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ORIGINAL CONTRIBUTION

CME

Emergency department condition acuity, length of stay, and revisits among deaf and hard-of-hearing patients: A retrospective chart review

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Abstract

Objective: Deaf and hard-of-hearing (DHH) patients are understudied in emergency medicine health services research. Theory and limited evidence suggest that DHH patients are at higher risk of emergency department (ED) utilization and poorer quality of care. This study assessed ED condition acuity, length of stay (LOS), and acute ED revisits among DHH patients. We hypothesized that DHH patients would experience poorer ED care outcomes.

Methods: We conducted a retrospective chart review of a single health care system using data from a large academic medical center in the southeast United States. Data were received from the medical center's data office, and we sampled patients and encounters from between June 2011 and April 2020. We compared DHH American Sign Language (ASL) users ($n = 108$), DHH English speakers ($n = 358$), and non-DHH English speakers ($n = 302$). We used multilevel modeling to assess the differences among patient segments in outcomes related to ED use and care.

Results: As hypothesized, DHH ASL users had longer ED LOS than non-DHH English speakers, on average 30 min longer. Differences in ED condition acuity, measured through Emergency Severity Index and triage pain scale, were not statistically significant. DHH English speakers represented a majority (61%) of acute ED revisit encounters.

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Conclusions: Our study identified that DHH ASL users have longer ED LOS than non-DHH English speakers. Additional research is needed to further explain the association between DHH status and ED care outcomes (including ED LOS and acute revisit), which may be used to identify intervention targets to improve health equity.

KEYWORDS
condition acuity, deaf and hard-of-hearing, emergency department, health care quality, length of stay

INTRODUCTION

Deaf and hard-of-hearing (DHH) patients are a government-delineated priority population for health services research, comprising 15% to 17% of people (or between 49 and 55 million) in the United States.[1,2] Although heterogenous with respect to sociomedical characteristics of hearing loss (e.g., age of onset, etiology, language modality), this population experiences disparities in social outcomes (e.g., education and un/underemployment) and health inequities across all major domains of health.[3] These inequities in social determinants are likely due to a fundamental cause[4]: a system of oppression known as audism, which privileges being non-DHH in society.[5] Audism has been linked to poorer access to resources that promote healthier behavior and improved health care navigation (e.g., health literacy, English proficiency, general communication access),[3,6,7] likely contributing to this population's higher risk of emergency department (ED) utilization when compared to non-DHH patients.[3,8–12]

Despite evidence that DHH patients are more likely to use the ED than non-DHH patients,[3,8–12] to our knowledge, there have been no comparative studies that have primarily assessed indicators of ED care processes, including condition acuity, length of stay (LOS), and revisits among DHH patients. Further, assessing the intersection of language modality (i.e., American Sign Language [ASL] vs. spoken English) and being DHH is crucial to understanding opportunities to improve ED care for this population given the association of patient satisfaction and health care service uptake with adequate language access.[13,14] DHH English speakers are more likely to have adult-onset hearing loss (e.g., age-related hearing loss) and have better English proficiency than DHH ASL users.[3,6] ASL is a natural language distinct from English[15] and is used by at least 500,000 individuals in the United States.[16] As ASL is a distinct language and not known by most health care providers, providers require the use of an ASL interpreter to facilitate patient–provider communication.[17]

Preliminary descriptive studies, however, suggest that DHH patients who use ASL to communicate use the ED for less acute conditions than non-DHH English-speaking patients and also have higher risk of revisiting within a 36-month time frame.[8] This large time frame of ED revisits, however, does not provide information about acute ED revisits, which is of more interest to health services researchers. Other studies focused on ED care processes and quality indicators (e.g., LOS) found that patients who used an interpreter had longer LOS and more imaging studies[18]; this study, however, did not differentiate DHH ASL users and other non–English-speaking patient populations, decreasing the usability of these data to understand ED outcomes at intersection of disability and language modality. Furthermore, to our knowledge, there are no studies on the ED care outcomes analyzing DHH English-speaking patients as a distinctive patient group.

As ED utilization increases in the United States,[19,20] ED crowding remains a central concern for patient safety and patient health outcomes.[21–25] Patients who are Black, Hispanic, limited English proficient, or un/underinsured are at higher risk of experiencing the brunt of disparities in patient-centered care in the ED.[24–26] Theory and empirical evidence suggest that DHH patients experience similar disparities.[3] For example, DHH ASL users who require the use of an qualified interpreter may not receive a requested interpreter for hours, diminishing patient-centered communication and patient–provider trust and potentially increasing LOS.[3,27]

Therefore, the purpose of this study was to assess indicators of ED care-seeking and quality outcomes among DHH patients, segmenting by language modality. This study was conducted as a secondary quantitative aim of a larger explanatory sequential mixed-methods study investigating ED utilization among DHH patients.[3,12] In an explanatory sequential mixed-methods design, quantitative results inform the development of qualitative data collection procedures with the end goal of qualitative data being used to further explain quantitative findings.[28] In this current study, we hypothesized that DHH ASL users and DHH English speakers would be more likely to use the ED for conditions of lower acuity and pain and have longer ED LOS, than non-DHH English speakers. Lastly, as an exploratory aim, we assessed the prevalence of acute ED revisits (i.e., 9 days post–index ED encounter discharge) among each patient segment.

METHODS

Data source and sample

This study was designed as a retrospective chart review study, specifically comparing DHH ASL users, DHH English speakers, and non-DHH English speakers. Data are from a large academic medical center in the southeastern United States, which operates primary care clinics, specialty clinics, and hospitals in the region, including a main ED designated as a Level I trauma center and two full-service

emergency centers (all considered part of the ED). All data were provided by the office of the chief data officer of the medical center (i.e., no charts were reviewed/abstracted by the authors). The sampling frame consisted of patients who had used the medical center for any care between June 1, 2011, and April 3, 2020; these dates coincided with the beginning of the use of Epic at the medical center and the start of the study (before COVID-19 precautions were put in place in the region). DHH patients were identified using ICD-9-CM/ICD-10-CM hearing loss diagnosis codes and the associated language preference (i.e., English or ASL).

As described in previous papers,[12] the sample included 100% of DHH ASL users ($n = 277$), 1000 randomly sampled DHH English speakers, and 1000 randomly sampled non-DHH English speakers from the sample of patients served by the academic medical center. The sample size was determined based on previous studies[8,18] not formal power analysis.[29] The DHH English-speaking and non–DHH English-speaking samples were age-matched (on current age) to the age distribution of DHH ASL users to account for the confounding effect of age on hearing loss and poorer health outcomes. The analytic sample for this study included 108 DHH ASL users, 358 DHH English speakers, and 302 non-DHH English speakers who had used the ED. All study procedures were approved by the University of Florida's Institutional Review Board (201901488).

Measures

Outcome and covariate measures were selected based on the *Conceptual Model of Emergency Department Utilization among Deaf and Hard-of-Hearing Patients*[3] and resource/feasibility constraints based on structured data within the medical record. Alignment and operationalization between constructs in the conceptual model and variables used in this study are listed in Table S1.

Outcome measures

Outcome variables were measured at the encounter level and were nested within patients, as each patient may have multiple ED visits within the studied time frame. The outcome variables chosen were (1) Emergency Severity Index (ESI), (2) triage pain rating, (3) ED LOS, and (4) acute ED revisit.

ED condition acuity was conceptualized using two outcome variables: ESI classification and triage pain rating. The ESI is a five-level triage algorithm used to stratify patients based on encounter urgency and resource need.[30] The ESI classifies ESI 1 and ESI 2 as most urgent requiring lifesaving care or representing a high-risk situation, respectively. ESI 3, ESI 4, and ESI 5 are classified for encounters with lower condition acuity based on resource need, with higher resource need indicated by lower numbers. ESI scores were dichotomized to be "lower acuity" (ESI 3, ESI 4, or ESI 5) versus "high acuity" (ESI 1 or ESI 2).[30]

Triage pain ratings were measured using the Defense and Veterans Pain Rating Scale (DVPRS) 2.0. DVPRS is a pain scale that allows patients to rank their pain from 0 to 10, matched through a traffic light color-coding system, short descriptions, and illustrated facial expressions.[31] Given the use of additional visual aids,[32] this pain scale triaging system may be optimal for DHH patients.

ED LOS, in minutes, was calculated as the ED throughput time (from patient entry to disposition). Due to resource constraints, disposition (i.e., admission, treat and release) was not measured.

Lastly, we measured whether the ED encounter was a revisit to the ED within an acute time period, which may be indicative of discharge failure.[3,33] Acute ED revisit is operationalized in the literature using multiple time frames, including 48 h, 72 h, 7 days, and 30 days.[33,34] In this study, we chose a time period of 9 days. The period of 9 days is based on a study of ED discharges in Nebraska and Florida, which found that 9 days is the most appropriate cutoff for ED revisits.[35]

Covariates

Covariates were measured at both the encounter and the patient levels. As measures of ED burden, we accounted for ED census at time of encounter; we also adjusted for the encounter being in the past 36 months. The objective of including the latter was twofold: first, this variable allowed us to study ED utilization in the past 36 months (an outcome of interest in the larger study, unreported in this article), in addition to potential changes in ED policy over time. Other covariates were patient demographic characteristics, specifically age at time of encounter, gender, race, patient insured status, triage vital signs, and smoking status (combustible cigarettes).

Data analysis

This study sought to assess encounter-level outcomes that were nested within patients. We used frequencies, percentages, and means (with standard deviations) to describe the sample and outcome distributions. To test our hypotheses, we estimated multilevel (random-intercept) models in Mplus version 8.[36] Before estimating covariate adjusted models, we assessed the unconditional variance componence models to estimate within- and between-patient variance components. The intraclass correlation coefficient (ICC), calculated as the variance of between-patient differences over the sum of between- and within-patient differences, was used as a measure of between-patient variation.

To assess hypothesized differences in ESI classification between patient segments, we used multilevel logistic regression to estimate adjusted odds ratios. Encounter-level covariates were patient age, insured status, and whether the encounter was in the past 36 months; patient-level covariates were gender, race, and smoking status. Although vital signs may be helpful at triage, "an objective assessment of the patient, including the patient's chief complaint,

is often sufficient to categorize the patient as a higher acuity encounter (ESI level 1 or 2), or lower acuity encounter (ESI level 3, 4, or 5)."[30] Further, the ESI does not mandate the use of triage vital signs unless a patient is classified as ESI 3 (to determine whether the patient should move to ESI 2).[30] Therefore, triage vital signs were not included in the primary model. However, as vital signs are a helpful tool for acuity designations when communication barriers are present,[37] we conducted an additional analysis using categorical variables for triage vital signs within ESI-indicated danger zones (i.e., heart rate over 100 beats/min and respiratory rate over 20 breaths/min, respectively) and patient triage pain scores between 7 and 10.[30] (Triage blood pressure is not incorporated in the ESI vital sign algorithm, and oxygen saturation is only used if indicated.[30]) Hypothesized differences in patient pain rating (as a measure of condition acuity) were estimated by modeling DVPRS score collected at triage as a function of patient segment, patient demographic, encounter-level patient age, and insured status.

Lastly, we used multilevel negative binomial modeling to assess differences in ED LOS across the patient segments. ED LOS was modeled using a negative binomial multilevel model as a function of patient segment and patient demographic variables, and encounter-level age, insurance, ED census (based on time of encounter as a proportion of the maximum census in the study period), a binary variable indicating whether the encounter was in the past 36 months (to account for potential effects of time and changes in hospital policy), and whether the encounter was an acute revisit (within 9 days of index ED encounter). This model provides an incident rate ratio (IRR), which is a measure of LOS for a given independent variable. Estimation of the ICC of this negative binomial model was calculated as the variance of between-patient differences over the sum of between-patient differences and the dispersion parameter.[38] In all models, non–DHH English-speaker patient group was used as the referent, comparing them to DHH ASL-users and DHH English speakers.

RESULTS

Of the total sample, 39.0% of DHH ASL users ($n = 108$), 35.8% of DHH English speakers ($n = 358$), and 30.2% of non-DHH English speakers ($n = 302$) had an ED visit during the study time frame and were included in the analytic sample. These patients represented 446, 1521, and 823 ED encounters, respectively. The analytic sample was predominantly White and female and had an average age (at time of data extraction) of 48 years old (see Table 1). Encounter outcome distributions are described in Table 2 and are embedded in the results below.

Condition acuity

ESI

The majority of ED encounters were ranked as an ESI 3. The unconditional variance components model indicated that 20.7% of the total variance in ESI classification was at the patient level. Table 3 presents the results from the model explaining ESI classification, with and without danger vital signs included. When compared to non-DHH English speakers, neither DHH ASL users nor DHH English speakers had higher odds of being classified into lower-acuity ESI levels.

Triage pain

Patient triage pain scale ratings ranged from 0 to 10, with an average of 5.8 and a median of 7 (see Table 2). The unconditional model ICC was 24.4%, indicating that almost one-fourth of the variance in pain scale rating was at the patient level. The grand mean pain rating was 5.4, and there was significant patient-level and encounter-level variability. On average, patient-reported pain scores varied from the grand mean by 1.7, while encounter-level pain scores varied by 2.9. In the full model, neither of the DHH patient groups had pain scale ratings significantly different than non-DHH English speakers (see Table 4).

LOS

ED LOS ranged from 5 to 2796 min with an average LOS of 326 min (or slightly over 5 h) and a median of 262 min (or almost 4.5 h). The ICC indicated that 25.0% of the variance was at the patient level. When controlling for patient- and encounter-level characteristics, DHH ASL-using patients stayed in the ED 9% longer than non-DHH English-speaking patients (IRR 1.09, 95% CI 1.05–1.13, $p = 0.016$). On average, this equated to approximately 30 min longer ED LOS (95% CI 17–44 min). There were no significant differences between DHH English-speaking patients and non-DHH English speakers (Table 5).

Revisit

Out of 2790 ED encounters over the study period, 282 (10.1%) were acute revisits. We estimated the rate of revisit encounters by patient segment (i.e., number of revisit encounters/total encounters). Non-DHH English-speaking patients had the lowest point estimate rate of revisits (7.8%) while DHH English-speaking patients had the highest (11.3%); Clopper-Pearson 95% CIs for these estimates, however, were overlapping for all groups. Less than 10% (ICC 0.098) of the variance was at the patient level, indicating that the majority of variance in revisit outcomes were revisit encounter specific.

