart failure, and pneumonia) and patient experience, the authors noted that higher experience scores for overall care and discharge planning were associated with lower readmission rates for these conditions. They also concluded that patient experience scores were more predictive of 30-day readmission than clinical performance measures. Additionally, the authors predicted that if a hospital increased its total experience scores from the 25th percentile to the 75th percentile, there would be an associated decrease in readmissions by at least 2.3% for each of these conditions.[3] Practice management companies and the media have cited this finding to conclude that higher patient experience drives clinical outcomes such as 30-day readmission and that patients are often the best judges of the quality of care delivered.[4,5]

Other hospital-level studies have found that high 30-day readmission rates are associated with lower overall experience scores in a mixed surgical patient population; worse reports of pain control and overall care in the colorectal surgery population; lower experience scores with discharge preparedness

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in vascular surgery patients; and lower experience scores with physician communication, nurse communication, and discharge preparedness.[6-9] A patient-level study noted higher readmissions are associated with worse experience with physician and nursing communication along with a paradoxically better experience with discharge information.[10]

Because these studies used an observational design, they demonstrated associations rather than causality. An alternative hypothesis is that readmitted patients complete their patient experience survey after readmission and the low experience is the result, rather than the cause, of their readmission. For patients who are readmitted, it is unclear whether there is an opportunity to complete the survey prior to readmission and whether being readmitted may impact patient perception of quality of care. Using patient-level data, we sought to assess HCAHPS patient-experience responses linked to the index admission of the patients who were readmitted in 30 days and compare it with those patients who were not readmitted during this time period. We paid particular attention to when the surveys were returned.

METHODS

Study Design

We conducted a retrospective analysis of prospectively collected 10-year HCAHPS and Press Ganey patient survey data for a single tertiary care academic hospital.

Participants

All adult patients discharged from the hospital and who responded to the routinely sent patient-experience survey were included. Surveys were sent to a random sample of 50% of the discharged patients.

The exposure group was comprised of patients who responded to the survey and were readmitted within 30 days of discharge. After subtracting 5 days from the survey receipt date for expected delays related to mail delivery time and processing time, survey response date was calculated. The exposure group was further divided into patients who responded to the survey prior to their 30-day readmission ("Prereadmission responders") and those that responded to the survey after their readmission ("Postreadmission responders"). A sensitivity analysis was performed by changing the number of days subtracted from the survey receipt date by two days in either direction. This approach did not result in any significant changes in the results.

The control group comprised patients who were not readmitted to the hospital within 30 days of discharge and who did not have an admission in the previous 30 days as well ("Not readmitted" group). An additional comparison group for exploratory analysis included patients who had experienced an admission in the prior 30 days but were not readmitted after the admission linked to the survey. These patients responded to the patient-experience surveys that were linked to their second admission in 30 days ("2nd-admission responders" group; Figure).

Time Periods

All survey responders from the third quarter of 2006 to the first quarter of 2016 were included in the study. Additionally, administrative data on non-responders were available from July 2006 to August 2012. These data were used to estimate response rates. Patient level experience and administrative data were obtained in a linked fashion for these time periods.

Instruments

Press Ganey and HCAHPS surveys were sent via mail in the same envelope. Fifty percent of the discharged patients were randomized to receive the surveys. The Press Ganey survey contained 33 items encompassing several subdomains, including room, meal, nursing, physician, ancillary staff, visitor, discharge, and overall experience.

The HCAHPS survey contained 29 CMS-mandated items, of which 21 are related to patient experience. The development, testing, and methods for administration and reporting of the HCAHPS survey have been previously described and studies using this instrument have been reported in the literature.[11] Press Ganey patient satisfaction survey results have also been reported in the literature.[12]

Outcome Variables and Covariates

HCAHPS and Press Ganey experience survey individual item responses were the primary outcome variables of this study. Age, self-reported health status, education, primary language spoken, service line, and time taken to respond to the surveys served as the covariates. These variables are used by CMS for patient-mix adjustment and are collected on the HCAHPS survey. Additionally, the number of days to respond to the survey were included in all regression analysis to adjust for early responder effect.[13-15]

Statistical Analysis

"Percent top-box" scores were calculated for each survey item for patients in each group. The percent top-box scores were calculated as the percent of patients who responded "very good" for a given item on Press Ganey survey items and "always" or "definitely yes" or "yes" or "9" or "10" on HCAHPS survey items. CMS utilizes "percent top-box scores" to calculate payments under the VBP program and to report the results publicly. Numerous studies have also reported percent top-box scores for HCAHPS survey results.[12]

We hypothesized that whether patients complete the HCAHPS survey before or after the readmission influences their reporting of experience. To test this hypothesis, HCAHPS and Press Ganey item top-box scores of "Prereadmission responders" and "Postreadmission responders" were compared with those of the control group using multivariate logistic regression. "Prereadmission responders" were also compared with "Postreadmission responders."

"2nd-admission responders" were similarly compared with the control group for an exploratory analysis. Finally, "Postreadmission responders" and "2nd-admission responders" were compared in another exploratory analysis since both these groups responded to the survey after being exposed to the readmission, even though the "Postreadmission responders" group is administratively linked to the index admission.

The Johns Hopkins Institutional Review Board approved this study.

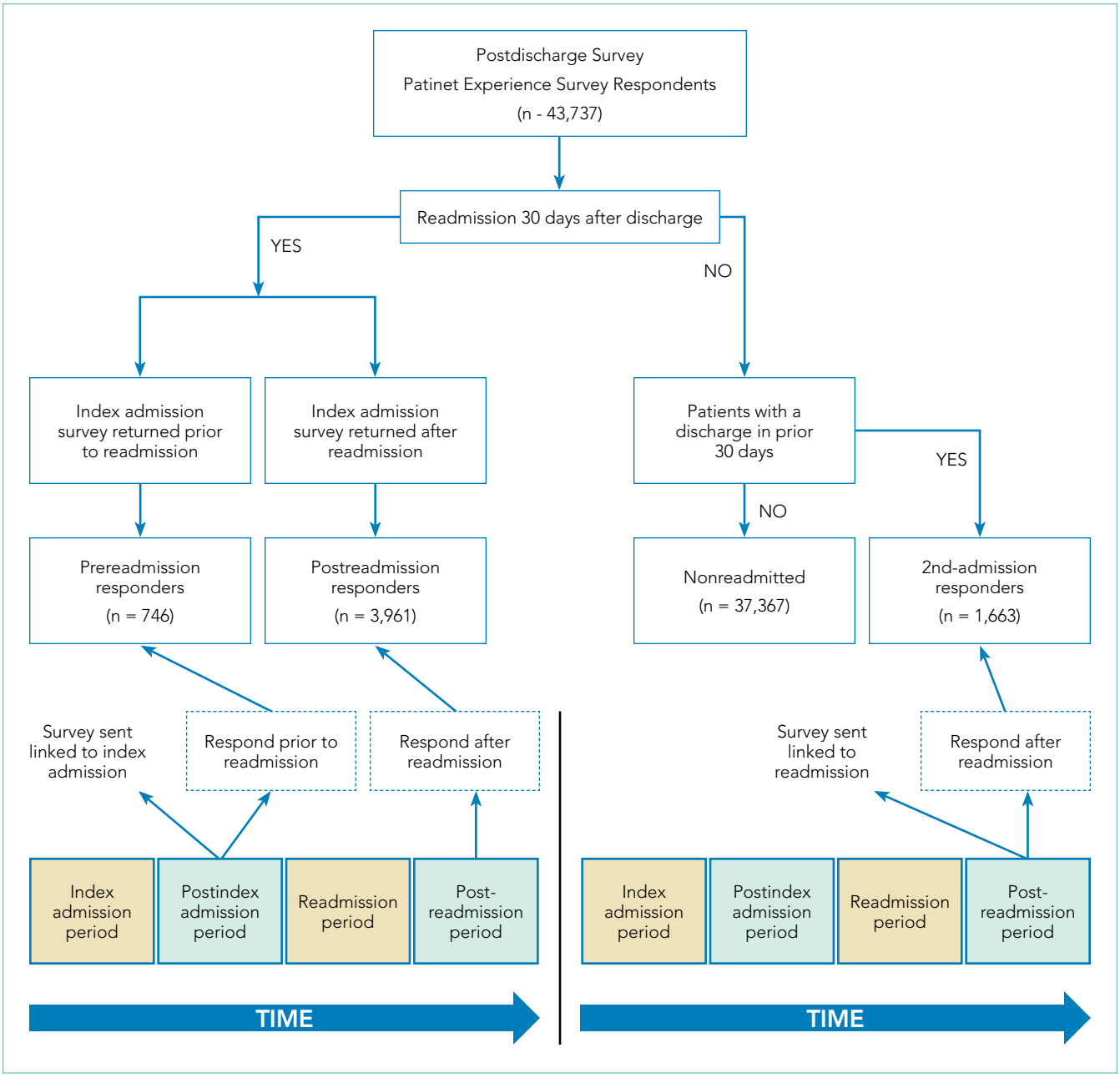

FIG. Postdischarge Survey, Patient Experience Survey Respondents.

RESULTS

There were 43,737 survey responders, among whom 4,707 were subsequently readmitted within 30 days of discharge. Among the readmitted patients who responded to the surveys linked to their index admission, only 15.8% returned the survey before readmission (prereadmission responders') and 84.2% returned the survey after readmission (postreadmission responders). Additionally, 1,663 patients responded to experience surveys linked to their readmission. There were 37,365 patients in the control arm (ie, patients who responded to the survey and were not readmitted within 30 days of discharge or in the prior 30 days; Figure). The readmission rate among survey responders was 10.6%. Among the readmitted patients, the median number of days to readmission was 10 days while the median number of days to respond to the survey for this group was 33 days. Among the nonreadmitted patients, the median number of days to return the survey was 29 days.

While there were no significant differences between the comparison groups in terms of gender and age, they differed on other characteristics. The readmitted patients were more often Medicare patients, white, had longer length of stay and higher severity of illness (Table 1). The response rate was lower among readmitted patients when compared to patients who were not readmitted (22.5% vs 33.9%, $P < .0001$). Press Ganey and HCAHPS survey responses. Postreadmission responders, compared with the nonreadmitted group, were less satisfied

TABLE 1. **Patient Characteristics**

Demographic characteristic	Prereadmission responders	Nonreadmitted	*P* Value	Postreadmission Responders	Nonreadmitted	*P* Value
Payor type						
Medicare	37.5%	32.6%	.001	40.2%	32.6%	< .0001
Medicaid	8.5%	7.3%		8.2%	7.3%	
Private	35.0%	35.0%		33.4%	35.3%	
Self-pay	0.13%	0.44%		0.41%	0.14%	
Other	19.0%	24.6%		17.8%	24.6%	
Nonwhite	23.8%	31.8%	< .0001	26.6%	31.8%	< .0001
Female	49.3%	50.7%	.37	49.4%	50.7%	.06
Age (mean)	58.7	57.3	.02	57.8	57.3	.05
LOS (mean)	7.20	4.74	< .0001	7.30	4.74	< .0001
APR-SOI (mean)	2.56	2.15	< .0001	2.57	2.15	< .0001

Abbreviations: LOS, length of stay; SOI, severity of illness

with multiple domains including physicians, phlebotomy staff, discharge planning, staff responsiveness, pain control and hospital environment. Patients were less satisfied with how often physicians listened to them carefully (72.9% vs 79.4%, aOR [adjusted odds ratio] 0.75, $P < .001$), how often physicians explained things in a way they could understand (69.5% vs 77.0%, aOR 0.77, $P < .0001$). While postreadmission responders more often stated that staff talked about the help they would need when they left the hospital (85.7% vs 81.5%, aOR 1.41, $P < .0001$), they were less satisfied with instructions for care at home (59.7% vs 64.9%. aOR 0.82, $P < .0001$) and felt less ready for discharge (53.9% vs 60.3%, aOR 0. 81, $P \leq .0001$). They were less satisfied with noise (48.8% vs 57.2%, aOR 0.75, $P < .0001$) and cleanliness of the hospital (60.5% vs 66.0%, aOR 0.76, $P < .0001$). Patients were also more dissatisfied with regards to responsiveness to call button (50.0% vs 59.1%, aOR 0.71, $P < .0001$) and need for toileting help (53.1% vs 61.3%, aOR 0.80 $P < .0001$). There were no significant differences between the groups for most of the nursing domains). Postreadmission responders had worse top-box scores, compared with prereadmission responders, on most patient-experience domains, but these differences were not statistically significant (Table 2).

We also conducted an exploratory analysis of the postreadmission responders, comparing them with patients who received patient-experience surveys linked to their second admission in 30 days. Both of these groups were exposed to a readmission before they completed the surveys. There were no significant differences between these two groups on patient experience scores. Additionally, the patients who received the survey linked to their readmission had a broad dissatisfaction pattern on HCAHPS survey items that appeared similar to that of the postreadmission group when compared to the nonreadmitted group (Table 3).

DISCUSSION

In this retrospective analysis of prospectively collected Press Ganey and HCAHPS patient-experience survey data, we found that the overwhelming majority of patients readmitted within 30 days of discharge respond to HCAHPS surveys *after* readmission even though the survey is sent linked to the first admission. This is not unexpected since the median time to survey response is 33 days for this group, while median time to readmission is 10 days. The dissatisfaction pattern of Postreadmission responders was similar to those who responded to the survey linked to the readmission. When a patient is readmitted prior to completing the survey, their responses appear to reflect the cumulative experience of the index admission and the readmission. The lower scores of those who respond to the survey after their readmission appear to be a driver for lower patient-experience scores related to readmissions. Overall, readmission was associated with lower scores on items in five of the nine domains used to calculate patient experience related payments under VBP.[16]

These findings have important implications in inferring the direction of potential causal relationship between readmissions and patient experience at the hospital level. Additionally, these patients show broad dissatisfaction with areas beyond physician communication and discharge planning. These include staff responsiveness, phlebotomy, meals, hospital cleanliness, and noise level. This pattern of dissatisfaction may represent impatience and frustration with spending additional time in the hospital environment.

Our results are consistent with findings of many of the earlier studies, but our study goes a step further by using patient-level data and incorporating survey response time in our analysis.[3,7,9,10] By separating out the readmitted patients who responded to the survey prior to admission, we attempted to address the ability of patients' perception of care to predict future readmissions. Our results do not support this idea, since prereadmission responders had similar experience scores to non-readmitted patients. However, because of the low numbers of prereadmission responders, the comparison lacks precision. Current HCAHPS and Press Ganey questions may lack the ability to predict future readmissions because of the timing of the survey (postdischarge) or the questions themselves.

TABLE 2. **Patient Experience Related to 30-Day Readmission: Comparison of Scores for Readmitted Patients (Divided into whether They Responded to the Survey Before or After They Were Readmitted) with Patients Who Were Not Readmitted.**

	%Top Box[a]					
Satisfaction Domains	**Prereadmission Responder (n = 746)[b]**	**Postreadmission Responders (n = 3,961)[b]**	**Not Readmitted (n = 37,367)[b]**	**Adjusted Odds Ratio[c] Prereadmission vs Postreadmission Responders**	**Adjusted Odds Ratio[c] Prereadmission vs Nonreadmitted**	**Adjusted Odds Ratio[c] Postreadmission vs Nonreadmitted**
HCAHPS ITEMS						
Nursing Communication						
Nurses treated with courtesy/respect	87.8	82.9	83.8	1.23	1.11	0.94
Nurses listened	78.5	71.1	72.5	1.32*	1.23	0.92
Nurses explained	78.7	70.7	73.9	1.37**	1.12	0.89*
Physician Communication						
Doctors treated with courtesy/respect	89.3	83.9	88.0	1.41*	1.15	0.83***
Doctors listened	79.2	73.0	79.2	1.75***	1.23	0.75****
Doctors explained	74.4	69.5	77.0	1.28	1.02	0.77****
Discharge Related						
Staff talk about help when you leave	83.0	85.7	81.5	0.87	1.21	1.41****
Info re: symptoms/prob to look for	91.1	91.8	91.9	0.95	1.01	0.98
Hospital Staff took pref into account[d]	56.8	53.5	54.0	1.04	1.21	1.00
Good understanding manage health[d]	65.0	58.1	61.6	1.25	1.18	0.93
Understood purpose of taking meds[d]	72.1	66.6	69.6	1.28	1.17	0.92
Hospital Environment						
Cleanliness of the hospital	64.4	60.5	66.0	1.14	0.88	0.76****
Quietness of the hospital	54.4	48.8	57.2	1.25*	0.92	0.75****
Misc.						
Call button help soon as wanted	62.5	50.0	59.1	1.41**	1.01	0.71****
Help toileting as soon as you wanted	56.9	53.1	61.3	1.02	0.79	0.80****
Pain well controlled	60.9	55.1	62.4	1.23	0.93	0.79*
Staff do everything help with pain	77.5	73.7	77.2	1.05	0.87	0.89
Staff describe medicine side effect	55.3	43.5	46.7	1.64***	1.39	0.86
Tell you what new medicine was for	81.1	73.9	76.3	1.39	1.28	0.95
Overall						
Rate hospital (0–10)	79.3	73.1	76.1	1.39*	1.28	0.92
Recommend hospital	84.7	80.2	82.1	1.43*	1.35	0.97
PRESS GANEY ITEMS						
Room						
Courtesy of person cleaning the room	66.4	62.4	61.0	1.05	1.02*	0.98
Room temperature	42.1	40.4	45.3	1.02	0.88*	0.86***
Noise level in and around the room	43.5	38.3	45.4	1.20	0.94	0.79****
Food						
Temperature of the food	26.6	25.5	31.1	1.32	0.92**	0.81****
Courtesy of person served food	64.4	60.1	57.7	1.47	1.23*	1.09
Ancillary Staff						
Courtesy of person took blood	67.0	59.1	64.0	1.32*	1.03	0.75****
Courtesy of person started IV	71.2	63.0	68.0	1.47*	1.08	0.76****
Visitor Related						
Accommodations & comfort visitors	57.1	53.7	55.7	1.16	1.07	0.95
Staff attitude toward visitors	72.6	69.9	69.2	1.05	1.06	1.02
Discharge						
Extent felt ready discharge	62.2	53.9	60.3	1.09	1.15	0.81****
Speed of discharge process	48.8	39.6	49.9	1.54***	0.98	0.67****
Instructions care at home	67.3	59.7	64.9	1.32*	1.04	0.82****
Misc						
Staff concern for your privacy	67.4	62.5	63.9	1.14	1.06	0.90
Staff addressed emotional needs	52.3	52.3	54.0	1.04	0.92	0.91*
Nurse promptness response to call	59.1	54.0	57.4	1.23	1.07	0.84****

Prereadmission responder = survey linked to index admission, returned prior to readmission. Postreadmission responder = survey linked to index admission returned after readmission

[a]% Top Box is the percentage of patients with top category responses (response "9–10" for rate hospital and "always" or "yes" for other HCAHPS categories.") These are raw unadjusted scores.

[b]N varied between different survey items

[c]Adjusted odds ratio and *P* value derived from logistic regression model adjusting for age, self-reported health status, education, primary language spoken, service line, and time taken to respond to survey served as the covariates.