DISCUSSION

DHH patients experience myriad deleterious social conditions that increase risk of poor health outcomes and ED utilization. Due

TABLE 1 Descriptive statistics of patient-level characteristics, by patient segment

	DHH ASL-users ($n = 108$) Group = 2	DHH English speakers ($n = 358$) Group = 1	Non-DHH English speakers ($n = 302$) Group = 0
Gender			
Woman	58.3% (63)	58.1% (208)	52.0% (157)
Man	41.7% (45)	41.9% (150)	48.0% (145)
Age (years)			
Mean (±SD)	49.2 (15.3)	48.5 (17.1)	45.9 (15.5)
Range	21–92	18–106	19–96
Race[a]			
White	62.6% (67)	73.4% (262)	67.3% (202)
Black/African American	32.7% (35)	20.7% (74)	21.7% (65)
Asian	0.9% (1)	1.1% (4)	3.7% (11)
Pacific Islander	None	None	None
Indigenous American	None	0.3% (1)	0.7% (2)
Multiracial or other	3.7% (4)	4.5% (16)	6.7% (20)
Most recent insurance payer			
Uninsured	0.9% (1)	11.5% (41)	23.8% (72)
Private	13.0% (14)	42.2% (151)	41.7% (126)
Medicaid	27.8% (30)	18.2% (65)	15.2% (46)
Medicare	54.6% (59)	24.3% (87)	15.2% (46)
Other	3.7% (4)	3.9% (14)	4.0% (12)
Smoking status			
Unknown	0.9% (1)	0.8% (3)	10.3% (31)
Current	14.8% (16)	18.7% (67)	22.8% (69)
Prior	16.7% (18)	26.0% (93)	15.2% (46)
Never	67.6% (73)	54.5% (195)	51.7% (156)

Abbreviations: ASL, American Sign Language; DHH, Deaf and hard-of-hearing.

[a]Some cases missing. Race missing = 4.

to social and health care disenfranchisement, DHH ASL users and DHH English speakers may be at higher risk of experiencing poorer ED care outcomes.[3,12,18,27] Therefore, this study aimed to identify hypothesized disparities in ED utilization among DHH ASL users and DHH English speaking when compared to non-DHH English-speaking patients.

We used ESI and triage pain scale rating to identify differences in condition acuity among DHH patients and non-DHH English speakers. No significant differences in condition acuity were identified between DHH ASL users and DHH English speakers when compared to non-DHH English speakers. Previous research in this setting has indicated that DHH ASL users and DHH English speakers are more likely to use the ED than non-DHH English speakers.[12] Paired with the present study's findings, these results suggest that although DHH ASL users and DHH English speakers are more likely to use the ED, they are not more likely to use for conditions of lower or higher acuity.

When adjusting for relevant patient- and encounter-level characteristics, DHH ASL users were found to have longer ED LOS than non-DHH English speakers. On average, the DHH ASL users' ED encounters were approximately 30 min longer. Previous research has suggested that ED LOS may be longer for DHH ASL users due to communication inaccessibility within the ED and longer wait times to get a qualified interpreter.[3,27] For example, DHH ASL users have reported waiting hours, sometimes over 8 h, for interpreter services in the ED, if one was ever requested by health care staff.[27] Further, Rotoli and colleagues[18] found that, among Spanish speakers and DHH ASL users, patients who used interpreter services had longer ED LOS than patients who did not. Importantly, the present study's context differs from that of Rotoli and colleagues', with the latter health system employing on-staff Spanish and ASL interpreters and the former only employing on-staff Spanish interpreters. While Rotoli and colleagues' finding may be attributed to increased patient–provider communication and shared decision making, in addition to waiting for an interpreter,[18,39] it is less likely that improved patient–provider communication was a contributor of ED LOS in this study. Previous research in the present study's context

TABLE 2 Descriptive statistics of encounter-level outcome variables, by patient segment

	DHH ASL users' encounters (n_{enc} = 446)	DHH English speakers' encounters (n_{enc} = 1521)	Non-DHH English speakers' encounters (n_{enc} = 823)
ESI classification			
Missing	1.1%	0.9%	1.0%
1	0.2%	0.1%	0.4%
2	16.8%	20.3%	15.2%
3	58.5%	55.5%	54.4%
4	21.1%	22.1%	27.6%
5	2.2%	1.1%	1.5%
Triage pain scale rating			
Mean (±SD) 95% CI	6.0 (±3.3) 5.7–6.4	5.8 (±3.4) 5.6–6.0	5.8 (±3.3) 5.5–6.0
Median	7.0	7.0	7.0
Range	0–10	0–10	0–10
Missing	29.4%	24.9%	25.2%
ED LOS (min)			
Mean (±SD) 95% CI	366.4 (±257.6) 342.4–390.4	317.8 (±259.8) 304.7–330.9	317.8 (±253.0) 300.4–345.2
Median	313.0	248.000	257.000
Range	5.0–1644.0	7.0–2796.0	12.0–2727.0
Acute revisit			
Not an acute revisit	89.7% (400)	88.7% (1349)	92.2% (759)
Acute revisit	10.3% (46) (95% CI 7.7%–13.5%)	11.3% (172) (95% CI 9.8%–13.0%)	7.8% (64) (95% CI 6.6%–10.6%)

Abbreviations: ASL, American Sign Language; DHH, Deaf and hard-of-hearing; n_{enc}, sample size of encounters.

indicated a widespread lack of use of in-person ASL interpreters in the ED, technological challenges with web-based interpreting services, and patients receiving written communication that failed to meet patients' information needs.[27] More studies, accounting for the presence or absence of interpreters at each encounter and other contextual factors, are needed to better understand the relationship between DHH status and ED LOS. Other factors associated with ED LOS in this study were ED census and ESI classification; these results are similar to those of other studies that are not focused on DHH patients.[40,41]

In total, 10% of encounters during the study period were acute revisits. Acute ED revisits can indicate discharge failure, which occurs when patients do not understand their diagnosis or treatment plan or have the resources to navigate health care.[33] Based on previous studies with this population[8,27] and the conceptual model,[3] DHH ASL users seem particularly at risk for ED discharge failure. A majority of acute ED revisits, however, were among DHH English speakers. An estimated 90% of the variance in acute ED revisits in this sample were at the encounter level, which represents the medical and social conditions patients were experiencing when revisiting the ED. Due to resource constraints, we were unable to link index ED encounters to acute ED revisit encounters—this prevented the development of multilevel models that could explain variation in revisits. Additional research is needed to understand the role of patient enabling and restricting factors in ED revisits, in addition to investigating the context of discharge for DHH patients.

LIMITATIONS

There are several limitations due to the study design and selected data source. First, we could not include all the relevant covariates in the model. As identified in the *Conceptual Model of Emergency Department Utilization among Deaf and Hard-of-Hearing Patients*, there are several nonpatient factors associated with ED care outcomes.[3] Many of these variables were not available, as they are not systematically collected in the medical record. For example, the presence of an interpreter likely influences ED LOS among DHH ASL users.[18] This variable could not be included in the analysis, because the health system does not routinely collect this in a structured

TABLE 3 Estimates for multilevel logistic regression of ESI condition acuity classification as a function of patient- and encounter-level characteristics

	Model 1: Unconditional model	Model 2: Full model, without triage vitals		Model 3: Full model, with triage vitals	
Characteristic	**Est.**	**aOR Est.**	**95% CI**	**aOR Est.**	**95% CI**
Encounter level					
Encounter in past 36 months		1.32	0.96–1.82	1.35	0.97–1.87
Patient age at time of encounter—Grand mean centered, ~43 years old.		1.02	1.01–1.02	1.02	1.01–1.03
Medicaid/uninsured status, binary		0.98	0.75–1.28	0.94	0.69–1.29
Triage pain scale, dichotomized (between 7 and 10)		—	—	0.89	0.66–1.81
Triage HR, dichotomized (ref. less than 100 beats/min)		—	—	1.66	1.25–2.19
Triage RR, dichotomized (ref. less than 20 breaths/min)		—	—	1.36	1.02–1.81
Patient level					
Patient segment (ref. non-DHH English speakers)					
DHH English speakers		1.34	0.98–1.84	1.39	0.99–1.95
DHH ASL users		1.00	0.66–1.49	1.07	0.67–1.71
Gender (ref. men)					
Women		0.73	0.56–0.95	0.75	0.57–0.99
Race (ref. White)					
Black		0.96	0.72–1.29	1.03	0.77–1.39
Other		0.70	0.38–1.28	0.73	0.42–1.26
Smoking status					
Former		1.22	0.86–1.73	1.25	0.86–1.83
Current		1.14	0.81–1.61	1.20	0.77–1.86
Model fit and variance estimates					
ICC	0.21				
Patient-level variance (SE)	0.86 (0.22)				
−2LL	−1310.99	−19,337.31		−22,725.84	
AIC	2607.99	38,928.50		45,533.68	
BIC	2613.48	38,928.50		45,776.966	

Note: Model 3 estimated in Mplus using full information maximum likelihood with Monte Carlo integration to account for missing data on triage vital signs, which increases model complexity leading to a higher −2LL, AIC, and BIC.

Abbreviations: AIC, Akaike Information Criteria; aOR, adjusted odds ratio; ASL, American Sign Language; BIC, Bayesian Information Criteria; DHH, Deaf and hard-of-hearing; ESI, Emergency Severity Index; HR = heart rate; ICC = intraclass correlation; LL, log likelihood; RR, respiration rate.

format. Qualitative analysis of unstructured/free-text clinical notes may provide additional insight into ED care processes for this population, including the presence of an interpreter.

Further, due to the sampling of one academic medical center, the study was limited in sample size and potentially generalizability. Attempts to use larger, more representative patient data sets (e.g., those by the Patient-Centered Outcomes Research Network [PCORnet]) were unsuccessful: at the time of the study, PCORnet did not systematically collect language modality for DHH ASL users,[42] preventing the opportunity to segment on the equity-relevant variable of language modality. Although the sampled health system did have language modality classifications for patients, there are no data available on the accuracy or validity of these classifications (which may be entered in primary and specialty clinics, in the ED, or inpatient). As health systems start to more accurately collect patients' language and disability accommodation needs, larger studies should be conducted to attempt to replicate these findings. Furthermore, this study used diagnostic codes to identify the sample for this study. Although diagnostic codes are used routinely in DHH health care research,[9,11,43] it is possible that there is misclassification

TABLE 4 Estimates for multilevel regression of triage pain rating scores as a function of patient- and encounter-level characteristics

	Model 1: Unconditional model		Model 2: Full model	
Characteristic	**Est.**	**SE**	**Est.**	**SE**
Intercept	5.43	0.10	4.49	0.25
Encounter level				
Encounter in past 36 months			0.11	0.18
Patient age at time of encounter[a]			−0.00	0.01
Medicaid/uninsured status			0.36	0.21
Revisit			0.01	0.27
Patient level				
Patient segment (ref. non-DHH English speakers)				
DHH English speakers			−0.19	0.22
DHH ASL users			0.51	0.30
Gender (ref. men)				
Women			0.58**	0.20
Race (ref. White)				
Black			0.89***	0.24
Other			0.29	0.40
Smoking status				
Former			0.29	0.25
Current			0.61*	0.27
Model fit and variance estimates				
ICC	0.24			
Patient-level variance	2.81***	0.36	2.35***	0.30
Encounter-level variance	8.68***	0.31	8.68***	0.42
−2LL	−5375.49		−25,085.61	
AIC	10,756.98		50,683.73	
BIC	10,773.89		50,915.14	

Note: Model 2 estimated with a full information maximum likelihood estimator which is why there is a larger sample size than in Model 1.

Abbreviations: AIC, Akaike Information Criteria; ASL, American Sign Language; BIC, Bayesian Information Criteria; DHH, Deaf and hard-of-hearing; ICC = intraclass correlation; LL, log likelihood; n_{enc}, sample size of encounters; n_{pt}, sample size of patients.

[a]Patient age at time of encounter is grand mean centered, at ~43 years old.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

of the exposure (i.e., some DHH patients may not be diagnosed as DHH).

DIRECTIONS FOR FUTURE RESEARCH

The results of this study indicate that, although DHH patients are at higher risk of ED utilization,[3,8,12] when compared to non-DHH English-speaking patients they do not present to the ED for conditions of higher or lower acuity or of higher or lower pain reporting at triage. However, DHH ASL users do, on average, have longer ED LOS. These findings represent the first epidemiological evidence in the peer-reviewed literature examining hypothesized disparities in ED care and measures of patient need (e.g., condition acuity) among DHH patients segmented by language modality. Additional research should assess if there are differences in how ED providers work with DHH patients, particularly in the presence of inaccessible patient–provider communication. Furthermore, future studies may assess differences in diagnostic and treatment outcomes (e.g., imaging for abdominal pain, receipt of pain medications), which may provide specific intervention and quality improvement targets for ED care. At time of submission, the authors of this study were concluding a qualitative study with DHH patients related to ED care decision making and treatment processes, which seeks to further explain results from the present study and inform future patient-centered ED outcomes research with this population.

TABLE 5 Estimates for multilevel negative binomial regression of ED LOS as a function of patient- and encounter-level characteristics

Characteristic	Model Estimates		
	Est.	SE	IRR
Intercept	5.45***	0.04	
Encounter-level			
Encounter in past 36 months	0.16***	0.03	1.18 (1.15 to 1.21)
ED revisit	−0.04	0.04	1.18 (1.13 to 1.22)
Patient age at time of encounter[a]	0.00***	0.00	0.96 (0.96 to 0.96)
DVPRS	0.01**	0.01	1.01 (1.01 to 1.02)
Census (% of census capacity)[b]	0.02***	0.00	1.02 (1.02 to 1.02)
ESI urgent (ref. Not urgent)	0.29***	0.03	1.33 (1.29 to 1.39)
Medicaid or uninsured status	−0.02	0.03	0.99 (0.96 to 1.01)
Patient-level			
Patient segment (ref. non-DHH English speakers)			
DHH English-speakers	−0.01	0.04	0.99 (0.96 to 1.03)
DHH ASL-users	0.09*	0.04	1.09 (1.05 to 1.13)
Gender (ref. Men)			
Women	0.05	0.03	1.05 (1.02 to 1.08)
Race (ref. White)			
Black	−0.09*	0.03	0.92 (0.90 to 0.95)
Other	−0.11	0.07	0.90 (0.84 to 0.96)
Smoking status (ref. never)			
Former	0.05	0.04	1.05 (1.01 to 1.09)
Current	0.04	0.04	1.04 (1.00 to 1.08)

Note: Models estimated using a maximum likelihood estimator with robust standard errors and Monte Carlo integration to account for missing data.

Abbreviations: ASL, American Sign Language; DHH, Deaf and hard-of-hearing; DVPRS, Defense and Veterans Pain Rating Scale; ESI, Emergency Severity Index; IRR, incidence rate ratio; LL, log likelihood; LOS, length of stay.

[a]Patient age is grand mean centered at ~43 years old.

[b]Max census capacity is 114 patients; grand mean centered at ~38%.

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

CONCLUSIONS

Deaf and hard-of-hearing patients are at higher risk for experiencing disparities in ED care seeking and inequities in care processes.[3,8,12,18,27] This study provides evidence from a single, large academic medical center in the southeast United States. Although disparities in triage acuity were not observed, Deaf and hard-of-hearing ASL users have, on average, 9% longer ED length of stay (~30 min) than non–Deaf and hard-of-hearing English speakers. Further, Deaf and hard-of-hearing English speakers account for a majority of acute ED revisits. Additional research is needed that continues to address ED care for Deaf and hard-of-hearing patients, segmenting on relevant sociomedical variables and, particularly, language modality.

AUTHOR CONTRIBUTIONS

Conceptualization—Tyler G. James, Michael M. McKee, JeeWon Cheong. Methodology—Tyler G. James, M. David Miller, Michael M. McKee, Thomas A. Pearson, Elham Mahmoudi, Julia R. Varnes, JeeWon Cheong. Formal analysis—Tyler G. James. Resources—Tyler G. James, JeeWon Cheong. Writing, original draft—Tyler G. James, Meagan K. Sullivan. Writing, review, and editing—Tyler G. James, M. David Miller, Michael M. McKee, Meagan K. Sullivan, Jason Rotoli, Thomas A. Pearson, Elham Mahmoudi, Julia R. Varnes, JeeWon Cheong. Supervision—M. David Miller, Michael M. McKee, Thomas A. Pearson, Julia R. Varnes, JeeWon Cheong. Funding acquisition—Tyler G. James.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL CONTRIBUTION

Increased identification of cannabis use among drivers involved in motor vehicle collisions using an expanded cannabis inventory

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Abstract

Objectives: The objectives of this study were to implement and examine the potential capture rate of a novel instrument, the Expanded Cannabis Inventory, in a population of emergency department (ED) patients presenting after motor vehicle collisions (MVC).

Methods: Study participants who presented to the ED after MVC were recruited from three hospitals in cannabis-legal states (Denver, CO; Portland, OR; and Sacramento, CA). Research assistants (RAs) administered the Expanded Cannabis Inventory, which includes a wide variety of products that have become readily available in states where cannabis is legal, in addition to assessments related to patient demographic characteristics, general health, cannabis attitudes, and dependency measures. RAs also obtained blood samples for delta-9-THC and metabolites.

Results: Among 692 participants who provided responses to questions about cannabis use, 292 (42%) reported past-year use. Seventy-eight (27%) of those identified as using cannabis were only captured due to items in the expanded instrument. These patients were more likely to be White and were more likely to perceive daily use to be of high risk. Fewer had Cannabis Use Disorder Inventory Test (CUDIT) scores consistent with hazardous cannabis use. However, more of the patients only captured by the expanded instrument had high measured blood levels of delta-9-THC on samples obtained in the ED.

Conclusions: Changing cannabis use patterns must be reflected in our measurements for clinical practice, research, and surveillance. Instruments that are the current standard in clinical practice capture limited data and may no longer perform well enough to identify a complete cohort or to provide insight into the health behaviors of patients.

KEYWORDS
cannabis, emergency department, instrument, marijuana, motor vehicle collisions

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INTRODUCTION

Detecting cannabis use in the emergency department (ED) is important for clinical and research reasons. Accurate identification provides relevant information about symptoms and appropriate treatments and referrals, identifying a complete cohort of patients, and capturing factors related to health conditions of interest. Both clinicians and researchers in the ED often rely on self-report to determine drug use; self-report for drug use overall is feasible and reliable and can be systematically deployed.[1,2]

However, there are pitfalls with standard means of asking about cannabis. Surveillance questions asking about "illegal" drug use may perform poorly if use is seen as normative. Further, in states where cannabis is legal for recreational use, availability of a wide variety of cannabis products (such as increasingly popular concentrates and edibles[3]), the narrow language of standardized instruments for cannabis use may lead to systematic under capture. For example, the Cannabis Abuse Screening Test (CAST),[4] the Cannabis Problems Questionnaire (CPQ),[5] and the Marijuana Craving Questionnaire[6] ask only about smoked cannabis and/or refer only to "joints," without mention of any of the other numerous forms and modes of delivery now readily available.

The objective of this study was to preliminarily explore the use of a novel instrument that includes a wide variety of types of cannabis and modes of delivery, the Expanded Cannabis Inventory, in a population of injured ED patients. We hypothesized that a broader instrument would capture a larger population of cannabis users who would be missed if only asked specifically about smoked forms.

METHODS

The current study was embedded in a larger cross-sectional study[7] of drivers presenting to the ED in three hospitals in Denver, Colorado; Portland, Oregon; and Sacramento, California, due to injuries sustained in a motor vehicle collision (MVC). The parent study aimed to examine the drug and alcohol use of injured drivers in cannabis-legal states and characterize crash characteristics, injury severity, usual drug use, and a variety of patient and contextual characteristics related to substance use and driving risk. The general methods and instruments are as described below, but the current study focuses on the screening questions in particular.

Research assistants (RAs) recruited English-speaking patients ages 18 and older who presented to the EDs within 8 h of being involved in an MVC as the driver. At the Portland site, RAs recruited 24 h a day, 7 days a week from April 2017 to November 2019; at the other two sites, recruitment occurred between 7 a.m. and 12 a.m. from October 2018 to October 2019 (Denver) and November 2018 to November 2019 (Sacramento). Colorado legalized cannabis for recreational use in 2012, Oregon legalized in 2014, and California legalized in 2016.[8] The three study sites are all urban, academic, Level I trauma centers with annual volumes of approximately 48,000 (Portland), 125,000 (Denver), and 85,000 (Sacramento) visits per year.

We excluded patients who were under arrest and those presenting with acute psychiatric conditions. Patients who were felt to be clinically intoxicated on presentation and thus unable to provide immediate consent were followed until the patient became clinically sober, per the ED clinical staff, and regained capacity to consent for self (based on a mini-mental exam administered by the RA). For patients otherwise unable to consent, consent for biosamples and medical record review was sought via a legally authorized representative (LAR) acting on the subject's behalf. Patients for whom an LAR could not be located were followed for the duration of their hospital stay and periodically assessed for capacity to consent and participate in the interview. Participants were provided a $30 gift card for completing the study.

We interviewed participants about drug use in the 8 h prior to the MVC and in the past year. The Expanded Cannabis Inventory was developed by our study team through a multistep process. First, we performed an online web search for forms of cannabis. We the examined products commercially available at local dispensaries in Portland, Oregon. A preliminary instrument was iteratively reviewed by the team until no additional revisions were identified. Finally, it was piloted for face validity with an initial three patients reporting cannabis use and revised further with their feedback. The final expanded instrument included a wide variety of products that have become readily available in states where cannabis is legal, including candy, beverages, and hash concentrates. The screening portion of the instrument is included as Appendix S1.

RAs administered the instrument as part of a structured interview about the mechanism of the MVC, sociodemographic information, general health information, perceptions of cannabis risk, and the Cannabis Use Disorder Identification Test-Revised (CUDIT-R),[9] The CUDIT-R is an 8-item validated instrument scored on a 5-point likert scale (0–4), with a total score of 8 considered positive for hazardous use and a total score of 12 considered positive for cannabis use disorder.

Blood samples for delta-9-THC and its metabolites were collected in the parent study to examine risk of MVC at various levels of measured THC and to compare biosamples to self-report. These were obtained after arrival to the ED prior to consent, for timeliness, but were discarded if consent was not subsequently obtained. Plasma samples for cannabinoid testing were frozen at −80°C and then thawed for analysis by high-performance liquid chromatography/tandem mass spectrometry.

We examined the prevalence of different forms of cannabis reported by participants and compared characteristics of patients who would have been identified with only a simple joint/smoking question and those who would only have been captured with an expanded instrument, including how these populations differed by demographics, blood cannabis results (stratified into tertiles based on common state legal limit of 5 ng/mL and common laboratory threshold of 15 ng/mL), cannabis dependency measures, and cannabis risk perceptions.

The study was approved by the institutional review boards of the respective institutions. Given the sensitive nature of the study

information obtained from participants, a National Institutes of Health certificate of confidentiality was obtained.

RESULTS

Among 692 participants who provided responses to questions about cannabis use, 292 (42%) reported past-year use. Marijuana (274, 94%) was more common than hash (41, 14%), and smoked forms via joint, spliff, or blunt were the most common forms of marijuana use (132, 48%). However, many other forms and routes of marijuana use were also reported, including glass pipe/bowl (101, 37% of marijuana use), vaping pens (58, 21%), and food or drink products (52, 19%). Hash (concentrate) use was reported by 41 (14%) of participants and included a variety of concentrates (wax, oil, butane solvent extraction).

Twenty-seven percent of those identified as using cannabis reported only using forms presented in the expanded instrument (Table 1). Compared to those reporting smoking cannabis, these patients were more likely to be White (75% vs. 57.8%, p = 0.04) and were more likely to perceive daily use to be of high risk (43.4% vs. 30.6%, p = 0.04). Fewer had CUDIT-R scores consistent with hazardous use (26.9% vs. 46.7%, p = 0.002). More of the patients captured only by the expanded instrument were likely to be THC negative (69.7% vs. 50%) but also more in this group had high measured blood levels of delta-9-THC (>15 ng/mL, 15.1% vs. 8.2%) on samples obtained in the ED.

DISCUSSION

With an expanded cannabis use instrument, we captured wide variability in types of use that would not be captured on traditional marijuana questionnaires. In this study, if we had hypothetically asked only about joints and similar forms of use, we may not have captured or characterized 27% of cannabis use.

Previously reported averages among[10] injured ED patients in U.S. hospitals (15% by biosample, 19.7% by self-report) are generally lower than what we discovered in our study, although we did not conduct a formal comparison.[11] Using content that includes different types of consumption will allow research studies to characterize use patterns accurately. Knowledge of cannabis types and methods when interviewing study subjects may help decrease feelings of generalization and stigmatization. Our expanded survey also allows a chance for the patient to say what other products they may be using, informing research teams as the cannabis industry continues to evolve with new products and modes of use.

TABLE 1 Characteristics of patients reporting joint and other smoked forms versus additional patients captured by expanded instrument: reporting[a] for usual (past 12-month use)

	Standard instrument patient capture	Expanded instrument patient[b] capture	*p*-value
Total	214 (73)	78 (27)	N/A
Demographics			
Female	82 (38.3)	31 (39.7)	0.83
Race: White	123 (57.9)	57 (75.0)	0.04[c]
Black	28 (13.1)	4 (5.3)	
Hispanic	52 (24.3)	11 (14.5)	
Other	10 (4.7)	4 (5.3)	
Age (years)	35.1 (±13.3)	37.4 (±14.9)	0.20
Dependency (8+ CUDIT)	100 (46.7)	21 (26.9)	0.002[c]
Perceived risk weekly use	34 (16.4)	14 (18.4)	0.680
Perceived risk daily use	64 (30.6)	33 (43.4)	0.04[c]
Self-reported use of cannabis prior to MVC[d]	33 (15.5)	114 (8.2)	0.58
Biosample results			0.001[c]
THC negative	97 (50.0)	46 (69.7)	
<5 ng/ml	48 (24.8)	6 (9.1)	
5–15 ng/ml	33 (17.0)	4 (6.1)	
>15 ng/ml	16 (8.2)	10 (15.1)	

Note: Data are reported as *n* (%) or mean (±SD).

Abbreviations: CUDIT, Cannabis Use Disorder Identification Test; MVC, motor vehicle collision.

[a]Among those reporting acute cannabis use.

[b]Including vaping pens, vaporized forms, waterpipes or bongs, troches, candy, lozenges or drops, food or beverage, medications, or hash concentrates.

[c]Statistically significant differences.

[d]Within 8 h of MVC.

Expanded capture may have other implications when it comes to epidemiologic snapshots of drug use and emergency care. If traditional and expanded instruments capture patients of certain racial and ethnic backgrounds differently, as occurred in our sample, this may lead to a skewed picture of populations with drug use and potentially perpetuate stigma: however, our ability to fully examine this question may be limited by our systematic exclusion of non–Spanish-speaking patients.

Those reporting cannabis use other than joints/blunts/spliffs also had a number of other differences in other self-reported metrics related to their drug use, with greater risk perception around regular frequent cannabis use and fewer scoring within a dependency range on the CUDIT. This may reflect different contexts of use, including more naïve episodic recreational use, such as seen in cannabis tourism.[12]

LIMITATIONS

There were several limitations of our study. For convenience, only English-speaking patients were included, so this limits the generalizability of the findings. The survey instrument has not been formally validated and still needs development work in diverse populations and cannabis markets. All patients were asked to take the full instrument, so the differentiation between those that would have been captured by asking about smoked forms versus other forms is hypothetical. Study participants represent MVC injured drivers, so findings cannot be generalized to all ED patients and may bias our findings toward a population that is healthier, younger, and more affluent. Recruitment of drivers in MVCs may have created a bias in participation or in reporting of cannabis use due to concern for legal or medical consequences. Blood levels may have missed some patients with low levels or who used at the early end of our time cutoff for inclusion in the study.[13,14] We recruited from EDs within cannabis-legal states, so findings are applicable primarily to states where cannabis has been similarly liberalized and with an environment of normalization and high availability of a wide variety of cannabis products. However, across the United States, the climate is one of increasing cannabis liberalization and access.