[d]These items were introduced in 2012 and have fewer responses

* $P < .05$; ** $P \leq .01$; *** $P \leq .001$; **** $P \leq .0001$

Abbreviation: HCAHPS, Healthcare Providers and Systems

TABLE 3. **Patient Experience Related to 30-Day Readmission: Comparison of HCAHPS Top-Box Scores for Readmitted Patients Responding to Survey Linked to Readmission with Patients Responding to Survey Linked with Index Admission and with Patients that Were Not Readmitted.**

	%Top Box[a]				%Top Box[a]			
Satisfaction Domains	**2nd-Admission Responders (n = 1,663)[b]**	**Postreadmission Responders (n = 3,961)[b]**	**Adjusted Odds Ratio[c]**	***P* Value[c]**	**2nd-Admission Responders (n = 1,663)[2]**	**Not Readmitted (n = 37,367)[2]**	**Adjusted Odds Ratio[c]**	***P* Value[c]**
Nursing Communication								
Nurses treated with courtesy/respect	81.9	82.9	0.94	.27	81.9	83.8	0.97	.40
Nurses listened	69.1	71.1	1.00	.16	69.1	72.5	0.98	.24
Nurses explained	71.4	70.7	0.98	.69	71.4	73.9	0.86	.29
Physician Communication	82.6	83.9	0.91	.11	82.6	87.5	0.87	.006
Doctors treated with courtesy/respect	72.5	73.0	0.98	.58	72.5	79.2	0.88	.0002
Doctors listened	69.6	69.5	0.92	.84	69.6	77.0	0.84	.02
Doctors explained								
Discharge Related	85.9	85.7	0.91	.71	85.9	81.5	1.34	.001
Staff talk about help when you leave	91.3	91.8	1.00	.96	91.3	91.9	0.99	.95
Info re: symptoms/prob to look for	51.0	53.5	0.99	.28	51.0	54.0	0.93	.91
Hospital staff took pref into account[d]	56.9	58.1	0.89	.35	56.9	61.6	0.96	.19
Good understanding manage health[d]	65.4	66.6	0.96	.80	65.4	69.6	0.77	.43
Understood purpose of taking meds[d]								
Hospital Environment								
Cleanliness of the hospital	60.0	60.5	0.93	.89	60.0	66.0	0.83	< .0001
Quietness of the hospital	48.4	48.8	0.85	.55	48.4	57.2	0.79	.0002
Call button help soon as wanted	46.7	50.0	0.87	.009	46.7	59.1	0.72	< .0001
Help toileting as soon as you wanted	48.9	53.1	0.96	.05	48.9	61.3	0.86	< .0001
Pain well controlled	52.5	55.1	0.74	.83	52.5	62.4	0.67	.001
Staff do everything to help with pain	69.7	73.7	0.93	.02	69.7	77.2	0.86	.003
Staff describe medicine side effect	41.4	43.5	0.99	.84	41.4	46.7	0.88	.07
Tell you what new medicine was for	70.5	73.9	0.72	.02	70.5	76.3	0.77	< .0001
Overall								
Rate hospital (0–10)	72.3	73.1	0.97	.30	72.3	76.1	0.86	.01
Recommend hospital	78.9	80.2	0.96	.54	78.9	82.1	0.87	.27

2nd-readmission responder = survey linked to readmission. Postreadmission responder = survey linked to index admission returned after readmission.
[a]% Top Box is the percentage of patients with top category responses (response "9–10" for rate hospital and "always" or "yes" or "definitely yes" for other categories).
[b]N varied between different survey items.
[c]*P* value derived from logistic regression model adjusting for age, self-reported health status, education, primary language spoken, service line, and time taken to respond to survey served as the covariates.
[d]These items were introduced in 2012 and have fewer responses.
Abbreviation: HCAHPS, Hospital Consumer Assessment of Healthcare Providers and Systems.

Overall, postreadmission responders are dissatisfied with multiple domains of hospital care. Many of these survey responses may simply be related to general frustration. Alternatively, they may represent a patient population with a high degree of needs that are not as easily met by a hospital's routine processes of care. Even though the readmission rates were 10.6% among survey responders, 14.6% of the survey responses were associated with readmissions after accounting for those who respond to surveys linked to readmission. These patients could have significant impact on cumulative experience scores.

Our study has a few limitations. First, it involves a single tertiary care academic center study, and our results may not be generalizable. Second, we did not adjust for some of the patient characteristics associated with readmissions. Patients who were admitted within 30 days are different than those not readmitted based on payor, race, length of stay, and severity of illness, and we did not adjust for these factors in our analysis. This was intentional, however. Our goal was to better understand the relationship between 30-day readmission and patient experience scores as they are used for hospital-level studies, VBP, and public reporting. For these purposes, the scores are not adjusted for factors, such as payor and length of stay. We did adjust for patient-mix adjustment factors used by CMS. Third, the response rates to the HCAHPS were low and may have biased the scores. However, HCAHPS is widely used for comparisons between hospitals has been validated, and our study results have implications with regard to comparing hospital-level performance. HCAHPS results are relevant to policy and have financial consequences.[17] Fourth,

our study did not directly compare whether the relationship between patient experience for the postreadmission group and nonreadmitted group was different from the relationship between the prereadmission group and postreadmission group. It is possible that there is no difference in relationship between the groups. However, despite the small number of prereadmission responders, these patients tended to have more favorable experience responses than those who responded after being readmitted, even after adjusting for response time. Although the *P* values are nonsignificant for many comparisons, the directionality of the effect is relatively consistent. Also, the vast majority of the patients fall in the postreadmission group, and these patients appear to drive the overall experience related to readmissions. Finally, since relatively few patients turned in surveys prior to readmission, we had limited power to detect a significant difference between these prereadmission responders and nonreadmitted patients.

Our study has implications for policy makers, researchers, and providers. The HCAHPS scores of patients who are readmitted and completed the survey after being readmitted reflects their experience of both the index admission and the readmission. We did not find evidence to support that HCAHPS survey responses predict future readmissions at the patient level. Our findings do support the concept that lower readmissions rates (whether due to the patient population or processes of care that decrease readmission rates) may improve HCAHPS scores. We suggest caution in assuming that improving patient experience is likely to reduce readmission rates.

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Appraising the Evidence Supporting *Choosing Wisely®* Recommendations

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Despite the growing enthusiasm surrounding the *Choosing Wisely®* campaign, little is known regarding the evidence underlying these recommendations. We extracted references for all 320 recommendations published through August, 2014, including the 10 adult and pediatric recommendations published by the Society for Hospital Medicine. We then categorized each item by evidence strength, and then assessed a sample of referenced clinical practice guidelines (CPGs) using the validated Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument. Among all recommendations, 70.3% cited CPGs, whereas 22.2% cited primary research as their highest level of evidence. Moreover, 7.8% cited case series, review articles, editorials, or lower quality data as their highest level of evidence. Hospital medicine recommendations were more likely to cite CPGs (90%) as their highest level of evidence. Among the sampled CPGs, the median overall score obtained using AGREE II was 54.2% (interquartile range [IQR] 33.3%-70.8%), whereas among hospital medicine-referenced CPGs, the median overall score was 58.3% (IQR 50.0%-83.3%). These findings suggest that *Choosing Wisely®* recommendations vary in terms of evidence strength. *Journal of Hospital Medicine* 2018;13:688-691. Published online first April 25, 2018. © 2018 Society of Hospital Medicine

As healthcare costs rise, physicians and other stakeholders are now seeking innovative and effective ways to reduce the provision of low-value services.[1,2] The *Choosing Wisely®* campaign aims to further this goal by promoting lists of specific procedures, tests, and treatments that providers should avoid in selected clinical settings.[3] On February 21, 2013, the Society of Hospital Medicine (SHM) released two *Choosing Wisely®* lists consisting of adult and pediatric services that are seen as costly to consumers and to the healthcare system, but which are often nonbeneficial or even harmful.[4,5] A total of 80 physician and nurse specialty societies have joined in submitting additional lists.

Despite the growing enthusiasm for this effort, questions remain regarding the *Choosing Wisely®* campaign's ability to initiate the meaningful de-adoption of low-value services. Specifically, prior efforts to reduce the use of services deemed to be of questionable benefit have met several challenges.[2,6] Early analyses of the *Choosing Wisely®* recommendations reveal similar roadblocks and variable uptakes of several recommendations.[7-10] While the reasons for difficulties in achieving de-adoption are broad, one important factor in whether clinicians are willing to follow guideline recommendations from such initiatives as *Choosing Wisely®* is the extent to which they believe in the underlying evidence.[11] The current work seeks to formally evaluate the evidence supporting the *Choosing Wisely®* recommendations, and to compare the quality of evidence supporting SHM lists to other published Choosing Wisely® lists.

METHODS

Data Sources

Using the online listing of published *Choosing Wisely®* recommendations, a dataset was generated incorporating all 320 recommendations comprising the 58 lists published through August, 2014; these include both the adult and pediatric hospital medicine lists released by the SHM.[4,5,12] Although data collection ended at this point, this represents a majority of all 81 lists and 535 recommendations published through December, 2017. The reviewers (A.J.A., A.G., M.W., T.S.V., M.S., and C.R.C) extracted information about the references cited for each recommendation.

Data Analysis

The reviewers obtained each reference cited by a *Choosing Wisely®* recommendation and categorized it by evidence strength along the following hierarchy: clinical practice guideline (CPG), primary research, review article, expert opinion, book, or others/unknown. CPGs were used as the highest level of evidence based on standard expectations for methodological rigor.[13] Primary research was further rated as follows:

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TABLE 1. **Highest Quality of Evidence per Recommendation**

Reference Category	All Recommendations (n, %)	Hospital Medicine Recommendations (n, %)
Clinical Practice Guideline	225 (70.3%)	9 (90%)
Primary Research Article	71 (22.2%)	1 (10%)
Systematic review and meta-analysis	29 (9.1%)	–
Randomized controlled trial	13 (4.1%)	–
Observational study	28 (8.8%)	1 (10%)
Case series	1 (0.3%)	–
Review Article	7 (2.2%)	–
Editorial/Opinion	7 (2.2%)	–
Others	10 (3.1%)	–

systematic reviews and meta-analyses, randomized controlled trials (RCTs), observational studies, and case series. Each recommendation was graded using only the strongest piece of evidence cited.

Guideline Appraisal

We further sought to evaluate the strength of referenced CPGs. To accomplish this, a 10% random sample of the *Choosing Wisely®* recommendations citing CPGs was selected, and the referenced CPGs were obtained. Separately, CPGs referenced by the SHM-published adult and pediatric lists were also obtained. For both groups, one CPG was randomly selected when a recommendation cited more than one CPG. These guidelines were assessed using the Appraisal of Guidelines for Research and Evaluation (AGREE) II instrument, a widely used instrument designed to assess CPG quality.[14,15] AGREE II consists of 25 questions categorized into six domains: scope and purpose, stakeholder involvement, rigor of development, clarity of presentation, applicability, and editorial independence. Guidelines are also assigned an overall score. Two trained reviewers (A.J.A. and A.G.) assessed each of the sampled CPGs using a standardized form. Scores were then standardized using the method recommended by the instrument and reported as a percentage of available points. Although a standard interpretation of scores is not provided by the instrument, prior applications deemed scores below 50% as deficient.[16,17] When a recommendation item cited multiple CPGs, one was randomly selected. We also abstracted data on the year of publication, the evidence grade assigned to specific items recommended by *Choosing Wisely®*, and whether the CPG addressed the referring recommendation. All data management and analysis were conducted using Stata (V14.2, StataCorp, College Station, Texas).

RESULTS

A total of 320 recommendations were considered in our analysis, including 10 published across the two hospital medicine lists. When limited to the highest quality citation for each of the recommendations, 225 (70.3%) cited CPGs, whereas 71 (22.2%) cited primary research articles (Table 1). Specifically, 29 (9.1%) cited systematic reviews and meta-analyses, 28 (8.8%) cited observational studies, and 13 (4.1%) cited RCTs. One recommendation (0.3%) cited a case series as its highest level of evidence, seven (2.2%) cited review articles, seven (2.2%) cited editorials or opinion pieces, and 10 (3.1%) cited other types of documents, such as websites or books. Among hospital medicine recommendations, nine (90%) referenced CPGs and one (10%) cited an observational study.

For the AGREE II assessment, we included 23 CPGs from the 225 referenced across all recommendations, after which we separately selected six CPGs from the hospital medicine recommendations. There was no overlap. Notably, four hospital medicine recommendations referenced a common CPG. Among the random sample of referenced CPGs, the median overall score obtained by using AGREE II was 54.2% (interquartile range [IQR] 33.3%-70.8%, Table 2). This was similar to the median overall among hospital medicine guidelines (58.2%, IQR 50.0%-83.3%). Both hospital medicine and other sampled guidelines tended to score poorly in stakeholder involvement (48.6%, IQR 44.1%-61.1% and 47.2%, IQR 38.9%-61.1%, respectively). There were no significant differences between hospital medicine-referenced CPGs and the larger sample of CPGs in any AGREE II subdomains. The median age from the CPG publication to the list publication was seven years (IQR 4-7) for hospital medicine recommendations and three years (IQR 2-6) for the nonhospital medicine recommendations. Substantial agreement was found between raters on the overall guideline assessment (ICC 0.80, 95% CI 0.58-0.91; Supplementary Table 1).

In terms of recommendation strengths and evidence grades, several recommendations were backed by Grades II-III (on a scale of I-III) evidence and level C (on a scale of A-C) recommendations in the reviewed CPG (Society of Maternal-Fetal Medicine, Recommendation 4, and Heart Rhythm Society, Recommendation 1). In one other case, the cited CPG did not directly address the *Choosing Wisely®* item (Society of Vascular Medicine, Recommendation 2).

TABLE 2. **AGREE II Assessment by Domain for Random Sample of Referenced Clinical Practice Guidelines (CPGs)**

Domain	Sample of All CPGs (Median Scaled Score %, IQR) (n = 6)	Hospital Medicine CPGs (Median Scaled Score %, IQR) (n = 24)
1. Scope and Purpose	75.0 (72.2-83.3)	84.7 (75.0-91.7)
2. Stakeholder Involvement	47.2 (38.9-61.1)	48.6 (44.4-61.1)
3. Rigor of Development	54.2 (34.4-74.0)	66.1 (59.4-74.0)
4. Clarity of Presentation	80.6 (75.0-86.1)	80.6 (80.6-83.3)
5. Applicability	50.0 (37.5-64.6)	52.1 (47.9-62.5)
6. Editorial Independence	50.0 (37.5-64.6)	60.4 (25.0-70.8)
Overall Guideline Assessment	54.2 (33.3-70.8)	58.3 (50.0-83.3)

Abbreviations: CPGs, clinical practice guidelines; IQR, interquartile range.

DISCUSSION

Given the rising costs and the potential for iatrogenic harm, curbing ineffective practices has become an urgent concern. To achieve this, the *Choosing Wisely®* campaign has taken an important step by targeting certain low-value practices for de-adoption. However, the evidence supporting recommendations is variable. Specifically, 25 recommendations cited case series, review articles, or lower quality evidence as their highest level of support; moreover, among recommendations citing CPGs, quality, timeliness, and support for the recommendation item were variable. Although the hospital medicine lists tended to cite higher-quality evidence in the form of CPGs, these CPGs were often less recent than the guidelines referenced by other lists.

Our findings parallel those of other works that evaluate evidence among *Choosing Wisely®* recommendations and, more broadly, among CPGs.[18–21] Lin and Yancey evaluated the quality of primary care-focused *Choosing Wisely®* recommendations using the Strength of Recommendation Taxonomy, a ranking system that evaluates evidence quality, consistency, and patient-centeredness.[18] In their analysis, the authors found that many recommendations were based on lower quality evidence or relied on nonpatent-centered intermediate outcomes. Several groups, meanwhile, have evaluated the quality of evidence supporting CPG recommendations, finding them to be highly variable as well.[19–21] These findings likely reflect inherent difficulties in the process, by which guideline development groups distill a broad evidence base into useful clinical recommendations, a reality that may have influenced the *Choosing Wisely®* list development groups seeking to make similar recommendations on low-value services.

These data should be taken in context due to several limitations. First, our sample of referenced CPGs includes only a small sample of all CPGs cited; thus, it may not be representative of all referenced guidelines. Second, the AGREE II assessment is inherently subjective, despite the availability of training materials. Third, data collection ended in April, 2014. Although this represents a majority of published lists to date, it is possible that more recent *Choosing Wisely®* lists include a stronger focus on evidence quality. Finally, references cited by *Choosing Wisely®* may not be representative of the entirety of the dataset that was considered when formulating the recommendations.

Despite these limitations, our findings suggest that *Choosing Wisely®* recommendations vary in terms of evidence strength. Although our results reveal that the majority of recommendations cite guidelines or high-quality original research, evidence gaps remain, with a small number citing low-quality evidence or low-quality CPGs as their highest form of support. Given the barriers to the successful de-implementation of low-value services, such campaigns as *Choosing Wisely®* face an uphill battle in their attempt to prompt behavior changes among providers and consumers.[6-9] As a result, it is incumbent on funding agencies and medical journals to promote studies evaluating the harms and overall value of the care we deliver.

CONCLUSIONS

Although a majority of *Choosing Wisely®* recommendations cite high-quality evidence, some reference low-quality evidence or low-quality CPGs as their highest form of support. To overcome clinical inertia and other barriers to the successful de-implementation of low-value services, a clear rationale for the impetus to eradicate entrenched practices is critical.[2,22] *Choosing Wisely®* has provided visionary leadership and a powerful platform to question low-value care. To expand the campaign's efforts, the medical field must be able to generate the high-quality evidence necessary to support these efforts; further, list development groups must consider the availability of strong evidence when targeting services for de-implementation.

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The Influence of Hospitalist Continuity on the Likelihood of Patient Discharge in General Medicine Patients

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Hospitalists responsible for specific inpatients may change during their hospitalization. To measure the association of hospitalist continuity with the adjusted daily discharge probability, 6,405 admissions (38,967 patient-days, 5,208 patients) to a general medicine service at a tertiary care teaching hospital in 2015 were investigated. Continuity was measured as the consecutive number of days – including weekends – a hospitalist treated a particular team of patients. After accounting for important covariables, discharge probability increased significantly with hospitalist continuity; the adjusted daily discharge probabilities for an average patient with a new physician vs. one on service for four continuous weeks were 18.1% and 25.7%, respectively ($P < .001$). Hospitalist continuity did not influence hospital mortality. Increasing hospitalist continuity could decrease hospital length of stay. *Journal of Hospital Medicine* 2018;13:692-694. Published online first March 26, 2018. © 2018 Society of Hospital Medicine

In addition to treating patients, physicians frequently have other time commitments that could include administrative, teaching, research, and family duties. Inpatient medicine is particularly unforgiving to these nonclinical duties since patients have to be assessed on a daily basis. Because of this characteristic, it is not uncommon for inpatient care responsibility to be switched between physicians to create time for nonclinical duties and personal health.

In contrast to the ambulatory setting, the influence of physician continuity of care on inpatient outcomes has not been studied frequently. Studies of inpatient continuity have primarily focused on patient discharge (likely because of its objective nature) over the weekends (likely because weekend cross-coverage is common) and have reported conflicting results.[1-3] However, discontinuity of care is not isolated to the weekend since hospitalist-switches can occur at any time. In addition, expressing hospitalist continuity of care as a dichotomous variable (Was there weekend cross-coverage?) could incompletely express continuity since discharge likelihood might change with the consecutive number of days that a hospitalist is on service. This study measured the influence of hospitalist continuity throughout the patient's hospitalization (rather than just the weekend) on daily patient discharge.

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METHODS

Study Setting and Databases Used for Analysis

The study was conducted at The Ottawa Hospital, Ontario, Canada, a 1,000-bed teaching hospital with two campuses and the primary referral center in our region. The division of general internal medicine has six patient services (or "teams") at two campuses led by a staff hospitalist (exclusively general internists), a senior medical resident (2nd year of training), and various numbers of interns and medical students. Staff hospitalists do not treat more than one patient service even on the weekends.

Patients are admitted to each service on a daily basis and almost exclusively from the emergency room. Assignment of patients is essentially random since all services have the same clinical expertise. At a particular campus, the number of patients assigned daily to each service is usually equivalent between teams. Patients almost never switch between teams but may be transferred to another specialty. The study was approved by our local research ethics board.

The Patient Registry Database records for each patient the date and time of admissions (defined as the moment that a patient's admission request is entered into the database), death or discharge from hospital (defined as the time when the patient's discharge from hospital was entered into the database), or transfer to another specialty. It also records emergency visits, patient demographics, and location during admission. The Laboratory Database records all laboratory tests and their results.

Study Cohort

The Patient Registry Database was used to identify all individuals who were admitted to the general medicine services between January 1, 2015 and December 31, 2015. This time

TABLE. **Observed and Expected Number of Discharges by Physician Continuity**

Consecutive Days Hospitalist-Treated Patients	Patient Days	Number of Discharges		Observed/Expected (95% CI)
		Observed	Expected	
All	38,967	5,833	5,718.6	1.02 (0.99, 1.05)
1	6,686	802	829.3	0.97 (0.90, 1.03)
2-3	11,226	1,513	1,526.7	0.99 (0.94, 1.04)
4-6	9,952	1,679	1,600.4	1.05 (1.00, 1.10)
7+	11,103	1,839	1,762.2	1.04 (1.00, 1.09)

This table shows the observed and expected number of discharges from general internal medicine services by hospitalist continuity. The expected number of discharges on each day was determined using the TEND[4] model. The ratio of observed to expected number of discharges is presented in the final column with 95% confidence intervals. Ratios below one indicate that fewer people were discharged than expected, whereas ratios above one indicate that more people were discharged than expected.

Abbreviation: LAPS, Laboratory Abnormality Physiological Score.[5]

frame was selected to ensure that data were complete and current. General medicine services were analyzed because they are collectively the largest inpatient specialty in the hospital.

Study Outcome

The primary outcome was discharge from hospital as determined from the Patient Registry Database. Patients who died or were transferred to another service were not counted as outcomes.

Covariables

The primary exposure variable was the consecutive number of days (including weekends) that a particular hospitalist rounded on patients on a particular general medicine service. This was measured using call schedules. Other covariates included tomorrow's expected number of discharges (TEND) daily discharge probability and its components. The TEND model[4] used patient factors (age, Laboratory Abnormality Physiological Score [LAPS][5] calculated at admission) and hospitalization factors (hospital campus and service, admission urgency, day of the week, ICU status) to predict the daily discharge probability. In a validation population, these daily discharge probabilities (when summed over a particular day) strongly predicted the daily number of discharges (adjusted R2 of 89.2% [$P < .001$], median relative difference between observed and expected number of discharges of only 1.4% interquartile range [IQR]: −5.5% to 7.1%). The expected annual death risk was determined using the HOMR-now! model.[6] This model used routinely collected data available at patient admission regarding the patient (sex, life-table-estimated one-year death risk, Charlson score, current living location, previous cancer clinic status, and number of emergency department visits in the previous year) and the hospitalization (urgency, service, and LAPS score). The model explained more than half of the total variability in death likelihood (Nagelkirke's R2 value of 0.53), seven was highly discriminative (C-statistic 0.92), and accurately predicted death risk (calibration slope 0.98).

Analysis

Logistic generalized estimating equation (GEE) methods were used to model the adjusted daily discharge probability.[8] Data in the analytical dataset were expressed in a patient-day format (each dataset row represented one day for a particular patient). This permitted the inclusion of time-dependent covariates and allowed the GEE model to cluster hospitalization days within patients.

Model construction started with the TEND daily discharge probability and the HOMR-now! expected annual death risk (both expressed as log-odds). Then, hospitalist continuity was entered as a time-dependent covariate (ie, its value changed every day). Linear, square root, and natural logarithm forms of physician continuity were examined to determine the best fit (determined using the QIC statistic[9]). Finally, individual components of the TEND model were also offered to the model with those which significantly improved fit kept in the model. The GEE model used an independent correlation structure since this minimized the QIC statistic in the base model. All covariates in the final daily discharge probability model were used in the hospital death model. Analyses were conducted using SAS 9.4 (Cary, North Carolina).

RESULTS

There were 6,405 general medicine admissions involving 5,208 patients and 38,967 patient-days between January 1, 2015 and December 31, 2015 (Appendix A). Patients were elderly and were evenly divided in terms of gender, with 85% of them being admitted from the community. Comorbidities were common (median coded Charlson score was 2), with 6.0% of patients known to our cancer clinic. The median length of stay was four days (IQR, 2-7), with 378 admissions (5.9%) ending in death and 121 admissions (1.9%) ending in a transfer to another service.

There were 41 different staff people having at least one day on service. The median total service by physicians was nine weeks (IQR 1.8-10.9 weeks). Changes in hospitalist coverage were common; hospitalizations had a median of 1 (IQR 1-2)

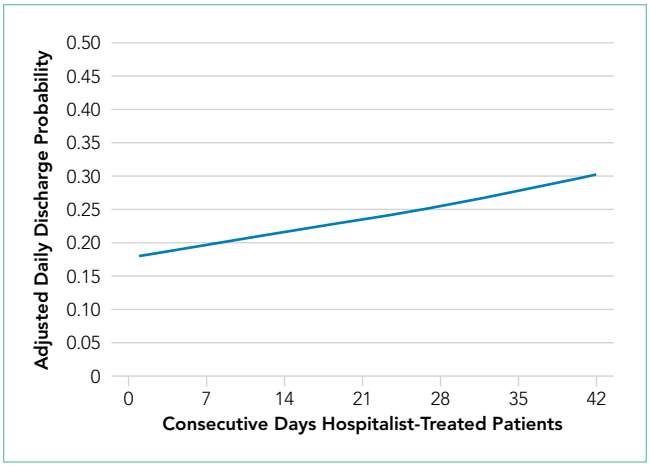

FIG. Independent association of hospitalist continuity and adjusted daily discharge probability. This graph plots the adjusted daily discharge probability (vertical axis) against hospitalist continuity (expressed as the consecutive number of days hospitalist treated patients, horizontal axis). This association is adjusted for all other covariates in the final model (Appendix C). The adjusted daily discharge probabilities presented here are those for a patient-day with reference values for all covariates (patient admitted emergently during the week but not on the first hospitalization day, with a TEND model[4] daily discharge probability of 10.9%, a LAPS of 45, and an expected probability of death in 1-year of 31.2%).

Abbreviations: CI, confidence interval; LAPS, Laboratory Abnormality Physiological Score.[5]

physician switches and a median of one (IQR 1-2) different physicians. However, patients spent a median of 100% (IQR 66.7%-100%] of their total hospitalization with their primary hospitalist. The median duration of individual physician "stints" on service was five days (IQR 2-7, range 1-42).

The TEND model accurately estimated daily discharge probability for the entire cohort with 5,833 and 5,718.6 observed and expected discharges, respectively, during 38,967 patient-days (O/E 1.02, 95% CI 0.99-1.05). Discharge probability increased as hospitalist continuity increased, but this was statistically significant only when hospitalist continuity exceeded four days. Other covariables also significantly influenced discharge probability (Appendix B).

After adjusting for important covariables (Appendix C), hospitalist continuity was significantly associated with daily discharge probability (Figure 1). Discharge probability increased linearly with increasing consecutive days that hospitalists treated patients. For each additional consecutive day with the same hospitalist, the adjusted daily odds increased by 2% (adjusted odds ratio [OR] 1.02, 95% CI 1.01-1.02, Appendix C). When the consecutive number of days that hospitalists remained on service increased from 1 to 28 days, the adjusted discharge probability for the average patient increased from 18.1% to 25.7%, respectively. Discharge was significantly influenced by other factors (Appendix C). Continuity did not influence the risk of death in hospital (Appendix D).

DISCUSSION

In a general medicine service at a large teaching hospital, this study found that greater hospitalist continuity was associated with a significantly increased adjusted daily discharge probability, increasing (in the average patient) from 18.1% to 25.7% when the consecutive number of hospitalist days on service increased from 1 to 28 days, respectively.

The study demonstrated some interesting findings. First, it shows that shifting patient care between physicians can significantly influence patient outcomes. This could be a function of incomplete transfer of knowledge between physicians, a phenomenon that should be expected given the extensive amount of information – both explicit and implicit–that physicians collect about particular patients during their hospitalization. Second, continuity of care could increase a physician's and a patient's confidence in clinical decision-making. Perhaps physicians are subconsciously more trusting of their instincts (and the decisions based on those instincts) when they have been on service for a while. It is also possible that patients more readily trust recommendations of a physician they have had throughout their stay. Finally, people wishing to decrease patient length of stay might consider minimizing the extent that hospitalists sign over patient care to colleagues.

Several issues should be noted when interpreting the results of the study. First, the study examined only patient discharge and death. These are by no means the only or the most important outcomes that might be influenced by hospitalist continuity. Second, this study was limited to a single service at a single center. Third, the analysis did not account for house-staff continuity. Since hospitalist and house-staff at the study hospital invariably switched at different times, it is unlikely that hospitalist continuity was a surrogate for house-staff continuity.

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Patient Perceptions of Readmission Risk: An Exploratory Survey

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Interventions to prevent readmissions often rely upon patient participation to be successful. We surveyed 895 general medicine patients slated for hospital discharge to (1) assess patient attitudes surrounding readmission, (2) ascertain whether these attitudes were associated with actual readmission, and (3) determine whether patients can estimate their own readmission risk. Actual readmissions and other clinical variables were captured from administrative data and linked to individual survey responses. We found that actual readmissions were not correlated with patients' interest in preventing readmission, sense of control over readmission, or intent to follow discharge instructions. However, patients were able to predict their own readmissions ($P = .005$) even after adjusting for predicted readmission rate, race, sex, age, and payer. Reassuringly, over 80% of respondents reported that they would be frustrated or disappointed to be readmitted and almost 90% indicated that they planned to follow all of their discharge instructions. Whether assessing patient-perceived readmission risk might help to target preventive interventions warrants further study. *Journal of Hospital Medicine* 2018;13:695-697. Published online first March 26, 2018. © 2018 Society of Hospital Medicine

Recent years have seen a proliferation of programs designed to prevent readmissions, including patient education initiatives, financial assistance programs, postdischarge services, and clinical personnel assigned to help patients navigate their posthospitalization clinical care. Although some strategies do not require direct patient participation (such as timely and effective handoffs between inpatient and outpatient care teams), many rely upon a commitment by the patient to participate in the postdischarge care plan. At our hospital, we have found that only about two-thirds of patients who are offered transitional interventions (such as postdischarge phone calls by nurses or home nursing through a "transition guide" program) receive the intended interventions, and those who do not receive them are more likely to be readmitted.[1] While limited patient uptake may relate, in part, to factors that are difficult to overcome, such as inadequate housing or phone service, we have also encountered patients whose values, beliefs, or preferences about their care do not align with those of the care team. The purposes of this exploratory study were to (1) assess patient attitudes surrounding readmission, (2) ascertain whether these attitudes are associated with actual readmission, and (3) determine whether patients can estimate their own risk of readmission.

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METHODS

From January 2014 to September 2016, we circulated surveys to patients on internal medicine nursing units who were being discharged home within 24 hours. Blank surveys were distributed to nursing units by the researchers. Unit clerks and support staff were educated on the purpose of the project and asked to distribute surveys to patients who were identified by unit case managers or nurses as slated for discharge. Staff members were not asked to help with or supervise survey completion. Surveys were generally filled out by patients, but we allowed family members to assist patients if needed, and to indicate so with a checkbox. There were no exclusion criteria. Because surveys were distributed by clinical staff, the received surveys can be considered a convenience sample. Patients were asked 5 questions with 4- or 5-point Likert scale responses:

(1) "How likely is it that you will be admitted to the hospital (have to stay in the hospital overnight) again within the next 30 days after you leave the hospital this time?" [answers ranging from "Very Unlikely (<5% chance)" to "Very Likely (>50% chance)"];

(2) "How would you feel about being rehospitalized in the next month?" [answers ranging from "Very sad, frustrated, or disappointed" to "Very happy or relieved"];

(3) "How much do you think that you personally can control whether or not you will be rehospitalized (based on what you do to take care of your body, take your medicines, and follow-up with your healthcare team)?" [answers ranging from "I have no control over whether I will be rehospitalized" to "I have complete control over whether I will be rehospitalized"];

(4) "Which of the options below best describes how you plan to follow the medical instructions after you leave the

TABLE. **Patient Survey Responses and Readmission Outcomes**

Survey Question (N respondents)	Likert Scale Choices[a]	N (%) Responses	N (%) Readmitted	Unadjusted *P* for Trend[b]
"*How likely* is it that you will be *admitted* to the hospital (have to stay in the hospital overnight) again within the next 30 days after you leave the hospital this time?" (n = 895)	1) Very unlikely (<5% chance)	352 (39.3%)	46 (13.1%)	*P* = .002
	2) Unlikely	229 (25.6%)	28 (12.2%)	
	3) Somewhat likely	156 (17.4%)	27 (17.3%)	
	4) Likely	73 (8.2%)	15 (20.6%)	
	5) Very likely (>50% chance)	85 (9.5%)	22 (25.9%)	
"How would you *feel* about being rehospitalized in the next month?" (n = 830)	1) Very sad, frustrated, disappointed	433 (52.2%)	68 (15.7%)	*P* = .43
	2) A little sad, frustrated, disappointed	265 (31.9%)	42 (15.9%)	
	3) Don't care	64 (7.7%)	6 (9.4%)	
	4) Happy or relieved	45 (5.4%)	11 (8.0%)	
	5) Very happy or relieved	23 (2.8%)	5 (21.7%)	
"How much do you think that you personally can control whether or not you will be rehospitalized (based on what you do to take care of your body, take your medicines, and follow-up with your healthcare team)?" (n = 840)	1) Complete control	111 (13.2%)	16 (14.4%)	*P* = .32
	2) A lot of control	213 (25.4%)	27 (11.7%)	
	3) Some control	240 (28.6%)	36 (15.0%)	
	4) Very little control	118 (14.0%)	18 (15.3%)	
	5) No control	158 (18.8%)	18 (15.3%)	
"Pick the item that best describes YOUR OWN VIEW of the care team's recommendations:" (n = 861)	1) Fully agree	697 (81.0%)	101 (14.5%)	*P* = .62
	2) Mostly agree	128 (14.9%)	24 (18.8%)	
	3) Somewhat agree	28 (3.3%)	2 (7.1%)	
	4) Do not agree at all	8 (0.9%)	2 (25.0%)	
"Which of the options best describes how you plan to follow the medical instructions after you leave the hospital?" (n = 863)	1) Plan to do EVERYTHING asked	770 (89.2%)	116 (15.1%)	*P* = .52
	2) Plan to do ALMOST EVERYTHING	76 (8.8%)	12 (15.8%)	
	3) Plan to do SOME things asked	15 (1.9%)	1 (3.7%)	
	4) Do NOT plan to do much of asked	2 (0.2%)	0 (0%)	

[a]Likert responses are paraphrased for brevity. See text for complete wording.
[b]Ordered patient responses were modeled continuously (1-4 or 1-5).

hospital?" [answers ranging from "I do NOT plan to do very much of what I am being asked to do by the doctors, nurses, therapists, and other members of the care team" to "I plan to do EVERYTHING I am being asked to do by the doctors, nurses, therapists and other members of the care team"]; and

(5) "Pick the item below that best describes YOUR OWN VIEW of the care team's recommendations:" [answers ranging from "I DO NOT AGREE AT ALL that the best way to be healthy is to do exactly what I am being asked to do by the doctors, nurses, therapists, and other members of the care team" to "I FULLY AGREE that the best way to be healthy is to do exactly what I am being asked to do by the doctors, nurses, therapists, and other members of the care team"].

Responses were linked, based on discharge date and medical record number, to administrative data, including age, sex, race, payer, and clinical data. Subsequent hospitalizations to our hospital were ascertained from administrative data. We estimated expected risk of readmission using the all payer refined diagnosis related group coupled with the associated severity-of-illness (SOI) score, as we have reported previously.[2-5] We restricted our analysis to patients who answered the question related to the likelihood of readmission. Logistic regression models were constructed using actual 30-day readmission as the dependent variable to determine whether patients could predict their own readmissions and whether patient attitudes and beliefs about their care were predictive of subsequent readmission. Patient survey responses were entered as continuous independent variables (ranging from 1-4 or 1-5, as appropriate). Multivariable logistic regression was used to determine whether patients could predict their readmissions independent of demographic variables and expected readmission rate (modeled continuously); we repeated this model after dichotomizing the patient's estimate of the likelihood of readmission as either "unlikely" or "likely." Patients with missing survey responses were excluded from individual models without imputation. The study was approved by the Johns Hopkins institutional review board.

RESULTS

Responses were obtained from 895 patients. Their median age was 56 years [interquartile range, 43-67], 51.4% were female, and 41.7% were white. Mean SOI was 2.53 (on a 1-4 scale), and median length-of-stay was representative for our medical service at 5.2 days (range, 1-66 days). Family members reported filling out the survey in 57 cases. The primary payer was Medicare in 40.7%, Medicaid in 24.9%, and other in 34.4%. A total of 138 patients (15.4%) were readmitted within 30 days. The Table shows survey responses and associated readmission rates. None of the attitudes related to readmission were predictive of actual readmission. However, patients were able to predict their own readmissions (*P* = .002 for linear trend). After adjustment for expected readmission rate, race, sex, age, and

payer, the trend remained significant (P = .005). Other significant predictors of readmissions in this model included expected readmission rate (P = .002), age (P = .02), and payer (P = .002). After dichotomizing the patient estimate of readmission rate as "unlikely" (n = 581) or "likely" (n = 314), the unadjusted odds ratio associating a patient-estimated risk of readmission as "likely" with actual readmission was 1.8 (95% confidence interval, 1.2-2.5). The adjusted odds ratio (including the variables above) was 1.6 (1.1-2.4).

DISCUSSION

Our findings demonstrate that patients are able to quantify their own readmission risk. This was true even after adjustment for expected readmission rate, age, sex, race, and payer. However, we did not identify any patient attitudes, beliefs, or preferences related to readmission or discharge instructions that were associated with subsequent rehospitalization. Reassuringly, more than 80% of patients who responded to the survey indicated that they would be sad, frustrated, or disappointed should readmission occur. This suggests that most patients are invested in preventing rehospitalization. Also reassuring was that patients indicated that they agreed with the discharge care plan and intended to follow their discharge instructions.

The major limitation of this study is that it was a convenience sample. Surveys were distributed inconsistently by nursing unit staff, preventing us from calculating a response rate. Further, it is possible, if not likely, that those patients with higher levels of engagement were more likely to take the time to respond, enriching our sample with activated patients. Although we allowed family members to fill out surveys on behalf of patients, this was done in fewer than 10% of instances; as such, our data may have limited applicability to patients who are physically or cognitively unable to participate in the discharge process. Finally, in this study, we did not capture readmissions to other facilities.

We conclude that patients are able to predict their own readmissions, even after accounting for other potential predictors of readmission. However, we found no evidence to support the possibility that low levels of engagement, limited trust in the healthcare team, or nonchalance about being readmitted are associated with subsequent rehospitalization. Whether asking patients about their perceived risk of readmission might help target readmission prevention programs deserves further study.

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The Association of Inpatient Occupancy with Hospital-Acquired *Clostridium difficile* Infection.