CONCLUSIONS

The world of recreational cannabis use is changing, and research methods need to change along with it. Instruments that have been standard in clinical practice capture limited data and may no longer perform well enough to identify a complete cohort or to provide insight into the health behaviors of patients. Other instruments have begun to emerge since the planning and design of this study, including the Daily Sessions, Frequency, Age of Onset, and Quantity of Cannabis Use Inventory (DFAQ-CU),[15] that have more detailed and broad questions about the many and varied forms of cannabis use that better represent the accessible market, so norms of measurement may already be shifting.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL CONTRIBUTION

Point-of-care echocardiography of the right heart improves acute heart failure risk stratification for low-risk patients: The REED-AHF prospective study

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Abstract

Objectives: Validated acute heart failure (AHF) clinical decision instruments (CDI) insufficiently identify low-risk patients meriting consideration of outpatient treatment. While pilot data show that tricuspid annulus plane systolic excursion (TAPSE) is associated with adverse events, no AHF CDI currently incorporates point-of-care echocardiography (POCecho). We evaluated whether TAPSE adds incremental risk stratification value to an existing CDI.

Methods: Prospectively enrolled patients at two urban-academic EDs had POCechos obtained before or <1 h after first intravenous diuresis, positive pressure ventilation, and/or nitroglycerin. STEMI and cardiogenic shock were excluded. AHF diagnosis was adjudicated by double-blind expert review. TAPSE, with an a priori cutoff of ≥17 mm, was our primary measure. Secondary measures included eight additional right heart and six left heart POCecho parameters. STRATIFY is a validated CDI predicting 30-day death/cardiopulmonary resuscitation, mechanical cardiac support, intubation, new/emergent dialysis, and acute myocardial infarction or coronary revascularization in ED AHF patients. Full (STRATIFY + POCecho variable) and reduced (STRATIFY alone) logistic regression models were fit to calculate adjusted odds ratios (aOR), category-free net reclassification index (NRI_{cont}), ΔSensitivity (NRI_{events}), and ΔSpecificity ($NRI_{nonevents}$). Random forest assessed variable importance. To benchmark risk prediction to standard of care, ΔSensitivity and ΔSpecificity were evaluated at risk thresholds more conservative/lower than the actual outcome rate in discharged patients.

Results: A total of 84/120 enrolled patients met inclusion and diagnostic adjudication criteria. Nineteen percent experiencing the primary outcome had higher STRATIFY scores compared to those event free (233 vs. 212, $p = 0.009$). Five right heart (TAPSE, TAPSE/PASP, TAPSE/RVDD, RV-FAC, fwRVLS) and no left heart measures improved

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prediction ($p < 0.05$) adjusted for STRATIFY. Right heart measures also had higher variable importance. TAPSE ≥ 17 mm plus STRATIFY improved prediction versus STRATIFY alone (aOR 0.24, 95% confidence interval [CI] 0.06–0.91; NRI_{cont} 0.71, 95% CI 0.22–1.19), and specificity improved by 6%–32% ($p < 0.05$) at risk thresholds more conservative than the standard-of-care benchmark without missing any additional events.

Conclusions: TAPSE increased detection of low-risk AHF patients, after use of a validated CDI, at risk thresholds more conservative than standard of care.

KEYWORDS

cardiology, echocardiography, emergency department, emergency medicine, heart failure, point-of-care ultrasound, risk stratification

INTRODUCTION

Acute heart failure (AHF) accounts for 1 million emergency department (ED) visits annually[1] and presents significant dilemmas for risk stratification and ED disposition.[2] Over 80% of AHF patients treated in United States EDs are admitted to the hospital, but as many as half may be low enough risk to avoid admission.[3–6] The forthcoming 2022 update to the American College of Emergency Physicians (ACEP) clinical policy on AHF[7] identified three validated clinical decision instruments (CDI)[8–10] that are useful for risk-stratification: the STRATIFY risk score,[8,11] the Emergency Heart Failure Mortality Risk Grade (EHMRG),[9,12] and the Ottawa Heart Failure Risk Scale (OHFRS).[10,13] While all three have validation test characteristics that exceed published performance of emergency physician (EP)-estimated risk[9] and actual disposition decisions,[12] none were deemed sufficient to direct AHF disposition on their own. Recent multicenter studies have shown that ED discharged AHF patients experience 30-day rates of death (3.8%)[14] and serious adverse events (7.1%) in STRATIFY's composite outcome[6] much greater than risk thresholds that EPs report as acceptable.[15] Nonetheless, in one study comparing EHMRG[9] to EP-estimated risk, not only did EHRMG perform significantly better but EPs frequently misclassified the highest risk patients as low risk (and vice versa). Given this, recent SAEM-endorsed expert consensus guidelines have identified "safely transitioning a larger proportion of patients to the outpatient setting"[16] and "prediction of low risk"[5] as critical needs in AHF clinical research.

In a previous pilot study we identified that tricuspid annulus plane systolic excursion (TAPSE) on EP-performed point-of-care echocardiography (POCecho) is associated with short-term adverse AHF events.[17] This compares to numerous studies of HF patients outside the ED setting, where TAPSE and other measures of right ventricular dysfunction (RVD) and/or pulmonary hypertension (PH) predict adverse outcomes,[18–29] often more strongly than LV dysfunction[30–42] or biomarkers.[37,42–46] Conversely, there is a stark absence of prior ED risk stratification studies that incorporate or consider echocardiography measures. Nevertheless, TAPSE[17,38,47–49] and other right heart measures[38,50] have been used by EPs with high interobserver reliability in the risk stratification of pulmonary embolus, suggesting feasibility for AHF risk stratification.

The Right ventricular Echocardiography in ED AHF (REED-AHF) study was a two-center prospective cohort[38] whose primary objective was to evaluate if ED TAPSE had additive and incremental predictive value for 30-day serious adverse events when used in conjunction with a validated and ACEP-endorsed CDI such as STRATIFY. We hypothesized that TAPSE, at an a priori ≥ 17-mm cutoff from our pilot study,[17] would improve risk stratification for STRATIFY's 30-day composite of serious adverse AHF events compared to STRATIFY alone. Secondarily, we sought to characterize the incremental value of 14 additional POCecho measures for the same purpose and evaluate how these alternative measures compare to TAPSE by variable importance and predictive value after adjusting for STRATIFY.

METHODS

The primary methods, protocol, design, and patient cohort of REED-AHF have been described previously.[38] REED-AHF was funded by an investigator-initiated grant (NH) from the Blue Cross Blue Shield Foundation of Michigan and approved by the Wayne State University Institutional Review Board. This report describes the primary aim of the study. This report has been prepared to adhere to the STROBE guidelines.[51]

Study design, setting, and population

REED-AHF was a prospective multicenter cohort study at two urban EDs with 80,000–100,000 annual visits each. Detroit Receiving Hospital is an urban-academic referral hospital and Level I trauma center; Sinai-Grace Hospital is an urban-community Level II trauma center. Both sites host 3-year emergency medicine (EM) residencies.

Patients were enrolled from September 2019 to February 2020 and November 2020 through March 2021. Enrollment was paused

during the intervening 8 months per institutional policies regarding clinical research during the early phase of the COVID-19 pandemic. Patients were screened 7 days per week by trained research staff and study personnel; however, enrollment was limited to times when a study sonographer was available.[38] Despite this, 25% of patients were enrolled between the hours of 5 p.m. and 8 a.m. and 18% on weekends.[38]

Full inclusion, exclusion, and diagnostic adjudication criteria have been described previously.[38] Patients with cardiogenic shock, STEMI, tachydysrhythmia requiring intravenous (IV) rate control and those deemed not to have AHF by the EP at disposition were excluded. Patients had to receive a POCecho and lung ultrasound (LUS) within <1 h after, or any time before, first initiation of any qualifying AHF treatment: IV loop diuretics, SL or IV nitroglycerin, noninvasive positive pressure ventilation (NIPPV), and/or intubation. Two experts (AA, MF) blinded to study outcomes adjudicated the ED diagnosis of AHF.[38]

Study protocol

The POCecho protocol, performed using a Vivid q ultrasound system, has been described previously.[38] A majority of POCechos were performed by a single EP sonographer (NH) without POCUS fellowship training, with fewer performed by a POCUS-trained co-investigator (RE or MF), PGY-2 EM resident (JL), or research cardiac sonographer (LG). Measurements were made first on the POC platform. A second offline measurement by a different investigator[38] blinded to the POC measures and clinical outcomes was also performed, to allow calculation of intraclass correlation (ICC) for all measures. All POCecho measures (see list of specific measures below) except RVOT acceleration time showed moderate–high inter-rater reliability (ICC > 0.7) between POC and offline analysis. Per protocol,[38] RVOT acceleration time was then overread by a testamur (RE) of the examination of special competence in adult echocardiography administered by the National Board of Echocardiography (NBE). Another NBE testamur (MF) performed blinded overreads of the free-wall right ventricular longitudinal strain (fwRVLS) measure on account of this being a more advanced echo measure, yielding ICC > 0.7.

Primary clinical risk measure: the STRATIFY risk score

Demographic and clinical variables were collected prospectively at enrollment, throughout hospitalization, and through 90-day follow-up as previously described.[38] The primary ED clinical measure of interest was the STRATIFY score,[8] and its component variables of age, BMI, brain natriuretic peptide, blood urea nitrogen, dialysis history, diastolic blood pressure, sodium, ED supplemental oxygen requirement, outpatient ACE inhibitor, QRS prolongation on electrocardiogram, respiratory rate, oxygen saturation, and cardiac troponin I.

STRATIFY was chosen as the primary clinical risk measure for a few reasons. First, as cited above, it is one of three CDIs endorsed by ACEP to be helpful in risk stratification.[7] Second, compared to EHMRG and OHFRS, it contains the largest number and greatest diversity of clinical variables which an EP may use and have access to in clinical decision making. Third, STRATIFY was derived to predict a hierarchical composite of several serious adverse AHF events which all have clinical significance (described below).[8]

Primary clinical outcome

The primary clinical outcome was the 30-day composite of serious adverse AHF events which STRATIFY was derived[8] and then validated[11] to predict. The composite includes death/CPR, mechanical cardiac support, intubation, new or emergent dialysis, and/or acute myocardial infarction (AMI)/percutaneous coronary intervention (PCI)/coronary artery bypass grafting (CABG). Previous validation[11] showed STRATIFY to predict this outcome with >0.7 area under the receiver operating characteristic curve (AUROC).

Outcomes were adjudicated by telephone follow-up, supplemented by multiple blinded abstractors reviewing electronic medical record data and health information exchange data for the state of Michigan as previously described.[38] AMI was defined based on the Fourth Universal Definition of MI,[52] adjudicated by multiple blinded raters.

Data analysis

All statistical analyses were performed in the R language (R Studio 2021.09.1). Patient characteristics were stratified by those with versus without the primary outcome, and echocardiography parameters by outcome and ED disposition, to calculate descriptive statistics using the Wilcoxon rank-sum test for continuous variables and Fisher's exact test for categorical variables ($\alpha = 0.05$).

Primary echo measure

Based on our pilot study which showed association between adverse events and TAPSE < 17 mm[17] and other published data in non-ED settings, our primary measure of interest was TAPSE, which was analyzed as a continuous variable with an a priori binary cutoff of ≥17 mm. To provide 80% power to detect an adjusted odds ratio (aOR) of 0.30 at this cutoff for prediction of the primary outcome, 111 patients were needed.

Secondary POCecho measures for comparison and exploratory analysis

Additional right heart measures included fwRVLS, RV-LV ratio, pulmonary artery systolic pressure (PASP) by tricuspid regurgitant jet velocity (i.e., which is also the right ventricular systolic pressure

[RVSP] under most scenarios}, TAPSE/PASP ratio, TAPSE/right ventricular diastolic diameter ratio (TAPSE/RVDD), RV fractional area change (FAC), pulmonary vascular resistance, and RVOT acceleration time. Left heart measures included left ventricular ejection fraction (LVEF), mitral E/A ratio, septal E', lateral E', E/E' ratio, and LV global longitudinal strain (LVGLS) by speckle tracking.

Exploratory analyses were conducted with two goals. First, we explored the possibility that measures besides TAPSE may have incremental value in risk stratification, since few descriptions of any POCecho measure exist in ED-based AHF risk stratification literature. Second, the other measures served as indirect comparators to TAPSE in evaluating our primary hypothesis. We approached comparison in two ways: (1) evaluating relative variable importance of all POCecho measures with STRATIFY in a random forest model and (2) modeling each POCecho variable in the same way as TAPSE in full (POCecho measure plus STRATIFY) and reduced (STRATIFY only) logistic regression models for measures of incremental improvement in prediction (logistic regression methods, below). Secondary POCecho measures were also analyzed as continuous variables and using a priori binary cutoffs corresponding to the American Society of Echocardiography guidelines[53–55] or, in the absence of a guideline-recommended value, prior AHF literature from settings outside the ED.[17,25,26,56,57]

Importance by random forest

The random forest model for assessing variable importance was run under the following specifications: (1) all 15 echo variables including TAPSE and the STRATIFY score were able to be incorporated into classification trees; (2) no more than two total variables (STRATIFY, plus one POCecho variable) were allowed to be sampled in a single classification tree (to prevent overfitting from any single model, e.g. incorporating three or more variables); and (3) 10,000 trees were grown for prediction of the clinical primary outcome using the randomForest package in R, with importance (mean decrease in Gini) calculated and plotted. Random forest utilized in this way aids in selection of independent variables (features) in the context of high dimensionality by calculating the importance of each variable in predicting the outcome of interest, of which mean decrease in Gini is a common importance measure.[58] The expected outcome was that STRATIFY would rise to the top as the most important overall variable, followed by the POCecho variables of importance after accounting for STRATIFY.