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Few studies have evaluated the relationship between high hospital occupancy and hospital-acquired complications. We evaluated the association between inpatient occupancy and hospital-acquired *Clostridium difficile* infection (CDI) using a novel measure of hospital occupancy. We analyzed administrative data from California hospitals from 2008–2012 for Medicare recipients aged ≥65 years with a discharge diagnosis of acute myocardial infarction, heart failure, or pneumonia. Using daily census data, we constructed patient-level measures of occupancy on admission day and average occupancy during hospitalization (range: 0-1), which were split into four groups. We used logistic regression with cluster standard errors to estimate the adjusted and unadjusted relationship of occupancy with hospital-acquired CDI. Across 327 hospitals, 558,344 discharges met our inclusion criteria. Higher admission day occupancy was associated with significantly lower adjusted likelihood of CDI. Compared to the 0-0.25 occupancy group, patients admitted on a day of 0.51-0.75 occupancy had 0.86 odds of CDI (95% CI 0.75-0.98). The 0.76-1.00 admission occupancy group had 0.87 odds of CDI (95% CI 0.75-1.01). With regard to average occupancy, intermediate levels of occupancy 0.26-0.50 (odds ratio [OR] = 3.04, 95% CI 2.33-3.96) and 0.51-0.75 (OR = 3.28, 95% CI 2.51-4.28) had over three-fold increased adjusted odds of CDI relative to the low occupancy group; the high occupancy group did not have significantly different odds of CDI compared to the low occupancy group (OR = 0.96, 95% CI 0.70-1.31). These findings should prompt exploration of how hospitals react to occupancy changes and how those care processes translate into hospital-acquired complications in order to inform best practices. *Journal of Hospital Medicine* 2018;13:698-701. Published online first June 27, 2018. © 2018 Society of Hospital Medicine

High hospital occupancy is a fundamental challenge faced by healthcare systems in the United States.[1-3] However, few studies have examined the effect of high occupancy on outcomes in the inpatient setting,[4-9] and these showed mixed results. Hospital-acquired conditions (HACs), such as *Clostridium difficile* infection (CDI), are quality indicators for inpatient care and part of the Centers for Medicare and Medicaid Services' Hospital-Acquired Conditions Reductions Program.[10-12] However, few studies – largely conducted outside of the US – have evaluated the association between inpatient occupancy and HACs. These studies showed increasing hospital-acquired infection rates with increasing occupancy.[13-15] Past studies of hospital occupancy have relied on annual average licensed bed counts, which are not a reliable measure of available and staffed beds and do not account for variations in patient volume and bed supply.[16] Using a novel measure of inpatient occupancy, we tested the hypothesis that increasing inpatient occupancy is associated with a greater likelihood of CDI.

METHODS

We performed a retrospective analysis of administrative data from non-federal, acute care hospitals in California during 2008–2012 using the Office of Statewide Health Planning and Development (OSHPD) Patient Discharge Data set, a complete census of all CA licensed general acute care hospital discharge records. This study was approved by the OSHPD Committee for the Protection of Human Subjects and was deemed exempt by our institution's Institutional Review Board.

Selection of Participants

The study population consisted of fee-for-service Medicare enrollees ≥65 years admitted through the emergency department (ED) with a hospital length of stay (HLOS) <50 days and a primary discharge diagnosis of acute myocardial infarction

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(MI), pneumonia (PNA), or heart failure (HF; identified through the respective Clinical Classification Software [CCS]).

The sample was restricted to discharges with a HLOS of <50 days, because those with longer HLOS (0.01% of study sample) were likely different in ways that may bias our findings (eg, they will likely be sicker). We limited our study to admissions through the ED to reduce potential selection bias by excluding elective admissions and hospital-to-hospital transfers, which are likely dependent on occupancy. MI, HF, and PNA diagnoses were selected because they are prevalent and have high inpatient mortality, allowing us to examine the effect of occupancy on some of the sickest inpatients.[17]

Hospital-acquired cases of CDI were identified as discharges (using ICD-9 code 008.45 for CDI) that were not marked as present-on-admission (POA) using the method described by Zhan et al.[18] To avoid small facility outlying effects, we included hospitals that had 100 or more MI, HF, and PNA discharges that met the inclusion criteria over the study years.

OSHPD inpatient data were combined with OSHPD hospital annual financial data that contain hospital-level variables including ownership (City/County, District, Investor, and Non-Profit), geography (based on health services area), teaching status, urbanicity, and size based on the number of average annual licensed beds. If characteristics were not available for a given hospital for one or more years, the information from the closest available year was used for that hospital (replacement required for 10,504 (1.5%) cases; 4,856 otherwise eligible cases (0.7%) were dropped because the hospital was not included in the annual financial data for any year. Approximately 0.2% of records had invalid values for disposition, payer, or admission route, and were therefore dropped. Patient residence zip code-level socioeconomic status was measured using the percentage of families living below the poverty line, median family income, and the percentage of individuals with less than a high school degree among those aged ≥ 25 years[19]; these measures were divided into three groups (bottom quartile, top quartile, and middle 50%) for analysis.

Measure of Occupancy

Calculating Daily Census and Bed Capacity

We calculated the daily census using admission date and HLOS for each observation in our dataset. We approximated the bed capacity as the maximum daily census in the 121-day window (+/- 60 days) around each census day in each hospital. The 121-day window was chosen to increase the likelihood of capturing changes in bed availability (eg, due to unit closures) and seasonal variability. Our daily census does not include patients admitted with psychiatric and obstetrics diagnoses and long-term care/rehabilitation stays (identified through CCS categories and excluded) because these patients are not likely to compete for the same hospital resources as those receiving care for MI, HF, and PNA. See Appendix Table 1 for definition of the occupancy terms.

Calculating Relative Daily Occupancy

We developed a raw hospital-specific occupancy measure by dividing the daily census by the maximum census in each 121-day window for each hospital. We converted these raw measures to percentiles within the 121-day window to create a daily relative occupancy measure. For example, median level occupancy day would correspond to an occupancy of 0.5; a minimum or maximum occupancy day would correspond to 0 or 1, respectively. We preferred a relative occupancy measure because it assumes that what constitutes "high occupancy" likely depends on the usual occupancy level of the facility.

Measuring Admission Day Occupancy and Average Occupancy over Hospitalization

Using the relative daily occupancy values, we constructed patient-level variables representing occupancy on admission day and average occupancy during hospitalization.

DATA ANALYSIS

First, we estimated descriptive statistics of the sample for occupancy, patient-level (eg, age, race, gender, and severity of illness), hospital-level (eg, size, teaching status, and urbanicity), and incident-level (day-of-the-week and season) variables. Next, we used logistic regression with cluster standard errors to estimate the adjusted and unadjusted association of occupancy with CDI. For this analysis, occupancy was broken into four groups: 0.00-0.25 (low occupancy); 0.26-0.50; 0.51-0.75; and 0.76-1.00 (high occupancy), with the 0.0-0.25 group treated as the reference level. We fit separate models for admission and average occupancy and re-ran the latter model including HLOS as a sensitivity analysis.

RESULTS

Study Population and Hospitals

Across 327 hospitals, 558,829 discharges (including deaths) met our inclusion criteria and there were 2,045 admissions with CDI. The hospital and discharge characteristics are reported in Appendix Table 2.

Relationship of Occupancy with CDI

With regard to admission occupancy, the 0.26-0.50 group did not have a significantly higher rate of CDI than the low occupancy group. Both the 0.51-0.75 and the 0.76-1.00 occupancy groups had 15% lower odds of CDI compared to the low occupancy group (Table). The adjusted results were similar, although the comparison between the low and high occupancy groups was marginally nonsignificant.

With regard to average occupancy, intermediate levels of occupancy (ie, 0.26-0.50 and 0.51-0.75 groups) had over 3-fold increased odds of CDI relative to the low occupancy group; the high occupancy group did not have significantly different odds of CDI compared to the low occupancy group (Table 1). The adjusted results were similar with no changes in statistical significance. Including HLOS tempered the adjusted odds of CDI to 1.6 for intermediate levels of occupancy, but these remained significantly higher than high or low occupancy.

DISCUSSION

Hospital occupancy is related to CDI. However, contrary to expectation, we found that higher admission and average

TABLE. **Admission and Average Occupancy Adjusted and Unadjusted Odds Ratios by Occupancy Group**[a]

	Admission Occupancy				Average Occupancy			
Occupancy group	No CDI (n, %)	CDI (n, %)	Unadjusted Odds for CDI (95% CI)	Adjusted Odds for CDI (95% CI)	No CDI (n, %)	CDI (n, %)	Unadjusted Odds for CDI (95% CI)	Adjusted Odds for CDI (95% CI)
0-25%	108,606 (99.59%)	442 (0.41%)	(ref)	(ref)	50,728 (99.86%)	71 (0.14%)	(ref)	(ref)
26-50%	132,035 (99.61%)	515 (0.39%)	0.96 (0.85-1.08)	0.97 (0.86-1.10)	177,789 (99.57%)	772 (0.43%)	**3.10 (2.38-4.05)**	**3.04 (2.33-3.96)**
51-75%	149,134 (99.65%)	513 (0.35%)	**0.85 (0.75-0.96)**	**0.86 (0.75-0.98)**	231,535 (99.64%)	1,079 (0.46%)	**3.33 (2.55-4.35)**	**3.28 (2.51-4.28)**
76+%	167,009 (99.65%)	575 (0.35%)	**0.85 (0.75-0.96)**	0.87 (0.75-1.01)	96,732 (99.87%)	123 (0.13%)	0.91 (0.67-1.24)	0.96 (0.70-1.31)

[a]0%-25% occupancy group served as the reference

Bold values are statistically significant at $P < .05$.

The following covariates were adjusted for the regressions: Patient-level (age, gender, race, Charlson Index, and community socioeconomic status), hospital-level (size, teaching status, and urbanicity), and incident-level (year, season, and day of the week) variables. In addition, the admission occupancy model included the mean hospital admission occupancy percentile, and the average occupancy model included the mean average occupancy percentile.

Abbreviation: CDI, *Clostridium difficile* infection.

occupancy over hospitalization were not related to more hospital-acquired CDI. CDI rates were highest for intermediate levels of average occupancy with lower CDI rates at high and low occupancy. CDI had an inverse relationship with admission occupancy.

These findings suggest that an exploration of the processes associated with hospitals accommodating higher occupancy might elucidate measures to reduce CDI. How do staffing, implementation of policies, and routine procedures vary when hospitals are busy or quiet? What aspects of care delivery that function well during high and low occupancy periods breakdown during intermediate occupancy? Hospital policies, practices, and procedures during different phases of occupancy might inform best practices. These data suggest that hospital occupancy level should be a routinely collected data element by infection control officers and that this should be linked with protocols triggered or modified with high or low occupancy that might affect HACs.

Previous studies in Europe found increasing hospital-acquired infection rates with increasing occupancy.[13-15] The authors postulated that increasing occupancy may limit available resources and increase nursing workloads, negatively impacting adherence to hand hygiene and cleaning protocols .[8] However, these studies did not account for infections that were POA. In addition, our study examined hospitals in California after the 2006 implementation of the minimum nurse staffing policy, which means that staff to patient ratios could not fall below fixed thresholds that were typically higher than pre-policy ratios.[19]

This study had limitations pertaining to coded administrative data, including quality of coding and data validity. However, OSHPD has strict data reporting processes.[20] This study focused on one state; however, California is large with a demographically diverse population and hospital types, characteristics that would help generalize findings. Furthermore, when using the average occupancy measure, we could not determine whether the complication was acquired during the high occupancy period of the hospitalization.

Higher admission day occupancy was associated with lower likelihood of CDI, and CDI rates were lower at high and low average occupancy. These findings should prompt exploration of how hospitals react to occupancy changes and how those care processes translate into HACs in order to inform best practices for hospital care.

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Pediatric Hospitalist Workload and Sustainability in University-Based Programs: Results from a National Interview-Based Survey

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Wide variability exists in the clinical workload of pediatric hospitalists without an accepted standard for benchmarking purposes. By using data obtained from interviews of pediatric hospital medicine (PHM) program leaders, we describe the clinical workload of university-based programs and report on the program sustainability perceived by PHM program leaders. The median clinical hours reported for a full-time pediatric hospitalist were 1,800 hours per year, with a median of 15 weekends worked per year. Furthermore, program leaders reported an ideal number of clinical hours as 1,700 hours per year. Half of the interviewed program leaders perceived their current models as unsustainable. Programs perceived as unsustainable were more likely than those perceived as sustainable to require a higher number of weekends worked per year or to be university employed. Further research should focus on establishing benchmarks for the workloads of pediatric hospitalists and on evaluating factors that can affect sustainability. *Journal of Hospital Medicine* 2018;13:702-705. Published online first June 27, 2018. © 2018 Society of Hospital Medicine

Pediatric hospital medicine (PHM) has grown tremendously since Wachter first described the specialty in 1996.[1] Evidence of this growth is seen most markedly at the annual Pediatric Hospitalist Meeting, which has experienced an increase in attendance from 700 in 2013 to over 1,200 in 2017[2]. Although the exact number of pediatric hospitalists in the United States is unknown, the American Academy of Pediatrics Section on Hospital Medicine (AAP SOHM) estimates that approximately 3,000-5,000 pediatric hospitalists currently practice in the country (personal communication).

As PHM programs have grown, variability has been reported in the roles, responsibilities, and workload among practitioners. Gosdin et al.[3] reported large ranges and standard deviations in workload among full-time equivalents (FTEs) in academic PHM programs. However, this study's ability to account for important nuances in program description was limited given that its data were obtained from an online survey.

Program variability, particularly regarding clinical hours and overall clinical burden (eg, in-house hours, census caps, and weekend coverage), is concerning given the well-reported increase in physician burn-out.[4,5] Benchmarking data regarding the overall workload of pediatric hospitalists can offer nationally recognized guidance to assist program leaders in building successful programs. With this goal in mind, we sought to obtain data on university-based PHM programs to describe the current average workload for a 1.0 clinical FTE pediatric hospitalist and to assess the perceptions of program directors regarding the sustainability of the current workload.

METHODS

Study Design and Population

To obtain data with sufficient detail to compare programs, the authors, all of whom are practicing pediatric hospitalists at university-based programs, conducted structured interviews of PHM leaders in the United States. Given the absence of a single database for all PHM programs in the United States, the clinical division/program leaders of university-based programs were invited to participate through a post (with two reminders) to the AAP SOHM Listserv for PHM Division Leaders in May of 2017. To encourage participation, respondents were promised a summary of aggregate data. The study was exempted by the IRB of the University of Chicago.

Interview Content and Administration

The authors designed an 18-question structured interview regarding the current state of staffing in university-based PHM programs, with a focus on current descriptions of FTE, patient volume, and workload. Utilizing prior surveys[3] as a basis, the authors iteratively determined the questions essential to understanding the programs' current staffing models and ideal models. Considering the diversity of program models, interviews allowed for the clarification of questions and answers. A question regarding employment models was included to

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determine whether hospitalists were university-employed, hospital-employed, or a hybrid of the two modes of employment. The interview was also designed to establish a common language for work metrics (hours per year) for comparative purposes and to assess the perceived sustainability of the workload. Questions were provided in advance to provide respondents with sufficient time to collect data, thus increasing the accuracy of estimates. Respondents were asked, "Do you or your hospitalists have concerns about the sustainability of the model?" Sustainability was intentionally undefined to prevent limiting respondent perspective. For clarification, however, a follow-up comment that included examples was provided: "Faculty departures, reduction in total effort, and/or significant burn out." The authors piloted the interview protocol by interviewing the division leaders of their own programs, and revisions were made based on feedback on feasibility and clarity. Finally, the AAP SOHM Subcommittee on Division Leaders provided feedback, which was incorporated.

Each author then interviewed 10-12 leaders (or designee) during May and June of 2017. Answers were recorded in REDCAP, an online survey and database tool that contains largely numeric data fields and has one field for narrative comments.

Data Analysis

Descriptive statistics were used to summarize interview responses, including median values with interquartile range. Data were compared between programs with models that were self-identified as either sustainable or unsustainable, with *P*-values in categorical variables from χ^2-test or Fischer's exact test and in continuous variables from Wilcoxon rank-sum test.

Spearman correlation coefficient was used to evaluate the association between average protected time (defined as the percent of funded time for nonclinical roles) and percentage working full-time clinical effort. It was also used to evaluate hours per year per 1.0 FTE and total weekends per year per 1.0 FTE and perceived sustainability. Linear regression was used to determine whether associations differed between groups identifying as sustainable versus unsustainable.

RESULTS

Participation and Program Characteristics

Of the 143 subscribers to the listserv, which includes community and university-based programs, 62 division leaders/directors that self-identified by university-based hospitalist programs initially responded, and 56 completed phone interviews. Of these 56 respondents, 48% were university employed. The remainder were hospital employed (27%), had joint university/hospital appointments (13%), practiced in a private group (5%), or other models (7%).

Administration

A wide variation was reported in the clinical time expected of a 1.0 FTE hospitalist. Clinical time for 1.0 FTE was defined as the amount of clinical service a full-time hospitalist is expected to complete in 12 months (Table 1). The median hours worked per year were 1800 (Interquartile range [IQR] 1620,1975; mean 1796). The median number of weekends worked per year was 15.0 (IQR 12.5, 21; mean 16.8). Only 30% of pediatric hospitalists were full-time clinicians, whereas the rest had protected time for nonclinical duties. The average amount of protected time was 20% per full-time hospitalist.

TABLE 1. **Demographics of Programs Interviewed**

	All (n = 56)
Total FTEs employed, median (IQR)	9.8 (5, 18)
Metric used to describe FTE	
Hours	22 (39%)
Shifts	15 (27%)
Weeks	19 (34%)
1.0 FTE in hours per year (converted from metric used)	
Mean (SD)	1,796 (232)
Median (IQR)	1,800 (1,620, 1,975)
Weekends total/year in 1.0 FTE	
Mean (SD)	16.8 (5.9)
Median (IQR)	15 (12.5, 21)
Cap on weekends, n (%)	28 (50%)
Pager overnight, n (%)	36 (64%)
Average pager burden (1-5 scale, with lower = less)	2.41
Expansion of staff/coverage seasonally, n (%)	18 (32%)
Back-up system formally in place, n (%)	30 (54%)
Census cap in place, n (%)	22 (39%)
Percentage working full clinical FTE, median (IQR)	30 (6, 56)
Average buyout for nonclinical %, median (IQR)	20 (17.5, 34.5)

Abbreviations: FTE, full-time equivalent; IQR, interquartile range; SD, standard deviation.

Sustainability and Ideal FTE

Half of the division leaders reported that they or their hospitalists have concerns about the sustainability of the current workload. Programs perceived as sustainable required significantly fewer weekends per year (13 vs 16, $P < .02$; Table 2) than those perceived as unsustainable. University-employed programs were more likely to be perceived as unsustainable (64% unsustainable vs 32% unsustainable, $P < .048$), whereas programs with other employment models were more likely to be perceived as sustainable (Table 2). Total hours currently worked did not differ significantly between programs perceived as sustainable and unsustainable. Respondents reported an ideal workload for a 1.0 FTE of 1,700 clinical hours (median). The hours worked per year for programs perceived as sustainable were statistically closer to their ideal than those perceived as unsustainable ($P = .46$; Table 2).