Logistic regression and measures of incremental predictive value/improvement

Risk thresholds

Reduced (STRATIFY score alone) and full (POCecho measure plus STRATIFY) logistic regression models were fit[59] for the primary outcome to calculate unadjusted odds ratios (OR), aOR, and category-free (i.e., continuous) net reclassification index (NRI_{cont}). NRI measures the degree by which addition of a single variable to an existing prediction model improves the classification of that model, focused on the observations which are reclassified to a different prediction category by the added predictor, and specifically whether or not those reclassifications resulted in fewer or greater correct classifications overall (i.e., net).[60] The NRI_{cont} assesses classification across all risk thresholds, while the categorical NRI assesses reclassification at specific risk cutoffs.[60] Variance inflation factor (VIF) was calculated to assess models for multicollinearity; all VIF were < 3. Models were internally validated using the bootstrap to assess optimism and produce bias-corrected estimates of AUROC,[59] so that reported estimates of performance are lower (more conservative) than the observed estimates, to account for the fact that new models tend to perform worse on external validation. Categorical NRI for various risk-thresholds were calculated separately for events (NRI_{events}) and nonevents ($NRI_{nonevents}$) by methods previously described[60] to enhance clinical utility and interpretability. Calculated this way, $NRI_{nonevents} = \Delta$Specificity and $NRI_{events} = \Delta$Sensitivity—i.e., the improvement or worsening in sensitivity and specificity in the standard risk stratification (i.e., STRATIFY score) after adding a novel risk marker (i.e., POCecho variable such as TAPSE)[60]; 95% confidence intervals (95%CI) were calculated and reported.

Benchmarking to clinical standard of care decision making

There is no currently agreed upon "acceptable" miss rate for serious adverse events at which patients should be considered for outpatient treatment of AHF after ED treatment. To account for this, we benchmarked categorical risk prediction and reclassification to standard-of-care risk stratification. Model predicted risk thresholds (i.e., miss rates) were chosen to be below the true/observed rate of the primary outcome among patients actually discharged from the ED by standard EP decision making. Thus, measures of categorical reclassification (NRI_{events}/ΔSensitivity and $NRI_{nonevents}$/ΔSpecificity) were calculated at thresholds that would ensure that the model's "miss rate" was more conservative than the standard-of-care miss rate. The rationale of this approach was that even if the exact value of an "acceptable miss rate" is debated, most EPs would likely agree that a model which misses fewer events than the standard of care is potentially useful, particularly if it can also increase identification of low risk (i.e., improved $NRI_{nonevents}$/ΔSpecificity) without adding missed events (i.e., no decline in sensitivity).

To increase precision in estimating the benchmark standard-of-care miss rate, we averaged the rate of events in discharged patients in REED-AHF[38] with the rate observed in CLEAR-AHF, a recent 257 prospective patient cohort from the same institution.[6] CLEAR-AHF[6] had similar adjudication of AHF diagnosis, adjudicated outcomes for the STRATIFY risk score, and similar inclusion criteria as REED-AHF, but was larger than REED-AHF and had slightly lower outcome rates.[38] Among 341 patients in both

cohorts, 8.3% of discharged patients experienced the primary outcome compared to 13.6% among admitted or observation patients.[6,38] Thus, 8% was chosen as the higher risk threshold to be evaluated (i.e., the least conservative integer risk threshold to still be more conservative than usual care). A low-end risk threshold of 3% was chosen to match the smallest risk-threshold for which STRATIFY was derived and validated.[8]

Sensitivity analysis: comparison to clinical features not captured by STRATIFY

Although STRATIFY was chosen as the primary baseline risk measure in part because of how many different clinical variables it incorporates, some important decision-making factors for EP risk stratification of AHF nevertheless are absent from the risk score. We analyzed several clinical factors not included in STRATIFY that could hypothetically add predictive value. First, past history of chronic obstructive pulmonary disease (COPD), PH, ED systolic blood pressure (SBP), pre-ED adherence to guideline-directed medical therapy, and sex were chosen a priori as patient-level factors that could be associated with both TAPSE and outcomes while not being incorporated in STRATIFY. Several treatment-level variables were chosen based on being possible therapeutic indications why a patient would not be a candidate for outpatient treatment (i.e., even if low risk for adverse events), including total ED IV furosemide dose, ED NIPPV, ED IV nitroglycerin, and any new or increased oxygen requirement during the ED visit compared to baseline. Finally, EP disposition decisions of discharge versus admission and ICU versus another level of care were included to assess actual clinical decision-making compared to the POCecho variables. EPs were blinded to all POCecho data during the study, including when selecting disposition.

Each of the variables here was tested for NRI_{cont} when added to STRATIFY by similar methods as described above for the echocardiography variables in sensitivity analyses. The hypothesis of these sensitivity analyses was that significant improvement in classification by any of these variables compared to STRATIFY alone would diminish the importance of any risk stratification benefit observed for a POCecho variable, since these clinical variables are more easily obtained through history and medical record review than a POCecho, are commonly found in current AHF risk stratification literature and ED-based CDIs, and/or inherently reflect the standard-of-care in EP decision-making.

RESULTS

Enrollment and time to POCecho

A total of 120 patients met initial inclusion criteria, with POCechos obtained at a median of −75 min (interquartile range [IQR] −131 to +13) before first IV loop diuretic, +33 min (+6 to +59) after initiation of PPV, −21 min (−49 to +23) before first IV/SL nitroglycerin, +33 min (−234 to +162) after first supplemental O_2 initiation, and +102 min (+47 to +177) after ED arrival. A CONSORT diagram with enrollment details has been previously published.[38] After exclusions for EP diagnosis at disposition of "not-AHF" (n = 11), failure to obtain consent from the patient or a representative within 24 hours of the POCecho (n = 20), and expert-adjudicated diagnoses of not-AHF (n = 5), 84 patients remained for analysis.

Descriptive clinical and echocardiographic characteristics

Description for selected clinical and POCecho measures are presented in Tables 1 and 2, respectively. Median (IQR) age was 62 (54–70) years, LVEF 28% (19%–38%), TAPSE 17 (13–23) mm, SBP 153 (132–173) mm Hg, and STRATIFY score 215 (198–233). Sixty percent were male (n = 50), 18% received NIPPV (n = 15), 3.6% (n = 3) were admitted to the ICU, 14% (n = 12) placed in outpatient observation, and 9.5% (n = 8) discharged from the ED.

Nineteen percent of patients (n = 16) had one or more serious adverse AHF events in the composite primary outcome at 30 days, including three (3.6%) deaths. Experiencing the primary outcome was associated with (Table 1) total STRATIFY score and the STRATIFY components of dialysis history and sodium concentration.

Among POCecho variables (Table 2), four right heart measures and no left heart measures were associated with the primary outcome: TAPSE (p = 0.011), TAPSE/PASP (p = 0.035), TAPSE/RVDD (p = 0.011), and fwRVLS (p = 0.034). There was no difference in TAPSE between admitted versus discharged patients (Table 2) to suggest unblinding of the treating EPs to the POCecho results.

Category-free reclassification

TAPSE improved category-free reclassification of events and nonevents compared to STRATIFY alone (NRI_{cont} +0.63 [95% CI +0.08 to +1.18]), as did TAPSE/RVDD (+0.67 [+0.18 to +1.16]) and fwRVLS (+0.49 [+0.01 to +0.98]). Significant reclassification by NRI_{cont} was not observed for other POCecho variables or any of the clinical variables of interest including past history of COPD, history of PH, new or increasing supplemental O_2 requirement, ED IV loop diuretic dose, ED NIPPV or intubation, ED IV nitroglycerin, or disposition decisions of ICU or discharge home (Table 3).

Categorical reclassification and improvement in test characteristics at clinically benchmarked risk thresholds

ED treatments and disposition decisions were similar between events and nonevents (Table 1). Figure 1 shows the ΔSensitivity (NRI_{events}) and ΔSpecificity ($NRI_{nonevents}$) obtained when TAPSE at

TABLE 1 Selected clinical characteristics of the cohort

Characteristic	Overall, $N = 84$[a]	No 30-day events, $n = 68$[a]	≥1 event at 30 days, $n = 16$[a]	p-value[b]
STRATIFY score for ED AHF				
Age (years)	62 (54–70)	61 (54–70)	65 (60–70)	0.8
BMI	28 (24–36)	30 (23–37)	27 (24–32)	0.8
Brain natriuretic peptide	1098 (568–1910)	1160 (500–1898)	688 (615–2151)	>0.9
Diastolic blood pressure (mm Hg)–arrival	90 (79–101)	89 (78–100)	94 (81–108)	0.5
Blood urea nitrogen	22 (17–36)	22 (17–33)	27 (22–37)	0.2
Sodium	138 (136–140)	139 (137–141)	136 (134–138)	0.001
Respiratory rate	20 (20–26)	20 (20–25)	22 (20–32)	0.4
SpO_2 (%)–arrival	97 (95–98)	96 (95–98)	99 (96–100)	0.11
Troponin I (ng/mL)	0.07 (0.04–0.13)	0.07 (0.03–0.12)	0.09 (0.07–0.22)	0.068
History of dialysis	5 (6.0)	2 (2.9)	3 (19)	0.045
Any supplemental oxygen in ED	47 (56)	36 (53)	11 (69)	0.3
ACE inhibitor or ARB	32 (38)	27 (40)	5 (31)	0.5
Wide QRS on ECG	17 (20)	13 (19)	4 (25)	0.7
Total ED stratify score	215 (198–233)	212 (196–228)	233 (218–266)	0.009
Ranked primary outcome (0–5) at 30 days				<0.001
0 = no 30-day event	68 (81)	68 (100)	0 (0)	
1 = AMI, PCI, and/or CABG	8 (9.5)	0 (0)	8 (50)	
2 = new or emergent dialysis	1 (1.2)	0 (0)	1 (6.2)	
3 = intubation	4 (4.8)	0 (0)	4 (25)	
4 = mechanical cardiac support	0 (0)	0 (0)	0 (0)	
5 = Death/CPR	3 (3.6)	0 (0)	3 (19)	
Other clinical characteristics[c]				
Systolic blood pressure (mm Hg)–arrival	153 (132–173)	152 (134–170)	156 (129–184)	0.7
Male sex	50 (60)	39 (57)	11 (69)	0.4
History of COPD, OSA, or OHS	55 (65)	43 (63)	12 (75)	0.4
History of pulmonary hypertension	27 (32)	23 (34)	4 (25)	0.5
IV furosemide (mg)				
ED	40 (40–40)	40 (40–40)	40 (20–40)	0.3
24 h	80 (40–80)	80 (40–80)	40 (40–80)	0.058
Total ED and hospital	120 (60–205)	120 (75–200)	180 (55–285)	0.3
Total ED and hospital furosemide > 200 mg[d]	21 (25)	14 (21)	7 (44)	0.1
Oxygen requirement in ED greater than baseline	39 (46)	30 (44)	9 (56)	0.4
ED NIPPV	15 (18)	12 (18)	3 (19)	>0.9
Intubated in ED	1 (1.2)	0 (0)	1 (6.2)	0.2
ED IV nitroglycerin	10 (12)	8 (12)	2 (12)	>0.9
ED disposition				
ICU	3 (3.6)	2 (2.9)	1 (6.2)	0.5
Observation	12 (14)	11 (16)	1 (6.2)	0.4
Discharged from ED	8 (9.5)	7 (10)	1 (6.2)	>0.9

Abbreviations: ACE, angiotensin-converting enzyme; AMI, acute myocardial infarction; ARB, angiotensin receptor blocker; BMI, body mass index; CABG, coronary artery bypass graft; ECG, electrocardiogram; ICU, intensive care unit; NIPPV, noninvasive positive pressure ventilation; PCI, percutaneous coronary intervention; SpO_2, oxygen saturation.

[a]Data are reported as median (IQR) or *n* (%).

[b]Wilcoxon rank-sum test; Fisher's exact test.

[c]See Harrison et al.[38] for a more comprehensive description of the REED-AHF cohort, including additional home/ED medications, medical history, risk scores, other additional factors.

[d]200 mg is the maximum IV furosemide allowed to be given as a single dose per the American College of Cardiology's recommendations.[61]

TABLE 2 Echocardiographic variables obtained on point-of-care examination at ED arrival

POCecho variable	Overall, *N* = 84	Admitted to hospital, *n* = 76	Discharged from ED, *n* = 8	p-value, admit vs. discharge	No 30-day event, *n* = 68	≥1 event at 30 days, *n* = 16	p-value, event[a] vs. no event
Right heart measures							
TAPSE (mm)	17 (13–23)	17 (13–23)	21 (17–22)	0.3	18 (14–23)	13 (12–16)	0.011
TAPSE/RVDD ratio (mm/mm)	3.73 (2.54–5.33)	3.70 (2.42–5.33)	4.32 (3.57–5.29)	0.4	4.09 (3.07–5.37)	2.73 (2.13–3.94)	0.035
TAPSE/PASP ratio (mm/mmHg)	0.37 (0.29–0.56)	0.35 (0.29–0.54)	0.49 (0.46–0.65)	0.03	0.39 (0.30–0.65)	0.29 (0.26–0.37)	0.011
PASP [RVSP] (mm Hg)	43 (33–50)	44 (35–51)	36 (30–43)	0.1	43 (33–49)	46 (37–53)	0.3
RV/LV diameter ratio	0.81 (0.71–0.95)	0.81 (0.71–0.95)	0.76 (0.65–0.92)	0.3	0.81 (0.69–0.91)	0.79 (0.73–1.01)	0.4
RVOT PW Doppler acceleration time (ms)	84 (67–104)	84 (67–104)	84 (75–98)	0.7	82 (68–104)	86 (64–101)	0.6
Pulmonary vascular resistance (Wood units)	3.47 (2.43–4.90)	3.47 (2.39–5.10)	3.08 (2.68–3.95)	0.6	3.41 (2.41–4.60)	4.20 (2.82–6.07)	0.2
RV FAC	0.33 (0.21–0.42)	0.32 (0.21–0.42)	0.37 (0.32–0.54)	0.14	0.34 (0.23–0.42)	0.28 (0.20–0.44)	0.4
fwRVLS	15 (11–21)	15 (11–21)	13 (10–20)	0.8	16 (11–21)	12 (7–15)	0.034
Left heart measures							
LVEF	28 (19–38)	29 (20–39)	20 (18–29)	0.14	28 (19–36)	34 (22–41)	0.4
E/A ratio	3.07 (1.48–4.16)	3.07 (1.48–4.16)	3.08 (1.53–3.88)	0.9	2.97 (1.49–4.32)	3.29 (1.51–4.10)	0.8
E/E'	18.5 (15.4–22.5)	18.7 (15.7–22.5)	16.4 (15.2–19.6)	0.6	18.5 (16.0–22.3)	18.7 (13.6–22.0)	0.6
E' septal	0.04 (0.03–0.06)	0.04 (0.03–0.06)	0.05 (0.03–0.06)	>0.9	0.05 (0.03–0.06)	0.04 (0.04–0.05)	0.6
E' lateral	0.06 (0.05–0.08)	0.06 (0.05–0.08)	0.06 (0.05–0.08)	0.7	0.06 (0.05–0.08)	0.06 (0.05–0.07)	0.3
LVGLS	6.8 (4.8–10.2)	6.9 (4.6–10.6)	6.7 (6.0–6.9)	0.8	6.9 (4.9–10.4)	6.7 (4.5–9.0)	0.4

Note: Fifteen echocardiographic variables were stratified by ED disposition (left) and occurrence of at least one event in the composite primary 30-day outcome[a] (right). All echocardiography measures were collected at the point of care less than 1 h after, or any time before, first initiation of an AHF treatment in the ED (positive pressure ventilation, IV loop diuresis, IV or sublingual nitroglycerin). Only TAPSE, its ratio to RVDD and PASP, and fwRVLS were associated with the primary outcome. Only the TAPSE/PASP ratio differed between dispositions, as determined by the treating EP blinded to echocardiography. Wilcoxon rank-sum test used for unadjusted statistical comparisons.

Abbreviations: FAC, fractional area change; fwRVLS, free-wall right ventricular longitudinal strain; LV, left ventricle; LVEF, left ventricular ejection fraction; PASP, pulmonary artery systolic pressure; POCecho, point-of-care echocardiography; RVSP, right ventricular systolic pressure; PW, pulsed wave; RV, right ventricle; RVDD, right ventricular diastolic diameter; RVOT, right ventricular outflow tract; TAPSE, tricuspid annular plane systolic excursion.

[a]30-day death, CPR, mechanical cardiac support, intubation, new or emergent dialysis, acute myocardial infarction, and/or coronary revascularization.

TABLE 3 Category-free net reclassification and receiver operating characteristic AUC for TAPSE and selected clinical comparators

Variable of Interest	Category-free net reclassification index (NRI_{cont}) [95% CI]	AUROC (validation/bias-corrected)	
		STRATIFY + variable of interest (full models)	Difference compared to STRATIFY score only (reduced model, AUC of 0.706)
TAPSE (mm)	+0.63 [+0.08 to +1.18]	0.756	+0.050
History COPD	+0.02 [−0.52 to +0.56]	0.683	−0.023
History pulmonary hypertension	+0.18 [−0.30 to +0.66]	0.676	−0.030
GDMT adherence before ED	+0.26 [−0.05 to +0.56]	0.712	+0.006
ED arrival SBP	−0.04 [−0.58 to +0.50]	0.689	−0.017
Male sex	+0.23 [−0.28 to +0.74]	0.685	−0.021
IV furosemide in ED	+0.44 [−0.10 to +0.98]	0.714	+0.008
New or increased O_2 requirement in ED	+0.19 [−0.33 to +0.71]	0.700	−0.006
ED NIPPV or intubation	−0.11 [−0.57 to +0.36]	0.690	−0.016
ED IV nitro	+0.21 [−0.20 to +0.62]	0.697	−0.009
ED disposition			
Discharge	+0.08 [−0.20 to +0.36]	0.725	+0.019
ICU	+0.22 [−0.19 to +0.64]	0.678	−0.028

Note: TAPSE improved net prediction/classification when added to the STRATIFY risk score (NRI_{cont} CI does not cross zero).[a] Overall, the risk stratification benefits added to STRATIFY by TAPSE were not observed for EP standard-of-care risk stratification or other observed variables. Potential confounding comorbidities and treatment differences outside of the 13 variables already captured by STRATIFY failed to match or explain the TAPSE-related improvement in classification (all NRI_{cont} $p > 0.05$) and prediction (smaller change in ROC AUC compared to TAPSE). Likewise, the improvement in classification and prediction observed with TAPSE was not observed in the actual disposition decisions of EPs blinded to echocardiogram results.

Abbreviations: COPD, chronic obstructive pulmonary disease; GDMT, guideline-directed medical therapy for heart failure; ICU, intensive care unit; NIPPV, noninvasive positive pressure ventilation; PH, pulmonary hypertension; ROC AUC, receiver operating characteristic area under the curve.

[a]Primary outcome of the STRATIFY score = 30-day death, CPR, mechanical cardiac support, intubation, new or emergent dialysis, acute myocardial infarction, and/or coronary revascularization.

the a priori cutoff of ≥17 mm was added to STRATIFY. At every risk threshold less (i.e., more conservative) than the 8.3% benchmark (standard-of-care event rate among discharged patients), TAPSE ≥ 17 mm significantly increased specificity without changing sensitivity. At the 8% cutoff, a peak 32% (95% CI 20%–44%) of event-free patients at 30 days would have been appropriately reclassified from high risk (i.e., by STRATIFY alone) to low risk (by STRATIFY and TAPSE ≥ 17 mm). At an even more conservative 4% predicted risk cutoff, 15% (6%–24%) of patients incorrectly classified as high risk by STRATIFY alone would have been appropriately reclassified to low risk. Figure S2 shows categorical reclassification for all of the 15 POCecho variables side-by-side. TAPSE, the TAPSE/PASP and TAPSE/RVDD ratios, and fwRVLS stood out across multiple cutoffs for increasing specificity beyond STRATIFY alone without sacrificing sensitivity.

Echocardiographic measure importance

Figure 2 presents variable importance for each POCecho measure in predicting the primary outcome. TAPSE was the most important POCecho measure. Despite being only a single variable, TAPSE was nevertheless almost three-fourths as important on its own as the entire 13-variable STRATIFY score. The five most important POCecho variables were right heart measures. E/e' was the most important left heart measure, followed by LVEF and LVGLS.

Echo measures adjusted for STRATIFY

Figure S1 presents ORs and the STRATIFY aOR's for each POCecho measure and the primary outcome, presented as continuous (OR/aOR per change in IQR) and binary variables. TAPSE had an aOR of 0.32 (95% CI 0.12–0.87) as a continuous variable and 0.24 (0.06–0.91) at the ≥17 mm a priori cutoff. Internally validated (bias-corrected) AUROC was 0.756 for TAPSE plus STRATIFY versus 0.706 in STRATIFY alone.

Four additional right heart variables were associated with the outcome after adjusting for STRATIFY: TAPSE/RVDD ratio (aOR 0.35 [0.13–0.94]), TAPSE/PASP ratio (0.38 [0.15–0.96]), RV-FAC (0.41 [0.17–0.94]), and fwRVLS (0.31 [0.11–0.9]). RV-LV ratio < 1 (but not as a continuous variable) was also associated with the primary outcome after adjustment (0.24 [0.06–0.78]). No left heart measures were associated with the primary outcome.

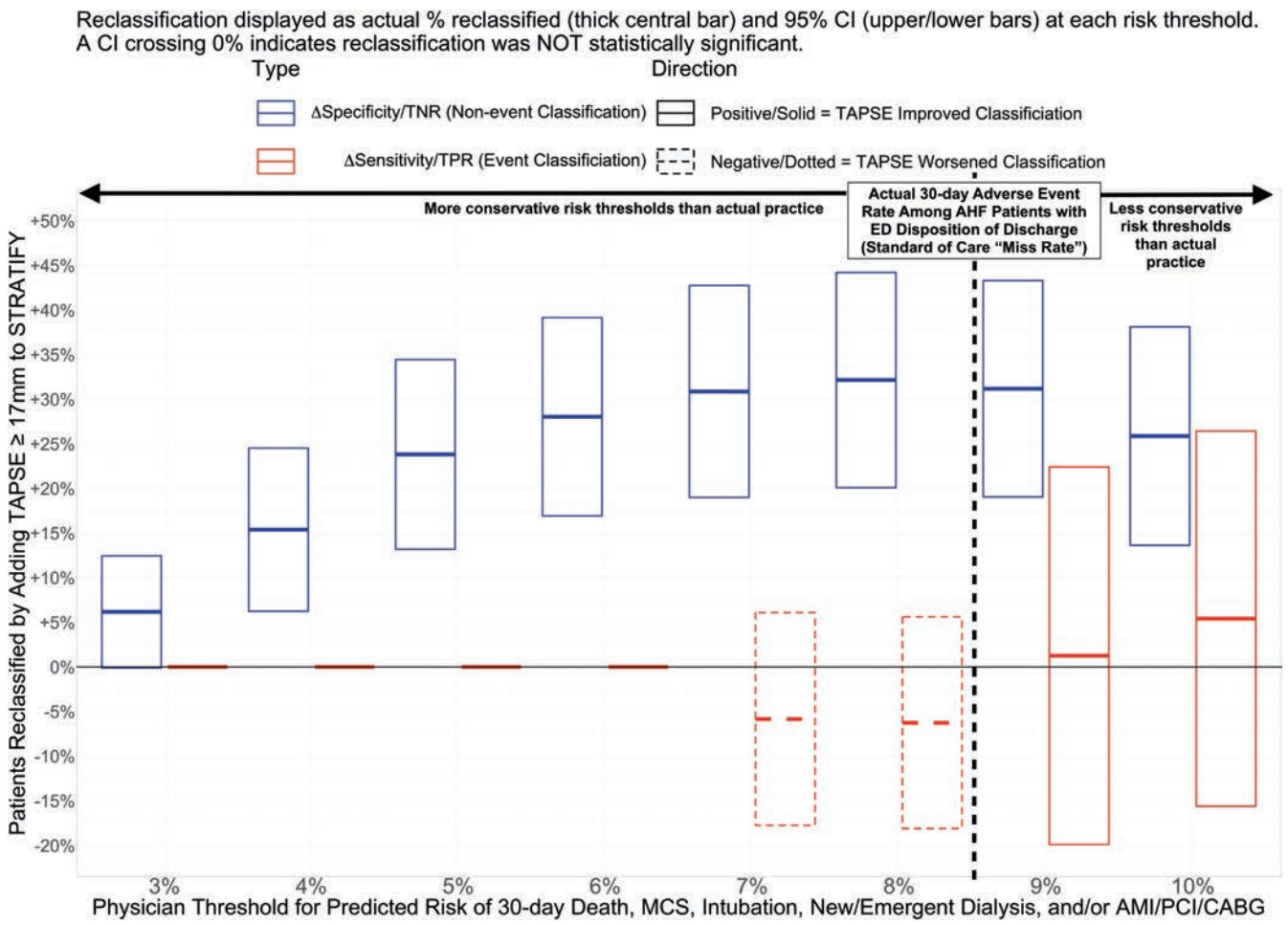


FIGURE 1 Change in sensitivity (NRI-Events) and specificity (NRI-Nonevents) when TAPSE is added to STRATIFY versus STRATIFY alone, for various thresholds of 30-day risk for serious adverse heart failure events. When added to the STRATIFY risk score, TAPSE ≥ 17 mm increased specificity (TNR/$NRI_{nonevents}$, i.e., correct identification of patients without a 30-day event) without any significant change in sensitivity (i.e., no change in missed events) for risk thresholds benchmarked to the actual 30-day outcome rate among discharged patients. If the use of TAPSE + STRATIFY were used conservatively (i.e., only at risk thresholds more conservative than the adverse event rate occurring under standard-of-care EP disposition decision making) there still would have been a significant increase in the number of low-risk patients identified without significant change in missed cases. AMI, acute myocardial infarction; CABG, coronary artery bypass graft; NRI, net reclassification index; MCS, mechanical cardiac support; PCI, percutaneous coronary intervention; TNR, true-negative rate = $NRI_{nonevents}$ = Δspecificity; TPR, true-positive rate = NRI_{events} = Δ sensitivity; TAPSE, tricuspid plane systolic excursion.

DISCUSSION

In this study, we prospectively validated pilot data suggesting that TAPSE improves risk stratification of AHF patients in the ED for clinically relevant adverse AHF events. We highlight four major findings. First, TAPSE improved risk classification beyond the previously validated[11] and ACEP-endorsed[7] STRATIFY CDI by multiple measures: NRI_{cont}, aOR, and the ability to identify low-risk AHF patients (i.e., higher $NRI_{nonevent}$/ΔSpecificity) without increasing "missed" high-risk patients (i.e., no change in NRI_{event}/ΔSensitivity). Second, TAPSE and other right-heart measures showed greater importance (Figure 2), effect size on STRATIFY adjusted odds (Figure S1), reclassification (Table 3), and prediction of low-risk (Figures 1 and S2) than left heart measures. Third, TAPSE improved classification even where other clinical factors not in the STRATIFY score did not (e.g., ED disposition, COPD, PH history, supplemental oxygen requirement, IV diuretic dose, NIPPV, etc.; Table 3). Fourth, improved identification of low-risk patients with TAPSE (Figure 1) was observed even when benchmarked to ensure that TAPSE miss rates were more conservative than real EPs' actual disposition decisions when blinded to the POCecho results.