DISCUSSION

This study updates what has been previously reported about the structure and characteristics of university-based pediatric

TABLE 2. **Comparison of Practices Reporting Sustainable and Unsustainable Models**

	All Programs n = 56	Unsustainable n = 28	Sustainable n = 28	*P*-value
1.0 FTE hours per year, median (IQR)	1,800 (1,620, 1,975)	1,800 (1,646, 2,000)	1,764 (1,620, 1,935)	.47
Weekends total per year, median (IQR)	15.0 (12.5, 21)	16 (13.5, 23.5)	13 (12, 16)	.02
University employed, n (%)	27 (48%)	18 (64%)	9 (32%)	.048
Dual university and hospital employed, n (%)	7 (13%)	2 (7%)	5 (18%)	
Hospital employed, n (%)	15 (27%)	6 (21%)	9 (32%)	
Private employed, n (%)	3 (5%)	0	3 (11%)	
Other, n (%)	4 (7%)	2 (7%)	2 (7%)	
Ideal 1.0 FTE, median (IQR)	1,700 (1,545, 1,813)	1,700 (1,500, 1,800)	1,696 (1,583, 1,831)	.55
Difference 1.0 FTE–Ideal FTE, median (IQR)	0 (0, 220)	125 (0, 321)	0, (0, 114)	.046

hospitalist programs.[3] It also deepens our understanding of a relatively new field and the evolution of clinical coverage models. This evolution has been impacted by decreased resident work hours, increased patient complexity and acuity,[6] and a broadened focus on care coordination and communication,[7] while attempting to build and sustain a high-quality workforce.

This study is the first to use an interview-based method to determine the current PHM workload and to focus exclusively on university-based programs. Compared with the study by Gosdin et al,[3] our study, which utilized interviews instead of surveys, was able to clarify questions and obtain workload data with a common language of hours per year. This approach allowed interviewees to incorporate subtleties, such as clinical vs total FTE, in their responses. Our study found a slightly narrower range of clinical hours per year and extended the understanding of nonclinical duties by finding that university-based hospitalists have an average of 20% protected time from clinical duties.

In this study, we also explored the perceived sustainability of current clinical models and the ideal clinical model in hours per year. Half of respondents felt their current model was unsustainable. This result suggested that the field must continue to mitigate attrition and burnout.

Interestingly, the total number of clinical hours did not significantly differ in programs perceived to be unsustainable. Instead, a higher number of weekends worked and university employment were associated with lack of sustainability. We hypothesize that weekends have a disproportionate impact on work-life balance as compared with total hours, and that employment by a university may be a proxy for the increased academic and teaching demands of hospitalists without protected time. Future studies may better elucidate these findings and inform programmatic efforts to address sustainability.

Given that PHM is a relatively young field, considering the evolution of our clinical work model within the context of pediatric emergency medicine (PEM), a field that faces similar challenges in overnight and weekend staffing requirements, may be helpful. Gorelick et al.[8] reported that total clinical work hours in PEM (combined academic and nonacademic programs) has decreased from 35.3 hours per week in 1998 to 26.7 in 2013. Extrapolating these numbers to an annual position with five weeks PTO/CME, the average PEM attending physician works 1,254 clinical hours. These numbers demonstrate a marked difference compared with the average 1,800 clinical work hours for PHM found in our study.

Although total hours trend lower in PEM, the authors noted continued challenges in sustainability with an estimated half of all PEM respondents indicating a plan to reduce hours or leave the field in the next five years and endorsing symptoms of burnout.[6] These findings from PEM may motivate PHM leaders to be more aggressive in adjusting work models toward sustainability in the future.

Our study has several limitations. We utilized a convenience sampling approach that requires the voluntary participation of division directors. Although we had robust interest from respondents representing all major geographic areas, the respondent pool might conceivably over-represent those most interested in understanding and/or changing PHM clinical models. Overall, our sample size was smaller than that achieved by a survey approach. Nevertheless, this limitation was offset by controlling respondent type and clarifying questions, thus improving the quality of our obtained data.

CONCLUSION

This interview-based study of PHM directors describes the current state of clinical work models for university-based hospitalists. University-based PHM programs have similar mean and median total clinical hours per year. However, these hours are higher than those considered ideal by PHM directors, and many are concerned about the sustainability of current work models. Notably, programs that are university-employed or have higher weekends worked per year are more likely to be perceived as unsustainable. Future studies should explore dif-

ferences between programs with sustainable work models and those with high levels of attrition and burnout.

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Cardiac Troponins in Low-Risk Pulmonary Embolism Patients: A Systematic Review and Meta-Analysis

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BACKGROUND: Patients with low-risk pulmonary embolism (PE) should be considered as per current scoring systems for ambulatory treatment. However, there is uncertainty whether patients with low scores and positive troponins should require hospitalization.

METHODS: We searched MEDLINE, SCOPUS, and Cochrane Library databases from inception to December 2016 and collected longitudinal studies that evaluated the prognostic value of troponins in patients with low-risk PE. The primary outcome measure was 30-day all-cause mortality. We calculated odds ratio (OR), likelihood ratios (LRs), and 95% confidence intervals (CI) by using random-effects models.

RESULTS: The literature search identified 117 candidate articles, of which 16 met the criteria for review. Based on pulmonary embolism severity index (PESI) or simplified PESI score, 1.2% was the all-cause mortality rate across 2,662 participants identified as low-risk. A positive troponin status in patients with low-risk PE was associated with an increased risk of 30-day all-cause mortality (odds ratio [OR]: 4.79; 95% confidence interval [CI]: 1.11 to 20.68). The pooled likelihood ratios (LRs) for all-cause mortality were positive LR 2.04 (95% CI, 1.53 to 2.72) and negative LR 0.072 (95% CI, 0.37 to 1.40).

CONCLUSION: The use of positive troponin status as a predictor of increased mortality in low-risk PE patients exhibited relatively poor performance given the crossed negative LR CI (1.0) and modest positive LR. Larger prospective trials must be conducted to elucidate if patients with low-risk PE and positive troponin status can avoid hospitalization. *Journal of Hospital Medicine* 2018;13:706-712. Published online first April 25, 2018. © 2018 Society of Hospital Medicine

Hospital stays for pulmonary embolism (PE) represent a significant cost burden to the United States healthcare system.[1] The mean total hospitalization costs for treating a patient with PE ranges widely from $8,764 to $37,006, with an average reported length of stay between four and five days.[2,3] This cost range is attributed to many factors, including type of PE, therapy-induced bleeding risk requiring close monitoring, comorbidities, and social determinants of health. Given that patients with low-risk PE represent the majority of the cases, changes in approaches to care for this population can significantly impact the overall healthcare costs for PE. The European Society of Cardiology (ESC) guidelines incorporate well-validated risk scores, known as the pulmonary embolism severity index (PESI) and the simplified PESI (sPESI) score, and diagnostic test recommendations, including troponin test, echocardiography, and computed tomography, to evaluate patients with PE at varying risk for mortality.[4] In these guidelines, the risk stratification algorithm for patients with a low PESI score or a sPESI score of zero does not include checking for the presence of troponin. In reality, practicing hospitalists frequently find that patients receiving a workup in the emergency department for suspected PE undergo troponin test. The ESC guidelines categorize patients with a low-risk score on PESI/sPESI, who subsequently have a positive troponin status, as intermediate low-risk and suggest consideration of hospitalization. The guidelines recommend patients with positive cardiac biomarkers to undergo assessment of right ventricular function through echocardiogram or computed tomography analysis. Moreover, the guidelines support early discharge or ambulatory treatment for low-risk patients who have a negative troponin status.[4]

The American College of Chest Physicians (ACCP) guidelines on venous thromboembolism (VTE) recommend that cardiac biomarkers should not be measured routinely in all patients with PE and that positive troponin status should discourage physicians from pursuing ambulatory treatment.[5] Therefore, ambiguity lies within both guidelines with regard to how hospitalists should interpret a positive troponin status in patients with low risk, which in turn may lead to unnecessary hospitalizations and further imaging. This systematic review and meta-analysis aims to provide clarity, both about gaps in literature and about how practicing hospitalists should interpret troponins in patients with low-risk PE.

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TABLE 1. **Characteristics of the Studies**

Source	Year	# Patients	Age[a]	% Males	Study Design	Risk Score	Type of Troponin	Primary Endpoints
Ahn et al.[7]	2016	228	59 ± 11.3	51	R	PESI	cTnI	30 d, 3 mo, 6 mo A-C mortality
Ozsu et al.[8]	2015	206	71 (58–80)	40	P	sPESI	cTnI, cTnT	90 d A-C mortality
Hakemi et al.[9]	2015	298	56 (±13)	51	R	PESI	hs-cTnI	5 d median events[b]
Lauque et al.[10]	2014	132	69 (±21)	51	P	PESI	cTnI-ultra	30 d A-C mortality & events[c]
Vuilleumier et al.[11]	2014	230	75 (69–82)	59	P	PESI	hs-cTnT	30 d events[d]
Jimenez et al.[12]	2014	848	72 (59–80)	49	P	sPESI	cTnI	30 d A-C mortality & events[e]
Ozsu et al.[13]	2013	121	70 (55–76)	43	P	sPESI	cTnT, hsTnT	30 d A-C mortality
Sanchez et al.[14]	2013	529	67 (52–77)	47	P	PESI	cTnI	30 d A-C mortality & events[f]
Barra et al.[15]	2012	142	70 ± 15	40	R	sPESI	cTnI	30 d A-C mortality
Lankeit et al.[16]	2011	526	71 (55–79)	51	P	sPESI	hs-cTnT	30 d A-C mortality & events[g]
Sanchez et al.[17]	2011	1291	74 (61–80)	45	R	sPESI	cTnI	30 d A-C mortality
Spirk et al.[18]	2011	369	67 (±21)	53	P	sPESI	cTn I or T, hs-TnT	30 d A-C mortality & recurrent PE
Vanni et al.[19]	2011	463[h]	>65 (73)	43.7	P	PESI	cTnI	In-hospital A-C & PE-related deaths
Jimenez et al.[20]	2011	591	74 (65–82)	43	P	PESI	cTnI	30 day PE-related mortality
Singanayagam et al.[21]	2010	411	>65 (55)	43.1	R	PESI	cTnI	30 day A-C mortality
Moores et al.[22]	2009	567	>65 (74)	43	P	PESI	cTnI	30 day A-C mortality

[a]Age is given as mean (±SD) or median (IQ) or >65 years (%)
[b]In-hospital death/CPR/ thrombolytic therapy
[c]cardiac arrest/CPR/ mechanical ventilation/ need for catecholamine support/recurrence of acute PE
[d]PE related death, recurrence of VTE, and major bleeding
[e]hemodynamic collapse, and/or recurrent PE
[f]secondary cardiogenic shock, or confirmed symptomatic recurrent VTE
[g]catecholamine support/endotracheal intubation/CPR
[h]Total was 510, but 463 pts were stratified using PESI
Secondary events were mostly not available except for the following studies: Ozsu 2015 = nonfatal symptomatic recurrent PE or nonfatal major bleeding; Lankeit= Recurrent PE/Major bleeding; Sanchez 2011=PE Related Mortality; Vanni= nonfatal PE recurrence/delayed hemodynamic instability/nonfatal major bleeding
Abbreviations: A-C, all-cause; P, prospective; PESI, pulmonary embolism severity index; R, retrospective; sPESI, simplified PESI.

METHODS

Data Sources and Searches

This systematic review and meta-analysis was performed in accordance with the established methods and Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines. We searched MEDLINE, SCOPUS, and Cochrane Controlled Trial Registry databases for studies published from inception to December 2016 by using the following key words: pulmonary embolism AND PESI OR "pulmonary embolism severity index." Only articles written in English language were included. The full articles of potentially eligible studies were reviewed, and articles published only in abstract form were excluded.

Study Selection

Two investigators independently assessed the abstract of each article, and the full article was assessed if it fulfilled the following criteria: (1) the publication must be original, (2) inclusion of objectively diagnosed, hemodynamically stable patients (normotensive patients) with acute PE in the inpatient or outpatient setting, (3) inclusion of patients ≥ 19 years old, (4) use of the PESI or sPESI model to stratify patients into a low-risk group irrespective of any evidence of right ventricular dysfunction, and (5) testing of cardiac troponin levels (TnI-troponin I, TnT-troponin T, or hs-TnI/TnT-high sensitivity troponin I/T) in patients. Study design, sample size, duration of follow-up, type of troponin used, definition of hemodynamic stability, and specific type of outcome measured (endpoint) did not affect the study eligibility.

Data Extraction and Risk of Bias Assessment

For each eligible article, we abstracted information and created two tables. Table 1 shows the study characteristics, and Supplementary Table 1 presents the outcomes of each individual study and the pooled outcomes. In cases where information regarding the specific number of outcomes from the paper is missing, we emailed the primary author. Two investigators independently evaluated studies that were included in the meta-analysis using the methodological risk of bias in

TABLE 2. **Summary Measures of the Association between Troponin Classification and Overall 30-day All-cause Mortality and Stratified by Study**

Source	Low-risk PE Patients	Tn+	Tn-	PPV	NPV	PLR (95% CI)		NLR (95% CI) OR		Odds Ratio OR	Odds Ratio (95% CI)	Odds Ratio *P* Value
Ozsu et al.[8]	57	5	52									
90-day mortality	4	3	1	0.60	0.98	19.88	(4.56–86.66)	0.26	(0.05–1.42)	76.50	(5.31–1102.4)	.0014
Hakemi et al.[9]	173	84	89									
In-hospital mortality	4	4	0	0.05	1.00	1.90	(1.36–2.65)	0.19	(0.01–2.64)	10.01	(0.53–188.75)	.1243
Lauque et al.[10]	84	17	67									
30-day mortality	1	1	0	0.06	1.00	3.82	(1.54–9.48)	0.31	(0.03–3.44)	12.27	(0.48–315.11)	.1300
Ozsu et al.[13]	45	14	31									
30-day mortality	0	0	0	0.00	1.00	1.59	(0.21-11.79)	0.73	(0.10-5.23)	2.17	(0.04–114.99)	.7016
Sanchez et al.[14]	329	44	278									
30-day mortality	2	NS	NS	NS	NS	NS	—	NS	—	NS	—	—
Lankeit et al.[16]	198	71	127									
30-day mortality	1	1	0	0.01	1.00	2.11	(0.93–4.79)	0.39	(0.04-4.29)	5.43	(0.22–134.95)	.3024
Moores et al.[22]	191	42	149									
30-day mortality	1	0	1	0.00	0.99	1.12	(0.10–12.57)	0.97	(0.43-2.16)	1.16	(0.05–29.11)	.9260
All studies pooled[a]	691	228	**463**									
30-day mortality[b]	7	6	1	0.03	1.00	2.04	(1.53–2.72)	0.72	(0.37–1.40)	4.79	(1.11–20.68)	.0357
Sensitivity Analysis[c]						3.40	(1.81–6.37)	0.59	(0.33–1.08)	11.01	(3.38–35.92)	<.0001

[a]Total number of low risk PE patients, Tn+, Tn-

[b]Pooled estimates of PPV, NPV, PLR, NLR, and OR for 30-day all-cause mortality do not include data from the Ozsu[8] and Sanchez[14] studies.

[c]Includes the Ozsu 2015 study and assumes the 2 PE patients with mortalities in the Sanchez 2013 were from troponin positive

Abbreviations: CI, confidence interval; NLR, negative likelihood ratio; NPV, negative predictive value; NS, data not supplied; PLR, positive likelihood ratio, PPV, positive predictive value.

accordance with the *Cochrane Handbook for Systematic Reviews of Interventions*. Each study was judged as being low, moderate, or high risk of bias (Supplementary Table 2). Disagreements were resolved with discussion between the two primary reviewers and obtaining a third opinion.

Statistical Analysis

Data were summarized by using 30-day all-cause mortality only because it is the most consistent endpoint reported by all of the included studies. For each study, 30-day all-cause mortality was analyzed across the two troponin groups, and the results were summarized in terms of positive predictive value (PPV), negative predictive value (NPV), positive likelihood ratio (PLR), negative likelihood ratio (NLR), and odds ratio (OR). To quantify the uncertainty in the LRs and ORs, we calculated 95% confidence intervals (CI).

Overall measures of PPV, NPV, PLR, and NLR were calculated on the pooled collection of data from the studies. LRs are one of the best measures of diagnostic accuracy; therefore, we defined the degree of probability of disease based on simple estimations that were reported by McGee.[6] These estimations are independent of pretest probability and include the following: PLR 5.0 increases the probability of the outcome by about 30%, whereas NLR 0.20 decreases the probability of the outcome by 30%. To identify reasonable performance, we defined a PLR > 5 as an increase in moderate to high probability and a NLR < 0.20 as a decrease in moderate to high probability.[6]

The overall association between 30-day all-cause mortality and troponin classification among patients with low-risk PE was assessed using a mixed effects logistic regression model. The model included a random intercept to account for the correlation among the measurements for patients within a study. The exponentiated regression coefficient for troponin classification is the OR for 30-day all-cause mortality, comparing troponin-positive patients to troponin-negative patients. OR is reported with a 95% CI and a *P* value. A continuity correction (correction = 0.5) was applied to zero cells. Heterogeneity was measured using Cochran Q statistic and Higgins I^2 statistic.

RESULTS

Search Results

Figure 1 represents the PRISMA flow diagram for literature search and selection process to identify eligible studies for inclusion.

Study Characteristics

The abstracts of 117 articles were initially identified using the search strategy described above. Of these, 18 articles were deemed appropriate for review based on the criteria outlined in "Study Selection." The full-text articles of the selected studies were obtained. Upon further evaluation, we identified 16

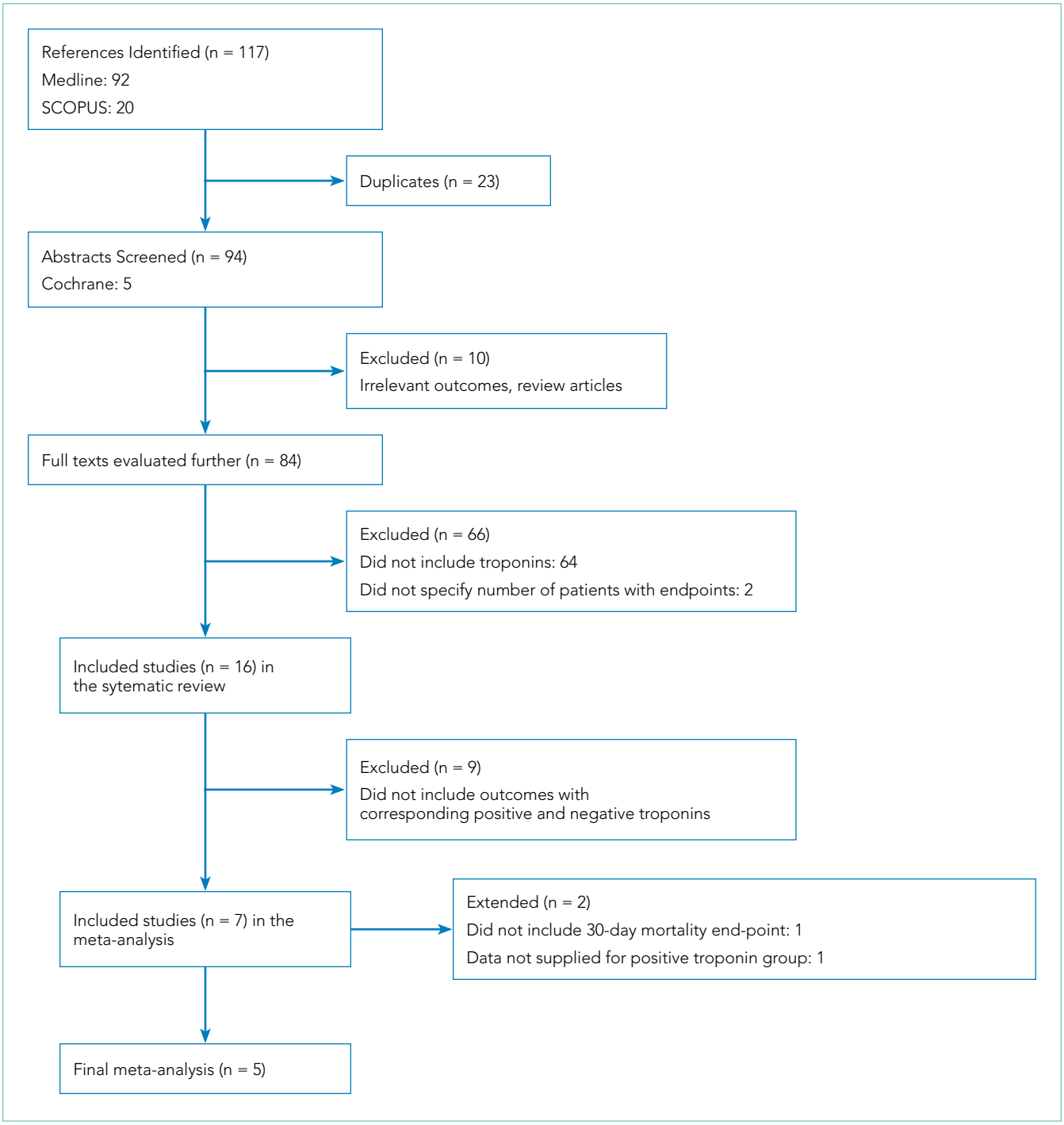

FIG 1. Flow Diagram for Study Selection

articles (Figure 1) eligible for the systematic review. Two studies were excluded because they did not provide the number of study participants that met the primary endpoints. The included studies were published from 2009–2016 (Table 1). For patients with low-risk PE, the number of patients with right ventricle dysfunction was either difficult to determine or not reported in all the studies.

Regarding study design, 11 studies were described as prospective cohorts and the remaining five studies were identified as retrospective (Table 1). Seven studies stratified participants' risk of mortality by using sPESI, and eight studies employed the PESI score. A total of 6,952 participants diagnosed with PE were obtained, and 2,662 (38%) were recognized as being low-risk based on either the PESI or sPESI. The sample sizes of the individual studies ranged from 121 to 1,291. The studies used either hs-cTnT, hs-cTnI, cTnT, cTnI, or a combination of hs-cTnT and cTnI or cTnT for troponin assay. Most studies used a pre-defined cut-off value to determine positive or negative

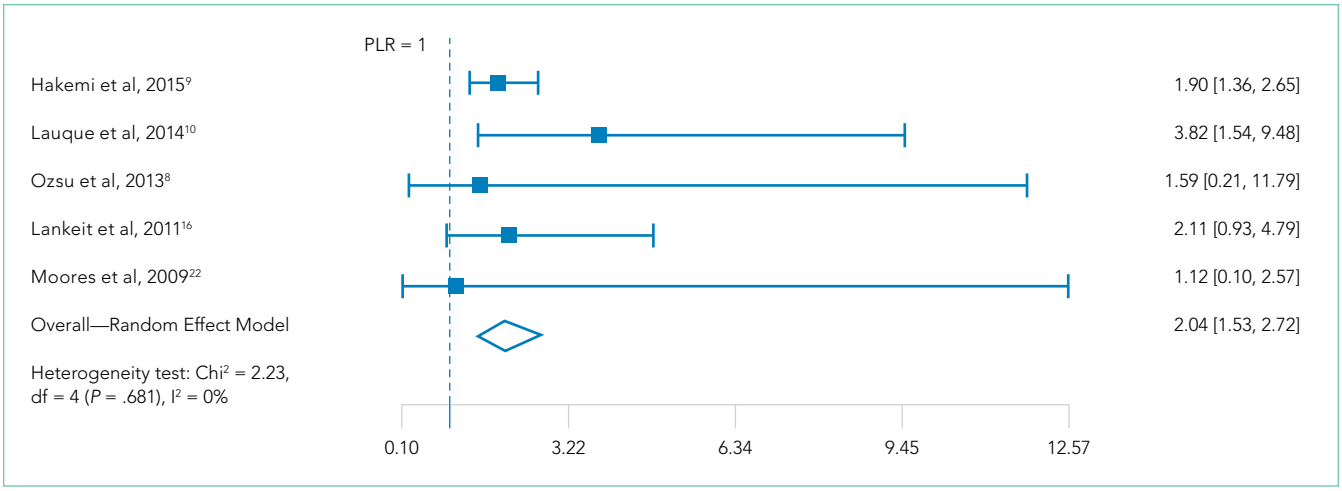

FIG 2. Positive Likelihood Ratio Forest Plot

troponin status.

Thirteen studies reported 30-day event rate as one of the primary endpoints. The three other studies included 90-day all-cause mortality, and two of them included in-hospital events. Secondary event rates were only reported in four studies and consisted of nonfatal PE, nonfatal major bleeding, and PE-related mortality.

Our systematic review revealed that five of the 16 studies used either hemodynamic decompensation, cardiopulmonary resuscitation, mechanical ventilation, or a combination of any of these parameters as part of their primary or secondary endpoint. However, none of the studies specified the number of patients that reached any of these endpoints. Furthermore, 10 of the 16 studies did not specify 30-day PE-related mortality outcomes. The most common endpoint was 30-day all-cause mortality, and only seven studies reported outcomes with positive or negative troponin status.

Outcome Data of All Studies

A total of 2,662 participants were categorized as being low risk based on the PESI or sPESI risk score. The pooled rate of PE-related mortality (specified and inferred) was five (0.46%) from six studies (1,093 patients), in which only two studies specified PE-related mortality as the primary endpoint (Vanni [2011][19] and Jimenez [2011][20]). The pooled rate of 30-day all-cause mortality was 24 (1.3%) from 12 studies (1,882 patients). In 14 studies (2,163 patients), the rates of recurrence of PE and major bleeding were three (0.14%) and six (0.28%), respectively.

Outcomes of Studies with Corresponding Troponin+ and Troponin–

Seven studies used positive or negative troponin status as endpoint to assess low-risk participants (Table 2). However, only five studies were included in the final meta-analysis because some data were missing in the Sanchez[14] study and the Oszu[8] study's mortality endpoint was more than 30 days. The risk of bias within the studies was evaluated, and for most studies, the quality was of moderate degree (Supplementary Table 1). Table 2 shows the results for the overall pooled data stratified by study. In the pooled data, 691 (75%) patients tested negative for troponin and 228 (23%) tested positive. The overall mortality (from sensitivity analysis) including in-hospital, 30-day, and 90-day mortalities was 1.2%. The NPVs for all individual studies and the overall NPV are one or approximately 1. The overall PPVs and by study were low, ranging from 0 to 0.60. The PLRs and NLRs were not estimated for an outcome within an individual study if none of the patients experienced the outcome. When outcomes were only observed among troponin-negative patients, such as in the study of Moores (2009)[22] who used 30-day all-cause mortality, the PLR had a value of zero. When outcomes were only observed among troponin-positive patients, as for 30-day all-cause mortality in the Hakemi (2015)[9], Lauque (2014)[10], and Lankeit (2011)[16] studies, the NLR had a value of zero. For zero cells, a continuity correction of 0.5 was applied. The pooled likelihood ratios (LRs) for all-cause mortality were positive LR 2.04 (95% CI, 1.53 to 2.72) and negative LR 0.072 (95% CI, 0.37 to 1.40). The OR for all-cause mortality was 4.79 (95% CI 1.11 to 20.68, $P = .0357$).

A forest plot was created to visualize the PLR from each study included in the main analysis (Figure 2).

A sensitivity analysis among troponin-positive patients was conducted using 90-day all-cause mortality outcome from the study of Ozsu[8] (2015) and the two all-cause mortality outcomes from the study of Sanchez[14] (2013). The pooled estimates from the 30-day all-cause mortality differed slightly from those previously reported. The PLR increased to 3.40 (95% CI 1.81 to 6.37), and the NLR decreased to 0.59 (95% CI 0.33 to 1.08).

DISCUSSION

In this meta-analysis of five studies, which included 691 patients with low-risk PESI or sPESI scores, those tested positive for troponin had nearly a five-fold increased risk of 30-day all-cause mortality compared with patients who tested negative. However, the clinical significance of this association is unclear given that the CI is quite wide and mortality could be associated with PE versus other causes. Similar results were reported

by other meta-analyses that consisted of patients with normotensive PE.[23-25] To our knowledge, the present meta-analysis is the first to report outcomes in patients with low-risk PE stratified by the presence of cardiac troponin.

A published paper on simplifying the clinical interpretation of LRs state that a positive LR of greater than five and a negative LR of less than 0.20 provide dependable evidence regarding reasonable prognostic performance.[6] In our analysis, the positive LR was less than five and the negative LR's CI included one. These results suggest a small statistical probability that a patient with a low PESI/sPESI score and a positive troponin status would benefit from inpatient monitoring; simultaneously, a negative troponin does not necessarily translate to safe outpatient therapy, based on our statistical analysis. Previous studies also reported nonextreme positive LRs.[23,24] We therefore conclude that low-risk PE patients with positive troponins may be eligible for safe ambulatory treatment or early discharge. However, the number of outcomes of interest (mortality) occurred in only six patients among the 228 patients who had positive troponin status. The majority of deaths were reported by Hakemi et al.[9] in their retrospective cohort study; as such, drawing conclusions is difficult. Furthermore, the low 30-day all-cause mortality rate of 2.6% in the positive troponin group may have been affected by close monitoring of the patients, who commonly received hemodynamic and oxygen support. Based on these factors, our conclusion is relatively weak, and we cannot recommend a change in practice compared to existing guidelines. In general, additional prospective research is needed to determine whether patients with low-risk PE tested positive for troponin can receive care safely outside the hospital or, rather, require hospitalization similar to patients with intermediate-high risk PE.

We identified a number of other limitations in our analysis. First, aside from the relatively small number of pertinent studies in the literature, most of the studies are of low-moderate quality. Second, the troponin classification in various studies was not conducted using the same assay, and the cut-off value determining positive versus negative results in each case may have differed. These differences may have created some ambiguity or misclassification when the data were pooled together. Third, although the mixed effects logistic regression model controls for some of the variations among patients enrolled in different studies, significant differences exist in terms of patient characteristics or the protocol for follow-up care. This aspect was unaccounted for in this analysis. Lastly, pooled outcome events could not be retrieved from all of the included studies, which would have resulted in a misrepresentation of the true outcomes.

The ESC guidelines suggest avoiding cardiac biomarker testing in patients with low-risk PE because this practice does not have therapeutic implications. Moreover, ESC and ACCP guidelines both state that a positive cardiac biomarker should discourage treatment out of the hospital. The ACCP guidelines further encourage testing of cardiac biomarkers and/or evaluating right ventricular function via echocardiography when uncertainty exists regarding whether patients may require close in-hospital monitoring or not. Although no resounding evidence suggests that troponins have therapeutic implications in patients with low-risk PE, the current guidelines and our meta-analysis cannot offer an overwhelmingly convincing recommendation about whether or not patients with low-risk PE and positive cardiac biomarkers are best treated in the ambulatory or inpatient setting. Such patients may benefit from monitoring in an observation unit (eg, less than 24 or 48 hours), rather than requiring a full admission to the hospital. Nevertheless, our analysis shows that making this determination will require prospective studies that will utilize cardiac troponin status in predicting PE-related events, such as arrhythmia, acute respiratory failure, and hemodynamic decompensation, rather than all-cause mortality.

Until further studies, hospitalists should integrate the use of cardiac troponin and other clinical data, including those available from patient history, physical exam, and other laboratory testing, in determining whether or not to admit, observe, or discharge patients with low-risk PE. As the current guidelines recommend, we support consideration of right ventricular function assessment, via echocardiogram or computed tomography, in patients with positive cardiac troponins even when their PESI/sPESI score is low.

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The Role of Hospital Medicine in Emergency Preparedness: A Framework for Hospitalist Leadership in Disaster Preparedness, Response, and Recovery

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Recent high-profile mass casualty events illustrate the unique challenges that such occurrences pose to normal hospital operations. These events create patient surges that overwhelm hospital resources, space, and staff. However, in most healthcare systems, hospitalists currently show no integration within emergency planning or incident response. This review aims to provide hospitalists with an overview of disaster management principles so that they can engage their hospitals' disaster management system with a working fluency in emergency management and the incident command system. This review also proposes a framework for hospitalist involvement in preparation, response, and coordination during periods of crisis. *Journal of Hospital Medicine* 2018;13:713-718. © 2018 Society of Hospital Medicine

Recent events, domestically and globally, have highlighted the numerous complex challenges that disasters and mass casualty incidents (MCIs) impose on hospitals. Mass casualty events result from natural phenomena (eg, hurricanes, tornadoes, and wildfires), accidents (eg, plane crashes, building collapses, and toxic waste spills), or man-made crises (eg, terrorism).[1-4] These events feature the potential to cause an acute surge of patients, which can overwhelm available hospital resources and personnel. Mass effect incidents are sustained crises, which often occur due to loss of infrastructure, epidemic infectious diseases, or need for hospital evacuations, and can completely overtax local and regional resources, thus requiring federal and state coordination.[5]

Hospital disaster response plans have traditionally centered on responses by the emergency department (ED) and associated surgical services to mass trauma-type events, without commensurate involvement of other hospital departments in either incident management operations or the planning process for mass effect incidents.[6,7] In particular, the role of hospitalists in the leadership structure of various hospital disaster command structures remains undefined.[8] However, recent disasters suggest that hospitalist involvement will highly benefit hospital emergency preparedness.[9] Hospitalists possess specialized expertise in patient triage and disposition; medical comanagement with surgical services; coordination of complex medical care (usually with continuous 24/7 in-house coverage); integration with the full spectrum of affiliated services, such as case management or patient rehabilitation; and quality improvement research.[10-12] At our institution, hospitalists are involved in the direct care of over 60% of the patients admitted across all medical and surgical services. Thus, we believe that hospitalists are uniquely qualified to offer leadership in disaster preparation, response, and recovery if integrated into hospitals' incident command architectures. For example, although numerous acute patient surges are due to trauma MCIs, hospitalists may nevertheless act as the primary care providers in disasters that are medical in nature or that require rapid hospital evacuation and patient transfer (Table 1).

Although truly large-scale disasters are uncommon, several recent incidents exemplify scenarios with remarkably extreme acute patient surges (defined as >20% of normal patient volumes), which completely overwhelm a hospital's capacity to maintain normal operations and require response from all available medical personnel, ideally in a preplanned and organized manner.[13] The Las Vegas shooting on October 1, 2017, for example, resulted in 546 trauma victims, inundating two local hospitals and one regional facility.[14,15] In another case, the deadliest tornado in modern US history struck Joplin, Missouri on May 22, 2011, destroying one of the two hospitals in the city and leaving an estimated 1,371 people injured, many of whom were presented to the one remaining area hospital.[16] One of our team members (J.P.), a storm chaser from out-of-town, reported to the remaining functioning hospital and oversaw an impromptu hospital unit that received patients from the damaged hospital, ultimately caring for approximately 40 patients with a combination of medical and surgical issues from presentation through eventual disposition or transfer to outlying hospitals.[17] Such incidents illustrate that during trauma events,

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TABLE 1. **Disaster Examples with Implications for Involvement of Hospitalists as Primary Providers.**

Disaster Type	Example	Implications for Hospitalists as Leaders
Epidemic Infectious Disease	Pandemic influenza	Hospital throughput of patients to subacute rehabilitation facilities, outpatient clinics, and decompression to other hospital services
Special Pathogens	Emerging viral pathogen (eg, Ebola)	Special quarantine procedures and care for patients with significant infections in dedicated isolation units
Terrorism	Chemical or radiation exposure Weaponized infective biologics	Specialized personnel and personal protective equipment (PPE)
Compromise of Hospital Infrastructure	Massive power loss, IT or communications failures, or structural damage to the hospital	Maintenance of normal patient care in system under duress; direct hospital evacuation and patient transfer
Natural Disaster Affecting Hospital	Extensive regional wildfire or earthquake	Rapid hospital evacuation and patient transfer or implementation of crisis standards of care

hospitalists play critical roles for continuity of care for hospitalized disaster victims.

Therefore, we propose a means for incorporating hospitalists into the coordinated hospital disaster response effort, first by providing hospitalists with an overview of disaster management principles to allow their engagement with hospitals' disaster management system with working fluency and second, by proposing a framework for hospitalist involvement in hospital emergency response. These recommendations stem from our experience and from similar recommendations from a number of evidence-based articles on intensive care medicine, disaster preparedness, and emergency medicine literature cited in this article. To our knowledge, no evidence-based literature discusses hospital medicine or internal medicine specific to emergency preparedness. We aim to change such condition with this article.

KEY PRINCIPLES OF INCIDENT MANAGEMENT AND PREPAREDNESS: A PRIMER FOR HOSPITALISTS

Effective participation in disaster response and planning requires a basic understanding of the organizational structures for incident management.[18,19] Overall disaster response within the United States is guided by the National Response Framework, a national-level strategy that directs coordination between military and civilian response efforts, the latter of which are structured by the National Incident Management System (NIMS).[20] NIMS organizes emergency management across all government levels (federal, state, and local) and the private sector under a common operational language and command structure. Both systems grew out of analyses of the September 11, 2001 attacks and Hurricane Katrina, indicating the need for a wider systemic organization to response efforts.[1] State-level efforts are designed to mobilize resources to assist in community-level operations. Incident management always falls to the local authorities. At this local level, discrete hospitals often take part in healthcare coalitions that act in conjunction with other health entities, local public health departments, and emergency medical services, forming a multiagency coordination system.[5] This healthcare coalition (emergency support function #8 health and medical), in support of emergency managers of city and county governments, forms the core of the medical response. One commonality to all emergency management is the concept of an "all-hazards" approach, which aims to develop a broad and flexible strategy for efficient management of nearly any type of incident. This "all-hazards" approach allows effective management through each of the four phases of incident management: preparation, response, recovery, and ongoing mitigation.