This is the first and most comprehensive prospective report on the utility of POCecho to aid in AHF risk stratification in the ED. Sax et al.[62] recently described the prognostic utility of historical LVEF in AHF in a large retrospective study, which we believe to be one of the few reports describing any echocardiographic variable in ED risk-stratification, whether POC or not. In addition to REED-AHF, other POCecho studies such as one by Favot et al.[63] and a previously reported secondary aim of REED-AHF[38] have described the utility of longitudinal changes from ED arrival to inpatient time-points, including with TAPSE.[38] Nevertheless, among the six or more described CDIs for ED risk stratification of AHF, none incorporate

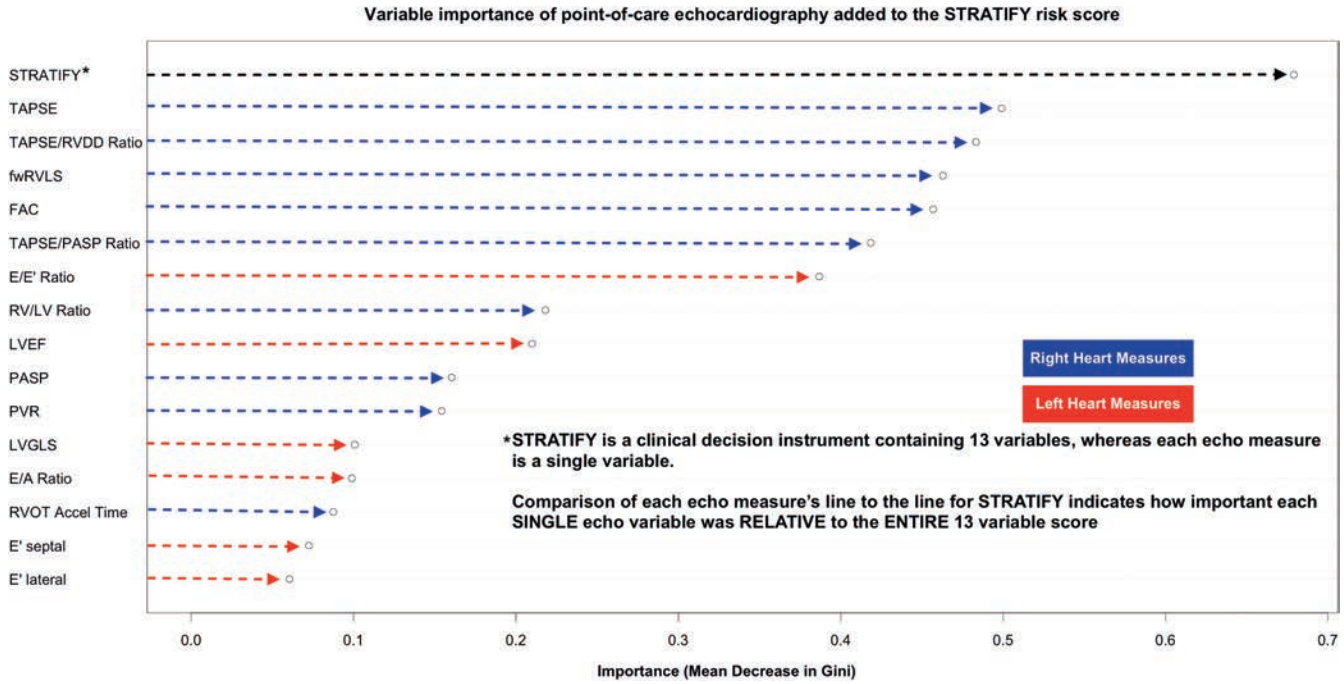


FIGURE 2 Relative importance of echocardiographic variables for predicting 30-day serious adverse heart failure events in conjunction with the STRATIFY decision instrument importance on random forest of each echocardiography variable in predicting the primary outcome of the STRATIFY decision score* after adjusting for the STRATIFY score itself. Eight of the 10 variables which added the most risk prediction to STRATIFY were right heart measures. TAPSE, the primary measure of interest, was the most important echocardiography variable. As a single variable, TAPSE was >70% as important as the entire 13 variable STRATIFY score in predicting STRATIFY's outcome. *30-day death, CPR, mechanical cardiac support, intubation, new or emergent dialysis, acute myocardial infarction, and/or coronary revascularization. FAC, RV fractional area change; fwRVLS, free-wall RV longitudinal strain; LV, left ventricle; LVEF, left ventricular ejection fraction; LVGLS, LV global longitudinal strain; PASP, pulmonary artery systolic pressure; PVR, pulmonary vascular resistance; PW, pulsed wave; RV, right ventricle; RVDD, right ventricular diastolic diameter; RVOT, right ventricular outflow tract; TAPSE, tricuspid annular plane systolic excursion.

echocardiographic variables.[64] This is despite copious literature describing the utility of right heart echocardiography measures for heart failure risk prediction outside of the ED setting.[6,18–37,39–46]

That echocardiography has so far been excluded from AHF risk stratification in the ED is surprising. Namely, being able to visualize the main organ affected in AHF to assess severity of presentation has clear face validity. Moreover, POCecho measures including TAPSE have been used with reliability and utility by EPs for risk stratification of other conditions like pulmonary embolism (PE).[47,48,50] Nevertheless, prior literature on the appropriate use of POC ultrasound in AHF for ED patients is highly limited to diagnosis and assessment of volume status[65] but not risk prediction. LUS, but not POCecho, has also been described for the latter purpose including the recent BLUSHED-AHF trial[66] and the previous publication from REED-AHF.[38] Concurrently, even the three strongest CDIs[8–10] described for ED risk stratification, two of which have been documented to outperform EP gestalt,[9,10] are viewed by ACEP as potentially useful but nevertheless not strong enough to guide disposition on their own.[7] With the existence of at least six different ED CDIs for AHF risk prediction utilizing a large overlap of the same clinical variables,[64] echocardiographic variables are among the last remaining "new" (i.e., previously unused) markers to include in ED risk stratification and potentially improve upon the status quo.

Our study has several strengths. First, we prospectively tested our primary hypothesis and found TAPSE to be useful not only as a continuous variable but also at the binary cutoff we specified a priori from prior research.[17] Due to a large effect size, we were able to detect a difference even with a slightly abbreviated sample size (on account of the COVID-19 pandemic) compared to our prespecified power analysis. TAPSE ≥ 17 mm, after adjusting for STRATIFY, predicted a further fourfold reduction in odds of adverse events which was greater than anticipated. Second, we used rigorous methods[38] to adjudicate AHF diagnosis and outcomes, including multiple blinded raters and multiple redundant information sources for follow-up, and included follow-up methods designed to detect outcomes occurring outside our institutions (e.g., HIE data and telephone follow-up). Third, ED ultrasound examinations were performed at the point of care primarily by attending physician and resident investigators (NH, JL) without advanced fellowship training in POCUS, but measurements were nevertheless shown to have high ICC with blinded expert testamurs of the NBE (MF, RE) and one additional blinded offline reviewer (LG). This included measurements expected to be the most challenging for EPs, such as fwRVLS. Every patient screened in whom a POCecho was attempted had adequate images to measure TAPSE, compared to two patients in whom LVEF (a basic POCecho requirement for all EM residents) could not be obtained. Fourth, we measured a broad swath of echocardiographic variables far earlier in

the treatment course than any prior studies of POC or formal echocardiography, while enrolling a broad mix of acuity. As shown in a previously published report from REED-AHF,[38] measures of RVD like TAPSE and those of PH like PASP changed dramatically between the initial ED echocardiograms and even 24 h later. The next earliest enrolling AHF study evaluating right heart function for risk prediction[25] included patients hours after hospital admission, meaning that we were able to observe RVD and PH that may otherwise have been missed. Finally, we used a novel approach with face validity to address a key risk of bias affecting all studies of ED risk prediction/stratification in AHF: i.e., the vast majority of AHF patients are admitted to the hospital, and admission could change risk compared to discharge. We approached this problem by tying our most important measures (ΔSensitivity [NRI_{events}] and ΔSpecificity [$NRI_{nonevents}$]) to risk thresholds more conservative than the actual outcome rates experienced by patients whom POCecho-blinded EPs chose to discharge. This was done to acknowledge the status quo: conservative disposition practices resulting in admission for 80%–90% of patients and < 50% of patients receiving an intervention requiring hospital admission (Table 1—new oxygen requirement, PPV/intubation, IV nitro, and/or higher total IV diuretic dose than allowed to be given as a single dose by ACC guidelines[61]). Concurrently, rather than seeking primarily to answer broad but less clinically actionable questions about prediction across the total spectrum of risk[60] (e.g., whether TAPSE improves AUROC), we asked whether TAPSE could improve identification of patients on the low-risk end of the spectrum whom clinicians might then be able to consider for outpatient therapy (discharge or observation). This approach was specifically designed to match the critical need of an unnecessarily high admission rate in the United States (possibly by 50% or more[8]) with a clinically actionable goal: if an ED patient has no absolute indications for inpatient status (e.g., supplemental oxygen), adding TAPSE ≥ 17 mm to a STRATIFY risk score can increase the odds of appropriately identifying individuals with lower-than-average rates of adverse 30-day events to help facilitate safe outpatient management in an otherwise high-risk population.

LIMITATIONS

Our study also has several limitations. First, despite the methods described to address the bias of high admission rates in AHF risk stratification literature, we cannot eliminate this bias entirely. The only way to do this completely would be to enforce mandatory EP disposition decisions in a randomized trial based on TAPSE and STRATIFY.

Second, our study was powered to detect whether TAPSE ≥ 17 mm could add predictive utility to the existing STRATIFY score, which is not the same as if we had refit a new model including all 13 individual variables in STRATIFY plus TAPSE (i.e. as the 14th). At the outcome rates observed, we would have required more than eight times the number of patients enrolled to have enough events to prevent overfitting on logistic regression fitting an entirely new CDI with as many variables[13] as STRATIFY. Given the feasibility of obtaining POCechos early in the course and the novel nature of our hypothesis among ED studies, this was not seen as feasible and therefore not the goal of REED-AHF. Based on our current results a future study of that scope may now be justified, to derive a de novo CDI including prospectively collected TAPSE and/or other POCecho markers alongside traditional clinical variables.

Third, we had slightly less than 10 events per variable when considering both the STRATIFY score and a POCecho variable (i.e., eight events per variable). Our sample size was slightly abridged due to the COVID-19 pandemic as discussed, and prior research has shown that as low as five events per variable is usually sufficient to prevent overfitting.[67] Moreover, the STRATIFY score actually performed better by AUROC in our sample (0.706 after bootstrap correction for bias/optimism) than in its original derivation,[8] making it doubtful that our results are due to poor performance of our chosen confounder (STRATIFY) in the 16 events observed. Likewise, predicted bias/optimism in the TAPSE-adjusted model[59] was overall low (AUROC optimism 0.026, with an observed AUROC 0.796 vs. 0.756 bias-corrected), suggesting a lower chance that a higher event count would have led to much worse performance in an external sample or if enrollment targets had been met. Nevertheless, we cannot say for certain how completion of the original enrollment target would have changed results, which in turn makes our results more hypothesis generating than overtly practice changing. Ultimately, as mentioned, a larger study than even our initial enrollment target will be needed to derive and then validate direct incorporation of TAPSE into a de novo CDI. A future study to externally validate our results here is also warranted, especially in view of this limitation.

Fourth, we did not directly test learning curves for TAPSE in EP hands (e.g., compared to current requirements for EM residency in POCecho), although ICC to experts was high and feasibility of EP-performed TAPSE for risk stratification has been demonstrated in prior studies of PE.[47,48] No patients were excluded from the current study for images insufficient to grade TAPSE, but a future study to directly describe learning curves and pedagogy in EM learners would be helpful.

Fifth, the study was not designed to compare POCecho variables head to head, and the abridged enrollment likely decreased this power even further. Given this, we cannot say that other echocardiography variables such as LVEF and mitral inflow parameters are of low utility, but rather only that we had low power to detect a difference among various echocardiography parameters. Nevertheless, other measures all had lower variable importance (Figure 2) and aOR effect size (Figure S1) than TAPSE.

Sixth, our population is medically underserved, predominantly non-White, coming from only two hospitals (DRH, SGH) and two institutions (Wayne State and Michigan State University College of Osteopathic Medicine). Generalizability to different populations is therefore uncertain.

CONCLUSIONS

Tricuspid annulus plane systolic excursion (TAPSE) significantly improved risk stratification compared to the validated STRATIFY clinical decision instrument. Most critically, TAPSE appears to improve detection of low-risk acute heart failure, even among patients misclassified as high risk. TAPSE, the TAPSE/PASP ratio, the TAPSE/RVDD ratio, and fwRVLS may all help increase the identification of low-risk acute heart failure patients in the ED who could be considered for outpatient treatment rather than hospital admission. Our hypothesis-generating results support a need to further define and evaluate point-of-care echocardiography's role in acute heart failure risk stratification. Future studies should investigate the incorporation of point-of-care echocardiography variables, and particularly right-heart measures, into acute heart failure clinical decision instruments given their demonstrated potential here, the face validity for acute heart failure risk-stratification, and the status of echocardiography as one of the few accessible clinical parameters not already used to risk-stratify acute heart failure in the emergency department.

AUTHOR CONTRIBUTIONS

Study concept and design: Nicholas E. Harrison, Robert Ehrman, Mark J. Favot, Phillip Levy, Aiden Abidov. Acquisition of the data: Nicholas E. Harrison, Laura Gowland, Jacob Lenning, Sarah Henry, Sushane Gupta, Robert Ehrman, Mark J. Favot. Analysis and Interpretation of the data: Nicholas E. Harrison, Jacob Lenning, Laura Gowland, Robert Ehrman, Mark J. Favot. Drafting of the manuscript: Nicholas E. Harrison. Critical revision of the manuscript for important intellectual content: all authors. Statistical expertise: Nicholas E. Harrison, Robert Ehrman. Acquisition of funding: Nicholas E. Harrison, Robert Ehrman, Mark J. Favot.

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CONFLICT OF INTEREST

JL, SH, SG, and LG report no conflicts of interest. NH's first institution, Wayne State University, has received grant money to conduct investigator-initiated research conceived and written by NH from BCBSMF. NH and their second institution, Indiana University, have received grant money to conduct investigator-initiated research conceived and written by NH from the Doris Duke Foundation and the National Institutes of Health (5KL2TR002530-05). NH's second institution, Indiana University, has received grant money for industry-initiated research from Abbott Laboratories and Roche Diagnostics. NH has received funding from Vave Health Inc. for consulting. RE has received grant money to conduct investigator-initiated research from the National Institutes of Health conceived and written by Dr. Peter Pang at Indiana University (1R34HL136986-01) and investigator-initiated research conceived and written by NH from BCBSMF. RE has received funding from UltraSight for consulting. MF has received grant money to conduct investigator-initiated research conceived and written by NH from BCBSMF. MF serves on the medical advisory board for Echonous Inc. and has received stock options from Echonous Inc. AA has received grant money to conduct investigator-initiated research conceived and written by NH from BCBSMF. PL has received funding for consulting from Apex Innovations, AstraZeneca, BMS, Mespere, Novartis, Cardionomics, Baim Institute, Ortho Clinical Diagnostics, Roche Diagnostics, Siemens, Hospital Quality Foundation. PL and their institution have received investigator-initiated research support from American Heart Association, Beckman Coulter, Agency for Healthcare Research and Quality (AHRQ), BCBSMF, Emergency Medicine Foundation, Edwards Lifesciences, CardioSounds, Michigan Department of Health and Human Services, Michigan Health Endowment Fund, Patient Centered Outcome Research Institute, and the National Institutes of Health NIH. PL is a member of the ACC's National Cardiovascular Data Registry Oversight Committee.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL CONTRIBUTION

Disparities in emergency department prioritization and rooming of patients with similar triage acuity score

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Abstract

Background: We identify patient demographic and emergency department (ED) characteristics associated with rooming prioritization decisions among ED patients who are assigned the same triage acuity score.