Direct supervision over incident management is achieved through an Incident Command System (ICS), a hierarchical organization of positions involved in response. The top supervisory structure of ICS (Incident Command and General Staff) is the same regardless of the locale in which it operates, allowing coherent interoperability with other agencies. Incidents of any size are managed with a scalable approach; subordinate ICS positions, which are tailored according to specific needs, can be activated as needed. Healthcare implementation of the ICS structure led to the development of the Hospital Incident Command System (HICS), which now serves as the national standard for hospital-based incident management and facilitates the capacity of individual hospitals to coordinate with other resources regionally and is a part of NIMS for emergency response (Figure 1).[21] The success of HICS-led regulatory agencies (namely the Centers for Medicare and Medicaid Services and the Joint Commission) to require ICS/HICS in-hospital incident response plans.[22] The most recent HICS (Version V) excludes physician involvement in the overall management chart. However, we demonstrate how the inherent flexibility in ICS can adapt to involve hospitalists. Although HICS serves as a backbone that requires institutionally specific modifications, other institutions, such as ours, commonly have entire branches or positions renamed, reapportioned, or created to fill their specific needs. Specialized training in ICS, NIMS, and other aspects of hospital emergency response is beyond the scope of this article but is available for free through the Department of Homeland Security and FEMA.[23]

Perhaps, the defining feature of ICS/HICS is its expandability, allowing the response efforts to be scaled and tailored in size, scope, and complexity of that of the incident.[24] At the same time, the principles of span of control and unity of com-

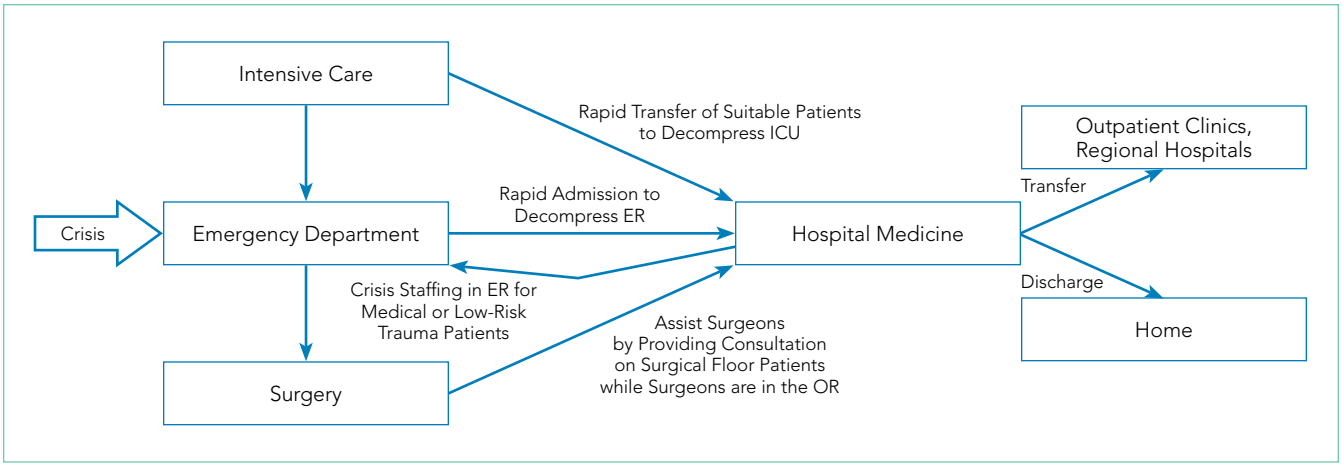

FIG 1. Hospital Medicine Master Flow.
Abbreviations: ER, emergency room; ICU, intensive care unit; OR, operating room.

mand promote efficient command structure by mandating each participant within the disaster response process to report to only one superior, whereas these superiors are limited to a manageable number of subordinates. For example, in Figure 2, all Strike Team Leaders report to the Hospitalist Unit Leader. Each strike team itself is comprised of approximately five similar assets (such as two physicians, two residents, and an advance practice provider).

PROPOSED FRAMEWORK FOR HOSPITALIST INVOLVEMENT

Although incidents vary in terms of their severity, acuity of onset, duration, and composition of patients, a defining feature of MCIs is the rapid surge of patients with acute needs. Many MCIs are easily absorbed by local facilities. However, smaller hospitals or hospitals receiving patients from larger-scale incidents may become overwhelmed, in which larger incidents may result in an acute surge of over 20% of hospital capacity.[13] Moreover, hospital surge capabilities have markedly diminished over the past decade due to overcrowding of emergency rooms, in part by admitted patients occupying the room space within the ED ("boarding"), further decreasing the hospitals' capacities to accept new patients.[25]

Our proposed framework for hospitalist involvement in MCI disaster response focuses on such a situation, with emphasis on augmentation of hospital surge capacity and facilitation of patient throughput and discharge. Notably, these goals are modified from the standard HICS architecture (Figures 1-2 and Table

TABLE 2. **Summary of Targeted Hospitalist Goals during Hospital Incident Response**

Goal and Rationale	Strike Team	Patient Example
1. Rapid intake of pending ER admits to medicine services *Rationale: free up ER bed space for incoming incident patients*	Admissions and Internal Transfers In Strike Team	32-year-old male presented to ER before incident with probable diabetic ketoacidosis, but full chemistry panel has not yet returned
2. Rapid intake of incident patients requiring admission to medicine services *Rationale: efficient intake of medicine admissions*	Admissions and Internal Transfers In Strike Team	55-year-old male who developed a non-ST segment elevation myocardial infarction while fleeing incident (no other injuries)
3. Offload noncritically ill patients from acute-care services *Rationale: free up bed space and staff on acute-care services*	Surgical Comanagement and Consulting Strike Team or Admissions and Internal Transfers In Strike Team	50-year-old female admitted to surgery 3 days prior to incident, now on postoperative day number 1 after laparoscopic cholecystectomy for gallstone-induced pancreatitis
4. Provide consultative medical management for incident patients on acute-care services *Rationale: assist in floor-level medical management of staff-limited services*	Surgical Comanagement and Consulting Strike Team	24-year-old female incident victim following rapid operative repair of lacerated femoral artery due to a gunshot wound, previously in hemorrhagic shock, now in need of continued fluid resuscitation (supervise surgical intern managing patient)
5. Coordinate rapid discharge of patients from general and specialty medicine services *Rationale: free up hospital bed space*	Discharges and Transfers Out Strike Team	62-year-old male admitted for elective cardiac stenting, no postprocedure complication and may discharge immediately to home
6. Assist with minor trauma overflow *Rationale: assist acute-care services with triage management*	Discharges and Transfers Out Strike Team	68-year-old female with ankle sprain sustained while fleeing incident (otherwise medically stable)
7. Ensuring current census of patients continue to receive medical care *Rationale: maintain standard of care*	Continuity of Operations Strike Team	74-year-old male with community acquired pneumonia on 7 L per minute of oxygen and hospital day number 2

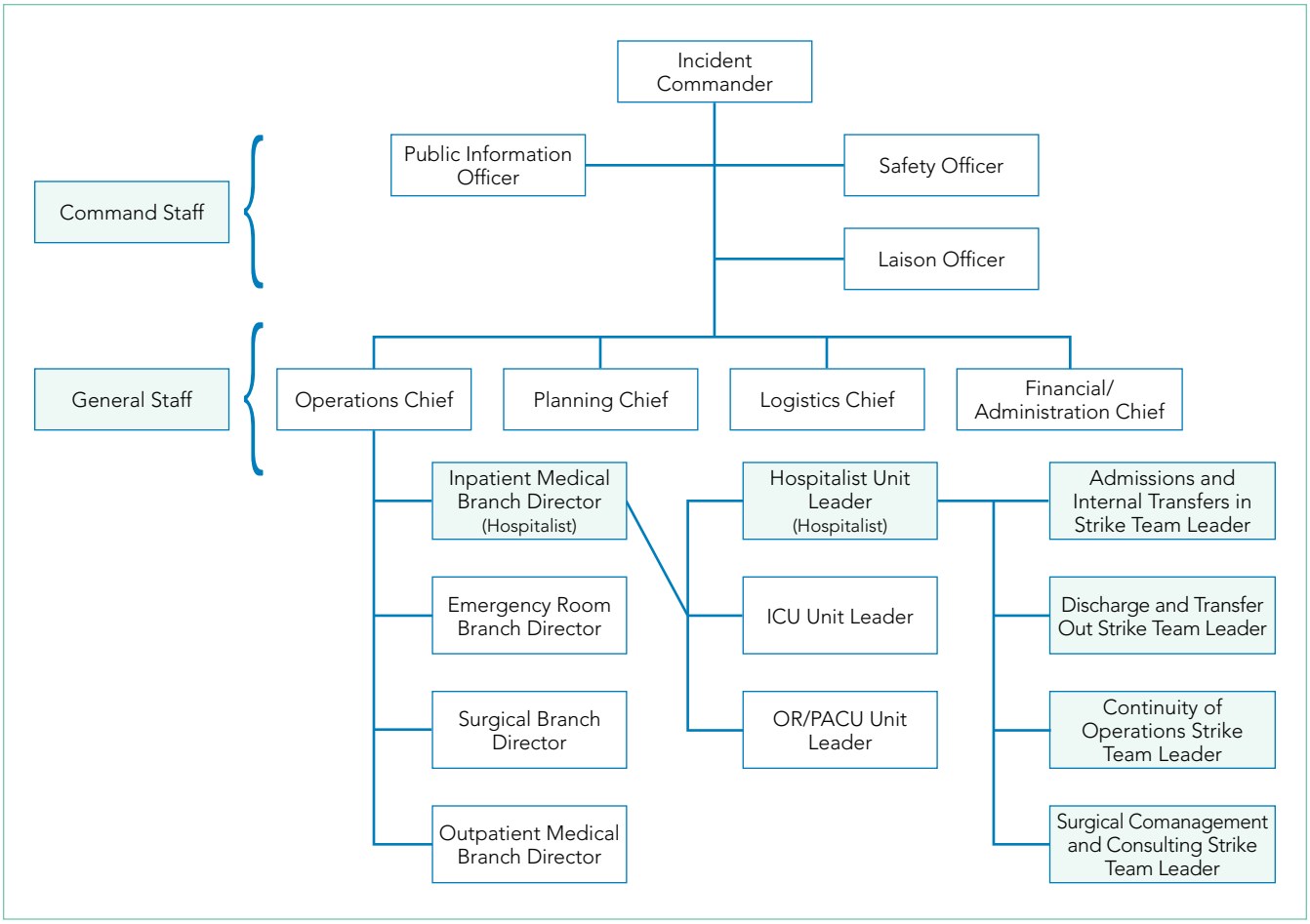

FIG 2. Incident Command Structure
Abbreviations: ICU, intensive care unit; OR, operating room; PACU, post-anesthesia care unit.

2). In this framework, hospitalists can play a critical role in decompressing the emergency room through admitting medical patients as rapidly as possible (even if preliminary workup is still pending), facilitating rapid discharge of patients to allow newer admissions to reach the floor, and prioritizing patients that could be transferred to other facilities or services and thus opening additional beds for admission (eg, accepting patients from the ICU or surgical floors to increase capacities on those services). Additionally, hospitalists can comanage surgical patients while surgeons are operating, assist intensivists with medical issues, and facilitate care of patients with minor injuries.

Using the HICS framework, each of those domains would be handled by a Strike Team led by one Team Leader whose goal is to operationalize various assets into a cohesive team specializing in those goals. Table 2 summarizes these goals, as presented in the context of patient examples.

To keep up with the ICS fundamentals, Hospitalist Unit Leaders may address a large MCI with all four strike teams or may only activate the strike teams needed for a less intensive MCI. For example, a bombing may result in a patient surge of 30% more than normal operations and thus demand a full response that includes all the strike teams noted above. By contrast, a bus accident with 20 injured patients may only require a Hospitalist Unit Leader to activate the "Admissions and Internal Transfers In" Strike Team to help offload a busy emergency room.

HOSPITALIST LEADERSHIP IN HOSPITAL EMERGENCY OPERATION PLAN DEVELOPMENT

Emergency management is comprised of four phases: preparation, response, recovery, and mitigation. The latter two phases are beyond the scope of this paper. Although most of our review has focused on modeling disaster response, hospitalist leadership remains critical in preparing for disasters. A disaster often psychologically overwhelms care providers, who feel compelled to help but are uncertain where to begin. To aid the members of a disaster response team, a state-of-the-art hospitalist group creates Job Action Sheets (JASs) for each position in their HICS organizational chart; these sheets codify how to respond and what roles are needed. These formal, protocolized sheets provide individuals assigned to these positions a description of their roles and responsibilities, including to whom they report and over whom they supervise, and include detailed checklists to aid in reaching critical milestones during the response phase. For example, the "Surgical Comanagement and Consulting" Strike Team Leader JAS would likely include the expectations of surgeons for assisting in patient management (ie, auto-consult-

ing on all postoperative patients) and whether nursing phone calls on surgical patients would be temporarily routed to the Strike Team during periods of OR surge.

Hospitalists are well suited as leaders in disaster preparation given their ability to coordinate care among a large spectrum of stakeholders. For example, case managers and social workers are essential members of a well-structured Discharge Strike Team. Their input is critical to ensure that disaster tactics – such as care coordination contracts with local skilled nursing facilities willing to expedite discharge in emergencies to their facilities – are in-place before a real MCI. During Hurricane Sandy, mass evacuation of affected hospitals was effective through the Healthcare Facility Evacuation Center (a healthcare coalition of the New York Hospital Association) but nevertheless plagued with issues regarding situational awareness, poor communication between facilities, and difficulty bundling patients with medical records to receiving facilities – items which can be identified, anticipated, and thoroughly vetted by hospitalists well in advance of a real-world evacuation.[26, 27]

As the Joint Commission mandates regular exercises of the emergency plan, protocols must be drilled regularly to uncover deficiencies and areas for improvement.[18] The most common failure patterns in Emergency Operation Plans (EOPs) include unrealistic and ineffective expectations and poor communication between different personnel and groups, resulting in confusion and obfuscation.[28-30] Therefore, EOPs need to be both comprehensive and realistic – characteristics that can only be tested through repeated drills. These characteristics can be tested during tabletop exercises, where hospitalists assume the role of a part of the ICS structure and with JAS in hand, attempt to reason how to respond to a given scenario.[31] Our experience is that small-scale drills conducted more frequently than the bare minimum mandated by the Joint Commission are far more effective for success in real-life situations.

Although no hospital EOP can anticipate every contingency, hospitalists can proactively practice contingency planning for sustained system-wide mass effect incidents, in which hospitals are unable to maintain normal operations and shift from standard to crisis conventions of care. For example, mass effect incidents (ie, hospital damage from an earthquake or a massive and persistent regional power failure), require planning for how a hospital-wide mass evacuation would unfold and how efforts from multiple ancillary hospital services (engineering, nursing, security, and patient transport) would be integrated. As of 2015, over 90% of hospitals have adopted an electronic health record, but only two-thirds of hospitals feature EOPs for information technology failures.[32,33] Given the large footprint of hospitalists in clinical practice, HICS principles appear ripe for application in IT outages and through development of ICS positions structured specifically to this type of contingency.[34]

CONCLUSION

Disasters unfold rapidly with marked patient surges and the potential to strain healthcare systems over an extended period. However, in both instances, hospitalists are possibly some of the most qualified clinicians to prepare for and respond to such events. Hospitalists need to assume a leadership role in emergency preparedness to integrate seamlessly into hospital incident command structures and to shape the interdepartmental relationships vital to success – skills at which hospitalists excel. Although no plan can address all possible disasters, familiarity with HICS and well-prepared and well-written JASs should help groups respond and succeed in almost all hazards.

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Inferior Vena Cava Filter Placement in Patients with Venous Thromboembolism without Contraindication to Anticoagulation

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The "Things We Do for No Reason" (TWDFNR) series reviews practices that have become common parts of hospital care but may provide little value to our patients. Practices reviewed in the TWDFNR series do not represent "black and white" conclusions or clinical practice standards but are meant as a starting place for research and active discussions among hospitalists and patients. We invite you to be part of that discussion.

Anticoagulation is the cornerstone of acute venous thromboembolism (VTE) management. Nonetheless, the use of inferior vena cava (IVC) filters in addition to anticoagulation is increasing, with wide variation in practice patterns and a growing recognition of filter-related complications. Rigorous randomized controlled data demonstrating that IVC filters, particularly the increasingly commonly placed retrievable filters, provide a mortality benefit are sparse. Given our review of IVC filter use and the lack of evidence demonstrating that IVC filters provide a mortality benefit, we recommend using anticoagulation alone for stable medical service patients admitted with acute VTE. In nuanced cases, hospitalists should engage in multidisciplinary care to develop individualized treatment options.

CASE PRESENTATION

A 65-year-old woman with a history of diabetes mellitus, metastatic breast cancer, and peptic ulcer disease presents to the Emergency Department for the evaluation of right thigh swelling, chest pain, and dyspnea after a transcontinental flight. Physical examination is notable for a pulse of 114 beats per minute, blood pressure of 136/93 mm Hg, respiratory rate of 14 breaths per minute, oxygen saturation of 95% on room air, and swelling of the right thigh. Computerized tomography imaging demonstrates multiple bilateral pulmonary emboli. Emergency department physicians begin anticoagulation and inform you that they have ordered the placement of a retrievable inferior vena cava (IVC) filter.

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BACKGROUND

Acute venous thromboembolism (VTE) accounts for more than 500,000 hospitalizations in the United States each year.[1] Although the management of VTE centers around anticoagulation, the concurrent use of IVC filters has increased over the past several decades.[2] Several observational studies have attempted to quantify IVC filter usage and have shown that overall filter placement has increased at an impressive rate. Within two decades, the number of patients undergoing IVC filter placement has increased nearly 25 times from 2,000 in 1979 to 49,000 in 1999.[2] Recent Medicare data show that claims for IVC filter placement procedures have increased from 30,756 in 1999 to 65,041 in 2008.[3] IVC filter placement rates are higher in the US than in other developed countries; one review projected that in 2012, the IVC filter placement rate in a given population in the US is 25 times higher than that in a similar population in Europe.[4]

The guidelines for IVC filter usage are largely based on expert opinion, and solid data regarding this intervention are lacking. This combination is problematic, especially because the practice is becoming commonplace, and filter-related complications are increasingly recognized. Additionally, the appropriateness of filter use varies among providers, as evidenced by a retrospective study in which three VTE experts reviewed medical records to determine the appropriateness of filter placement. They unanimously agreed that filter use was appropriate in 51% of the cases, unanimously agreed that filter use was inappropriate in 26% of the cases, and lacked consensus on the appropriateness of filter use in 23% of the cases.[5] The striking lack of consensus among experts underscores the wide range of opinion regarding the appropriateness of IVC filter placement on a case-by-case basis. Moreover, evidence suggests that physician adherence to guidelines for appropriate IVC filter use is suboptimal. One single-center study showed that only 43.5% of filters placed by interventional radiology practitioners met the guidelines established by the American College of Chest Physicians (ACCP), with a slightly increased percentage of filter placement meeting guidelines if the requesting provider is an IM-trained physician.[6]

WHY YOU MIGHT THINK IVC FILTER PLACEMENT IS HELPFUL IN PATIENTS WITH VTE WITHOUT CONTRAINDICATION TO ANTICOAGULATION

In theory, the concept of IVC filters makes intuitive sense—filters block the ascent of any thrombus from the lower extremities to prevent the feared complication of a pulmonary

embolism (PE). Unfortunately, rigorous data are limited, and consensus guidelines vary between different specialty organizations, further obfuscating the role of IVC filter placement in the management of VTE. For example, the ACCP recommends against the use of IVC filters in most patients with VTE receiving anticoagulation and does not list any prophylactic indications.[7,8] Meanwhile, the Society of Interventional Radiology lists prophylactic indications for IVC filter placement in certain patient populations, such patients with a risk of VTE and a high risk of bleeding, and notes numerous relative indications for IVC filter placement.[8] Notably, these differences in expert opinion likely influence practice patterns, as evidenced by the increase in IVC filter placement for relative indications.[9,10]

WHY IVC FILTERS PLACEMENT IN PATIENTS WITH VTE WHO CAN BE ANTICOAGULATED IS NOT HELPFUL

The Prevention du Risque d'Embolie Pulmonaire par Interruption Cave (PRECIP) trial is the most robust study supporting the 2016 ACCP recommendation against IVC filter use in patients that can receive anticoagulation.[7,11] This study randomized 400 patients with deep vein thrombosis (DVT) at high risk for PE to anticoagulation with or without permanent filter placement to address VTE and mortality rates associated with IVC filter placement. The trial showed that the VTE burden shifts in the presence of IVC filters. At 2-year follow-up, the group with IVC filters had nonsignificantly fewer PEs than the control group and an increased incidence of DVT. Mortality rates did not differ between groups.[11] At eight-year follow-up this shift in VTE burden is again seen given that the number of PEs in patients who received IVC filters decreased and the incidence of DVTs increased. Again, mortality did not differ between groups.[12] A subsequent study randomized 399 patients with DVT and acute symptomatic PE with at least one additional marker of severity to anticoagulation with or without retrievable IVC filter placement and showed no difference in recurrent PE or mortality at 3 or 6 months.[13] These results argue against placing retrievable filters in patients receiving anticoagulation.

The identification of associated adverse events further favor the judicious use of IVC filters. A retrospective review of the long-term complications of IVC filters based on imaging data showed a 14% fracture rate, 13% IVC thrombosis rate, and a 48% perforation rate.[14] Multiple studies have shown that the associated complication rates of retrievable filters are higher than those of permanent filters; such an association is concerning given that retrievable filter usage exceeds permanent filter usage.[14,15] The increase in retrievable filter usage is likely attributable to their attractive risk-benefit calculation. In theory, retrievable IVC filters should be perfect for patients who have conditions that increase VTE risk but create temporary contraindications, such as trauma or major surgery, to anticoagulation. However, anticoagulation is preferred over IVC filters in the long term because the complication rates of IVC filters increase with dwell time.[16] Given the reports of adverse events and concern that IVC filters are not appropriately removed, the Food and Drug Administration recommends removing retrievable IVC filters once the risk of filters outweighs the benefits, which appears to be 29-54 days after implantation.[17] However, successful retrieval rates are low, both because of the low rates of removal attempts and because of the interference of complications, such as embedded or thrombosed filters, with removal.[10,18] As an example, in a retrospective review of all patients who received an IVC filter at an academic medical center over the period of 2003-2011, nearly 25% of patients were discharged on anticoagulation after IVC filter placement.[10] This suggests that their contraindication to anticoagulation and need for IVC placement have passed by the time of discharge. Nevertheless, clinicians attempted filter retrieval in only 9.6% of these patients, representing a significant missed opportunity of treatment with anticoagulation rather than IVC filters.[10]

Factors such as filter plan documentation, hematology involvement, patient age ≤70 years, and establishment of dedicated IVC filter clinics are correlated with improved rates of filter removal; these correlations emphasize the importance of a clear follow-up plan in the timely removal of these devices.[18,19]

WHEN MIGHT IT BE HELPFUL TO PLACE IVC FILTERS IN PATIENTS WITH NO CONTRAINDICATION TO ANTICOAGULATION?

IVC filter placement is inappropriate in the vast majority of patients with VTE who can be anticoagulated. However the ACCP does acknowledge that a small subset of patients – specifically, those with severe or massive PE – may fall outside this guideline.[7] Clinicians fear that these patients have low cardiopulmonary reserve and may experience hemodynamic collapse and death with another "hit" from a recurrent PE. This recommendation is consistent with the evidence that in unstable patients with PE, IVC filter placement is associated with decreased in-hospital mortality.[20] Data remain limited for this situation, and the decision to place an IVC filter in anticoagulated but unstable patients is an individualized one.

WHAT YOU SHOULD DO INSTEAD: REFRAIN FROM IVC FILTER PLACEMENT AND TREAT WITH SYSTEMIC ANTICOAGULATION

In stable patients admitted to the medical service with VTE and who can be anticoagulated, there is little evidence that placement of an IVC filter will improve short- or long-term mortality. Hospitalists should anticoagulate these patients with a vitamin-K antagonist, heparin product, or novel oral anticoagulants.

RECOMMENDATIONS

- Anticoagulate hemodynamically stable patients who are admitted to the medical service with VTE and who do not have a contraindication to anticoagulation. Do not place a permanent or retrievable IVC filter.
- IVC filter placement may benefit unstable patients who may experience hemodynamic collapse with an increased PE burden. IVC filter placement should be discussed with a multidisciplinary team.
- When discharging a patient with an IVC filter, hospitalists should improve retrieval rates by scheduling subsequent re-

moval. The discharge summary should contain information about the IVC filter, as well as clear instructions regarding the plan for removal. The instructions should include radiology follow-up information and the designation of responsible physicians in case of questions.

CONCLUSION

Although IVC filter use is increasing, the evidence does not support their use in hemodynamically stable patients who can be anticoagulated. The patient described in the initial case has no contraindication to systemic anticoagulation. Therefore, she should be started on anticoagulation, and an IVC filter should not be placed.

Do you think this is a low-value practice? Is this truly a "Thing We Do for No Reason?" Share what you do in your practice and join in the conversation online by retweeting it on Twitter (#TWDFNR) and liking it on Facebook. We invite you to propose ideas for other "Things We Do for No Reason" topics by emailingTWDFNR@hospitalmedicine.org.

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A Shooting in the Hospital: When Domestic Violence Occurs in the Hospital, Reflection, and Response

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On September 12, 2017, a son walked into his mother's room in the surgical intensive care unit (ICU) of Dartmouth-Hitchcock Medical Center (DHMC) in Lebanon, New Hampshire, and shot her with a handgun. As an actively practicing hospitalist and the Chief Clinical Officer for DHMC, I immediately became involved with our hospitals' response to domestic violence, a homicide, and an issue that to this point we felt lived outside our walls.

Several hospital systems are struggling with violence entering their institutions, particularly in their psychiatry and emergency service areas, fueled in part by untreated mental health and the rising opioid epidemic. Although gun violence in hospitals is indeed rare, inside the hospital, it occurs often in the emergency department.[1] In New Hampshire, we suffer from a woefully underfunded state mental health infrastructure and one of the highest opioid death rates in the United States.[2]

DHMC is a 400-bed academic medical center, level 1 trauma center, and a National Cancer Institute (NCI)-designated cancer center that serves New Hampshire and eastern Vermont with its community and critical access hospitals and community group practices across the two states. With a wide geographic catchment area, our academic hospital at DHMC has one of the highest case-mix indices in the northeastern United States and is in the top 30 among hospitals of >300 beds in the United States.

After the shooting, the patient's son left the ICU without targeting anyone else, and despite video surveillance systems, he was not seen leaving the hospital. At the same time, a Code Blue was called to address the victim and her needs. The Critical Care staff struggled to attend to and resuscitate the victim, and my Medicine team, on call that day, was paged and rushed to the ICU to assist. In a unit trained to manage the sequelae of trauma, this event was painfully surreal. Ultimately, the surgical critical-care physician, attending to the patient, ended the resuscitation efforts when it was clear that the patient, now a homicide victim, could not be saved.

With the shooter's whereabouts unknown, a Code Silver (Active Shooter alert) was called. Then, following our "Run-Hide-Fight" training protocol, staff, patients, and visitors exited the building in large numbers and those that could not, sheltered in place. The operating room and the emergency department were secured and continued to function.

More than 160 law enforcement officers, including trained tactical and SWAT teams, from 13 different agencies arrived on scene. Ninety minutes after the shooting, the son was apprehended at a police traffic checkpoint, attempting to leave the hospital campus.

Our involvement in this event did not end at this point. Concerned about the possibility of other suspects or devices left in the hospital, the law enforcement officers swept our hospital. With a 1.2 million square foot campus, this would take another two hours, during which we still provided care to our patients and asked the staff and families to continue to seek safe shelter.

The shock of this terrible day was immediate and profound, leading to a thorough debrief and systematic analysis of how we might improve our processes and in turn help other organizations that might unfortunately face similar situations.

We reflected on how to better secure our hospital and to strengthen our coordination and collaboration with law enforcement. We increased our security presence not only in the ICU but also in our emergency department and developed individual unit-based security measures. We fast-tracked a unit-based shutdown plan that was already in process and increased our commitments to plan and drill for larger scenarios in conjunction with law enforcement agencies.

The physical location of our hospital was important in how our response unfolded. DHMC's unique rural location in northern New England added challenges specific to our location, which may provide an opportunity for other hospitals to consider. Although we were able to provide care, water, and transport during this tragedy on a warm day in September, caring for thousands of people outside a hospital during a typical subzero February would be a different story.

Communication during the event and how specifically to ask people to act were identified as a key area of improvement. We realized that our language and training around the various codes lacked clarity and specificity. As is familiar to many, in our hospital with Red, Blue, Black, Purple, and White codes, some staff (and certainly families and visitors) were not sure what to do in a "Code Silver." We worked to better define our language so that in a future event or in a drill, we would state in plain language that we have "an active shooter" or a "violence with weapons" event in progress with clear instructions on next steps. Our term "Run-Hide-Fight" was changed

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to "Avoid-Hide-Fight" to better reflect updated training and best practice for a future event. We revised our teaching and training materials and protocols, so that in the event of a similar situation, we could provide information in plain language, across numerous formats, and with some frequency to keep people apprised, even if the situation is not changing.

Our methods of ongoing communications were also reassessed. In our reviews, it became clear that the notification systems and the computer-based alerts seen on the computers of hospital staff were different from those at the medical school. Communication protocols on pagers and mobile phones and across social media such as Facebook and Twitter were redesigned. Though our institution has long had the ability to provide cell phone notifications during emergencies, not all employees and staff had elected to activate this feature. We also improved our speaker systems so that overhead paging and alerts could be heard outside the building.

Having improved personal reference materials on hand is important. We updated the cards attached to our ID badges with clear instructions about "active shooter" or "violence with weapon" situations. We also developed different response scenarios dependent on the campus location. An event in the ICU, for example, might require leaving the scene, although sheltering-in-place might be more appropriate for an offsite administrative building.

A significant challenge to our active-shooter situation was making sure that our staff, patients, visitors, and their families were adequately supported following the event. Learning from the experiences of other hospitals and communities, we undertook a deliberate process of preparedness and healing.[3] From our surgical ICU to our distant community group practices, we provided communication and avenues for personal support. Our Employee Assistance Program provided 24/7 support in a conference room in the surgical ICU and in other areas, on and off site, for all staff at Dartmouth-Hitchcock. The shooting affected those in the vicinity, as well as far away. Staff who had experienced domestic and other violence in their past were impacted in ways that required special care and attention. Some who were in adjacent rooms during the event were able to return to work immediately, whereas other staff, in separate units and more distant clinics, struggled and required leaves of absence. Through this event, we witnessed the personal and deep psychological impact of such violence. We held town halls, updated daily communications from our Incident Command Team, and maintained an open dialog across the organization.

In reflection, it is challenging to face this experience without the greater context of what we unfortunately experience all too often in America today. We have seen the spectrum from the shootings at Marjory Stoneman Douglas High School in Parkland, Florida, to the isolated events that rarely reach our national news and collective consciousness. It seems that we have already experienced a shooting at a school every week in the US.

There is even an overlap seen in domestic and mass shootings as we saw in the Sandy Hook Elementary School shootings in 2012, in which the tragic event was preceded by the shooter murdering his mother in her home.[4] Today, in the US, women are disproportionally the subject of domestic violence, and more than half of all killed are done so by a male family member. The presence of a gun in domestic violence situations increases the risk for homicide for women by 500%.[5-7] Our experience indeed mirrored this reality.

Many readers of this piece will recognize how similar their situation is to that of our hospital, that this happens elsewhere, not here. Although my institution has faced this as a tragedy that has tested our organization, one cannot also be deeply troubled by the greater impact of domestic and gun violence on healthcare and the American society today. Our staff and physicians have been witness and at times subject to such violence, and this experience has now made it even more poignant. Ultimately, and sadly, we feel that we are more prepared.

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Perioperative Management of ACE Inhibitor Therapy: Challenges of Clinical Decision Making Based on Surrogate Endpoints

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Renin-angiotensin inhibitors, which include angiotensin-converting enzyme (ACE) inhibitors and angiotensin II receptor blockers (ARBs), have demonstrated benefits in the treatment of several common cardiovascular and renal conditions. For example, they are prescribed to individuals with hypertension, heart failure with reduced ejection fraction (HFrEF), prior myocardial infarction, and chronic kidney disease with proteinuria. Perhaps unsurprisingly, many individuals presenting for surgery are already on long-term ACE inhibitor or ARB therapy. For example, such individuals comprised approximately one-third of the sample in the Vascular Events In Noncardiac Surgery Patients Cohort Evaluation (VISION) multicenter prospective cohort study of major inpatient noncardiac surgery.[1]

There is considerable controversy regarding how best to manage these cardiovascular medications during the perioperative period. The critical question pertains to whether renin-angiotensin inhibitors should be temporarily withdrawn 24 hours before surgery or continued uninterrupted up to the day of surgery. The main argument for withdrawing these medications is concern that they cause perioperative hypotension. For example, a recent systematic review of randomized controlled trials (RCTs) and cohort studies found that preoperative continuation of renin-angiotensin inhibitor therapy led to a significantly increased risk of intraoperative hypotension, albeit without associated effects on rates of death, major adverse cardiac events, or postoperative hypotension.[2] Notably, randomized trial evidence in this meta-analysis was limited to only five trials with a total of 774 participants. Conversely, preoperative interruption of renin-angiotensin inhibitor therapy also has risks. For example, there is a potential for unintended permanent discontinuation of medications with long-term benefits.[3] Furthermore, some prior cohort studies have demonstrated that the failure to resume renin-angiotensin inhibitor therapy promptly after surgery is associated with an elevated risk of postoperative mortality.[4,5] While these studies have methodological limitations related to survivorship bias and unmeasured confounders, they still raise concerns that the abrupt withdrawal of long-term cardiovascular therapy before major surgery can have adverse effects. While ACE inhibitor withdrawal has not shown adverse physiological effects in the perioperative setting, it has led to rebound myocardial ischemia in patients with prior myocardial infarction.[6]

Given this controversy, there is variation across hospitals[1] and practice guidelines with respect to perioperative management of renin-angiotensin inhibitors. For example, the 2017 Canadian Cardiovascular Society guidelines recommend that renin-angiotensin inhibitors be stopped temporarily 24 hours before major inpatient surgery,[7] and the 2014 European guidelines recommend continuing therapy in patients with HFrEF but temporarily interrupting therapy in patients with hypertension.[8] The 2014 American Heart Association and American College of Cardiology guidelines suggest that either continuation or interruption are reasonable options, but any interrupted therapy should be restarted postoperatively as soon as clinically feasible.[9]

In this issue of the *Journal of Hospital Medicine*, Shiffermiller and colleagues present a single-center RCT that provides additional high-quality data to improve our understanding of this important clinical issue.[10] In a sample of 275 patients undergoing nonvascular inpatient noncardiac surgery, omission of the final dose of preoperative ACE inhibitor therapy reduced the risk of intraoperative hypotension across multiple definitions, including any episode of systolic blood pressure less than 80 mm Hg (number needed to treat: 8), any episode of a systolic blood pressure less than 80 mm Hg necessitating vasopressor therapy (number needed to treat: 6), and total cumulative duration of intraoperative systolic blood pressure less than 80 mm Hg. In addition, the investigators found that preoperative interruption of ACE inhibitor therapy reduced the risk of postoperative hypotension (number needed to treat: 9), increased the risk of severe postoperative hypertension (number needed to harm: 9), and had no effect on clinical outcomes (eg, acute kidney injury, major adverse cardiac events). In conjunction with a recent systematic review,[2] these new data demonstrate that temporary preoperative discontinuation of renin-angiotensin inhibitors leads to reduced risks of intraoperative and postoperative hypotension, with the only major identified risk being episodes of postoperative hypertension.

This current evidence base suggests that, in most cases, perioperative physicians should temporarily interrupt renin-angiotensin inhibitor therapy before inpatient noncardiac surgery, provided that protocols are in place to resume treatment postoperatively as soon as clinically feasible. Nonetheless, clinicians must also be cognizant of the key limitations to current data,

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namely that hypotension, be it intraoperative or postoperative, remains essentially a surrogate endpoint.[11,12] Stated otherwise, the clinical importance of perioperative hypotension is largely predicated on its close association with clinically important or patient-relevant outcomes such as cardiovascular complications, acute kidney injury, and death.[13–16] There is an implicit assumption that a reduction in the risk of hypotension will necessarily lead to reduced rates of clinical adverse events. This assumption is unlikely to be true, especially since many different underlying mechanisms lead to hypotension in the dynamic perioperative environment, including decreased cardiac contractility, decreased heart rate, decreased intravascular volume status, and vasodilation. Consistent with this possibility, different perioperative interventions with similar effects on hypotension have shown quite different effects on clinical outcomes. For example, epidural analgesia invariably reduces perioperative blood pressure, yet it does not appear to increase the risk of postoperative complications.[17] Similarly, both beta-blockers and clonidine increase the risk of significant perioperative hypotension and bradycardia, yet only beta-blockers appear to lead to increased rates of mortality after noncardiac surgery.[18,19] Thus, the relationship between perioperative hypotension and outcomes is clearly complex. Unless a RCT demonstrates that a hypotension-reduction strategy leads to an improvement in clinical outcomes,[20] perioperative physicians should not assume that prevention of hypotension will always lead to improvements in patient-relevant clinical outcomes. Similar assumptions about other surrogate endpoints in cardiovascular medicine have sometimes been spectacularly incorrect.[12,21] To more definitively address this important clinical issue, RCTs must be specifically designed to compare the effects of renin-angiotensin inhibitor therapy withdrawal versus continuation on patient-relevant and clinically important outcomes, such as death, myocardial infarction, and stroke. Fortunately, some ongoing trials will address this question, either directly (ClinicalTrials.gov NCT03374449) or as a component of a hypotension-avoidance strategy (ClinicalTrials.gov NCT03505723).

Overall, perioperative physicians should now adopt the standard approach of temporarily withdrawing renin-angiotensin inhibitor therapy 24 hours before major inpatient noncardiac surgery. Nonetheless, they should do so cautiously, recognizing that the data underpinning this strategy remain weak. As with many aspects of perioperative medicine, more research remains needed.

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In Reference to "Improving the Safety of Opioid Use for Acute Noncancer Pain in Hospitalized Adults: A Consensus Statement from the Society of Hospital Medicine"

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We read with great interest the consensus statement on improving the safety of opioid use for acute noncancer pain by Herzig et al.[1] We strongly support the recommendations outlined in the document.

However, we would like to advocate for an additional recommendation that was considered but not included by the authors. Given the proven benefit—with minimal risk—in providing naloxone to patients and family members, we encourage naloxone prescriptions at discharge for all patients at risk for opioid overdose independent of therapy duration.[2] Even opioid-naive patients who are prescribed opioids at hospital discharge have a significantly higher risk for chronic opioid use.[3]

We support extrapolating recommendations from the Centers for Disease Control and Prevention and Substance Abuse and Mental Health Services Administration to prescribe naloxone to all patients at discharge who are at risk for an opioid overdose, including those with a history of overdose or substance use disorder as well as those receiving a prescription of ≥50 mg morphine equivalents per day or who use opioids and benzodiazepines.[4,5]

Given the current barriers to healthcare access, prescribing naloxone at discharge may be a rare opportunity to provide a potential life-saving intervention to prevent a fatal opioid overdose.

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Reply to "In Reference to Improving the Safety of Opioid Use for Acute Noncancer Pain in Hospitalized Adults: A Consensus Statement from the Society of Hospital Medicine"

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Hall et al. draw attention to the important question of whether some patients may benefit from a naloxone prescription when discharged from the hospital with a short-term opioid prescription for acute pain. Although all members of the working group agreed that naloxone is appropriate in some cases, we were hesitant to recommend this as a standard practice for several reasons.

First, the intent of our Consensus Statement[1] was to synthesize and summarize the areas of consensus in existing guidelines; none of the existing guidelines included in our systematic review make a recommendation for naloxone prescription in the setting of short-term opioid use for acute pain.[2] We believe that this may relate to the fact that the risk factors for overdose and the threshold of risk above which naloxone would be beneficial have yet to be defined for this population and are likely to differ from those defined in patients using opioids chronically.

Additionally, if practitioners follow the recommendations to limit prescribing for acute pain to the minimum dose and duration of an opioid that was presumably administered in the hospital with an observed response, then the risk of overdose and the potential benefit of naloxone will decrease. Furthermore, emerging data from randomized controlled trials demonstrating noninferiority of nonopioid analgesics in the management of acute pain suggest that we should not so readily presume opioids to be the necessary or the best option.[3-5] Data questioning the benefits of opioids over other safer therapies have particularly important implications for patients in whom the risks are felt to be high enough to warrant consideration of naloxone.

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