Methods: We performed a retrospective analysis of adult ED patients with similar triage acuity, as defined as an Emergency Severity Index (ESI) of 3, at a large academic medical center, during 2019. Violations of a first-come-first-served (FCFS) policy for rooming are identified and used to create weighted multiple logistic regression models and 1:M matched case–control conditional logistic regression models to determine how rooming prioritization is affected by individual patient age, sex, race, and ethnicity after adjusting for patient clinical and time-varying ED operational characteristics.

Results: A total of 15,781 ED encounters were analyzed, with 1612 (10.2%) ED encounters having a rooming prioritization in violation of a FCFS policy. Patient age and race were found to be significantly associated with being prioritized in violation of FCFS in both logistic regression models. The 1:M matched model showed a statistically significant relationship between violation of rooming prioritization with increasing age in years (adjusted odds ratio [aOR] 1.009, 95% confidence interval [CI] 1.005–1.013) and among African American patients compared to Caucasians (aOR 0.636, 95% CI 0.545–0.743).

Conclusions: Among ED patients with a similar triage acuity (ESI 3), we identified patient age and patient race as characteristics that were associated with deviation from a FCFS prioritization in ED rooming decisions. These findings suggest that there may be patient demographic disparities in ED rooming decisions after adjusting for clinical and ED operational characteristics.

KEYWORDS
emergency department, health disparities, triage

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INTRODUCTION

The emergency department (ED) triage process is a combination of objective and subjective rapid assessments that aim to identify and prioritize ED patients who need the most emergent or timely evaluation. Triage severity scales, such as the Emergency Severity Index (ESI),[1] assign patients to one of several different groups with more acute groups receiving priority over the less acute groups for treatment. Other triage scales, such as the Canadian Triage and Acuity Scale (CTAS),[2] also include guidance for how quickly patients should be treated. However, little systematic guidance exists for consistently prioritizing patients within the same ESI level, other than the use of a first-come-first-served (FCFS) policy among patients deemed initially to be of similar acuity. The FCFS paradigm among patients with similar triage acuity scores seems intuitive, but the process of a rapid triage assessment often uncovers subjective characteristics about a patient presentation that may influence the decision to violate a simplistic FCFS approach. This policy raises the question of what leads to rooming a patient in violation of this general FCFS guideline and whether or not this practice may lead to disparities in ED triage and timely access to emergency care. To date, there has been limited research investigating this potentially inequitable prioritization decision in the ED.

The primary objective of this study was to determine patient demographics and ED operational conditions associated with prioritization in rooming decisions for patients who were triaged into a similar acuity category. Specifically, we test the null hypothesis that rooming prioritization, defined by an FCFS violation, does not vary by patient sex, race, or ethnicity when controlling for acuity and clinical and ED operational characteristics.

METHODS

We performed a retrospective analysis on data from a large academic medical center in the Southeastern United States from January 1, 2019, through December 31, 2019. The study ED had a total of 59 beds divided among five adult care areas (A, B, C, D, and behavioral health) and one pediatric care area. Two of the adult care areas (A and B) operated 24 hours, care area D operated only during peak hours and focused mainly on low-acuity patients, and the remaining two (C and behavioral health ED) were primarily dedicated to behavioral health patients. All patients are initially triaged by one or more dedicated triage nurses who have received training on a standardized triage process including assigning an ESI level and who have discretion on rooming order based on subjective and other operational characteristics including room/bed type availability. Clinicians are able to pull patients directly to the care areas although this occurs rarely in this ED. In 2019, the study ED had a total of 62,552 ED visits, which is similar to the average annual number of ED visits to 44 academic EDs across the United States surveyed in 2016.[3]

Patients were included in this study if they had an ESI score of 3 at time of triage; were evaluated in the two primary care areas (A or B); and had complete event time stamps recorded in the electronic health record (EHR) including ED arrival, end of triage, rooming, and first seen by a provider time. We only included patients who were assigned an ESI score of 3 as this represents a majority of patients seen in the ED and has proven difficult to determine which patients need more timely care within the same ESI classification.[4] We restricted our analysis to only patients evaluated in two care areas (A and B) that both operate continuously around the clock and are similar in terms of staffing by providers and nursing. Patients were excluded if they were less than 18 years old, if their chief complaint was categorized as "mental health," or if they arrived via emergency medical services (EMS), as these three groups of patients follow a separate workflow in ED rooming decisions. Lastly, patients with a sex other than male or female were also removed since their extremely low count (0.014% of the ED census during 2019) in comparison could create unstable model parameter estimation and consequently unreliable statistically significant results for sex. The final study data set contained 15,781 ED patient encounters. Table 1 summarizes patient characteristics of the study population.

Primary outcome

The primary outcome was to determine violations of a FCFS policy in rooming decisions. We use the convention that under the FCFS policy patients are roomed according to the order of their end of triage time stamps (corresponding to the time patients enter the waiting room). A patient is said to be *prioritized* in violation of FCFS if they were roomed at least 15 minutes before another patient who had arrived at the waiting room before them. We also say a patient is *deprioritized* if they were roomed after some prioritized patient despite entering the waiting room before that prioritized patient.

The specific margin of 15 min used in our definition of violation of FCFS was chosen based on clinical judgment of the authors who practice emergency medicine and have first-hand experience with the rooming process and nursing workflow at the study ED. We also performed a sensitivity analysis using margins of 10 and 20 min.

Model covariates

The chief complaint for each patient encounter was grouped into one of 17 categories.[5] The weighted Elixhauser comorbidity score[6,7] is then calculated for each patient encounter using the provided ICD-10 diagnosis codes and the comorbidity package[8] in R. Select patient demographic categories were collapsed into fewer levels to avoid extremely unbalanced categories and to reduce the number of required parameters in the models. For race, "Native American," "Pacific Islander," "patient refused," "unknown," and "other" were combined into an aggregate "other" category. For ethnicity, "patient refused" and "unknown" were placed into a "other" category. For chief complaints, "general/minor" and "environmental" were combined into a single category and the three different "ENT" categories were combined into a single

TABLE 1 Characteristics of the study population and prioritized patients

	Study population (ESI 3 patients seen at care areas A and B)	Prioritized patients within the study population	Percentage prioritized
Sample size	15,781	1612	10.21
Age (years)	47.73 (±17.87)	49.72 (±18.44)	—
Age group (years)			
18–40	6124 (38.81)	577 (35.79)	9.42
40–55	4259 (26.99)	402 (24.94)	9.44
55–70	3487 (22.10)	393 (24.38)	11.27
>70	1911 (12.11)	240 (14.89)	12.56
Sex			
Male	6681 (42.34)	704 (43.67)	10.54
Female	9100 (57.66)	908 (56.33)	9.98
Race			
Caucasian	8015 (50.79)	925 (57.38)	11.54
African American	4529 (28.70)	410 (25.43)	9.05
Asian	283 (1.79)	24 (1.49)	8.48
Other	2954 (18.72)	253 (15.70)	8.56
Ethnicity			
Hispanic or Latino	2576 (16.32)	219 (13.59)	8.50
Not Hispanic or Latino	13,069 (82.81)	1377 (85.42)	10.54
Other	136 (0.86)	16 (0.99)	11.76
Complaint category			
Cardiovascular	2278 (14.44)	251 (15.57)	11.02
Ear, nose, throat	624 (3.95)	59 (3.66)	9.46
General/environmental	1321 (8.37)	187 (11.6)	14.16
Gastrointestinal	3796 (24.05)	315 (19.54)	8.30
Genitourinary	977 (6.19)	71 (4.40)	7.27
Neurologic	1298 (8.23)	140 (8.68)	10.79
Obstetrics/gynecology	555 (3.52)	54 (3.35)	9.73
Ophthalmology	312 (1.98)	73 (4.53)	23.40
Orthopedic	1565 (9.92)	146 (9.06)	9.33
Respiratory	1132 (7.17)	104 (6.45)	9.19
Skin	1182 (7.49)	131 (8.13)	11.08
Substance	214 (1.36)	17 (1.05)	7.94
Trauma	527 (3.34)	64 (3.97)	12.14

Note: Data are reported as mean (±SD) or *n* (%). The last column is column 3 divided by column 2 times 100.

category. Lastly, the average time from the end-of-triage time stamp to first-seen-by-provider time stamp is calculated for patients who enter the waiting room during the same hourly block as a proxy for measuring ED crowding. The day of week and the time of day in six 4-h blocks (12a.m. to 4a.m., 4a.m. to 8a.m., 8a.m. to 12p.m., 12p.m. to 4p.m., 4p.m. to 8p.m., and 8p.m. to 12a.m.) were also used as covariates.

Modeling technique

We first fitted a weighted logistic regression model on the data set for the study population (sample size 15,781) to identify patient characteristics and ED conditions that relate to whether a patient is prioritized in violation of FCFS. Prioritized patients in violation of FCFS received a response of 1, and all other patients (including those who were roomed according to FCFS and those who were deprioritized in violation of FCFS) were assigned a response of 0. Patient-level covariates in the model included patient age, sex, race, ethnicity, chief complaint category, and the weighted Elixhauser comorbidity score. ED-level operational covariates included the day of week and time of day when patients were roomed and average time from the end of triage to first provider time for the hourly block when that patient was roomed. Weights are assigned to each patient encounter according to the response that was assigned. If this model

was to remain unweighted, the imbalance between the two different classes (10.21% prioritized vs. 89.79% others) could lead to bias and affect the significance of the different predictors.[9] This model was fitted using maximum likelihood estimation with the glm function in R.[10]

We also created a matched 1:M case–control logistic regression model[11] to assess the differences between the prioritized and deprioritized patients. Compared to the previous logistic regression model, the 1:M modeling technique can be more robust to potential unmeasured confounders which are not included in the covariates and reduce bias in the statistical analysis.[12] For this matched model, we excluded patients who were not involved in a FCFS violation keeping only prioritized and deprioritized patients. Patients are grouped into various strata, with each stratum consisting of one prioritized patient and any deprioritized patients that had been present in the waiting room before this prioritized patient, resulting in 1612 strata. Hence, with this model, we directly matched each prioritized patient with multiple patients who were in the waiting room at the same time, had similar triage acuity, and had arrived earlier than this prioritized patient. This conditional logistic regression model with varying M is then formed with only the patient-related variables included. The model was then fitted using a Cox proportional hazards model.[13–16] For more details on this matched case–control model, interested readers are referred to the Supplementary Material.

Submodels corresponding to both types of logistic regression models were then created, with each submodel dropping one predictor from the full model. Likelihood ratio tests (LRTs) were then performed to determine the significance of each predictor ($p \leq 0.001$) assuming the remaining predictors are already accounted for in both types of models. After determining predictor significance, we then determined the direction of significance for those predictors by examining the coefficients of different models. We also conducted a multicollinearity analysis for both models and concluded that there is no indication of any serious multicollinearity (Supplemental Material Table S1).

All calculations and analysis were performed using R[10] 4.0.2. This study was exempted from full review by the institutional review board at the University of North Carolina at Chapel Hill.

RESULTS

During the study period 15,781 ED visits met the inclusion criteria. Included ED visits were composed of patients with mean age of 47.73 years, 57.66% of whom were female and 28.70% of whom were African American. The two most common chief complaint categories were gastrointestinal and cardiovascular (Table 1). A total of 1612 (10.2%) ED encounters were prioritized in violation of FCFS among patients with an ESI score of 3, where certain patient groups were more frequently prioritized than others. For example, Table 1 shows that 12.56% of patients who are more than 70 years old were prioritized whereas 9.42% of patients who are 18–40 years of age received priority. Similarly, according to Table 1, 11.54% of Caucasians were prioritized whereas only 9.05% of African Americans received priority. Both logistic and 1:M case–control logistic regression models were found to be statistically significant overall, with goodness-of-fit tests for the weighted logistic regression model and the LRT for the entire 1:M model both returning a p-value of <0.001.

The weighted logistic regression model found that patient age, race, chief complaint category, weighted Elixhauser score, day of week, time of day, and hourly average time from end of triage to provider were statistically significant with p-values of ≤0.001, whereas sex and ethnicity were not at this level of statistical significance (Table 2). In particular, older patients were more likely to be prioritized with an adjusted odds ratio (aOR) of 1.005 (95% confidence interval [CI] 1.002–1.007) for a 1-year increase in age. In addition, the likelihood of prioritization was significantly lower for African Americans when compared to Caucasians with an aOR of 0.751 (95% CI 0.688–0.818). Among the patient chief complaint categories, cardiovascular, general/environmental, neurologic, ophthalmology, and trauma were heavily associated with prioritization compared to the gastrointestinal complaints. Lastly, each of the ED operational characteristics were found to be statistically significant. After the patient covariates were accounted for, the model still found that significant associations existed between ED-level operational covariates and patient prioritization. The likelihood of prioritization changed depending on the day of week and time of day. In addition, it was also associated with average time until provider, with an aOR of 1.017 for an increase of 1 min.

Table 3 shows the results for the matched 1:M conditional logistic regression model. Using this approach, we found similar results to the weighted logistic regression model in terms of patient characteristics that correlate with rooming priority. The race predictor was overall significant and most notably the aORs for African Americans and others being prioritized compared to Caucasians were 0.636 (95% CI 0.545–0.743) and 0.561 (95% CI 0.401–0.784), respectively. Also, the aOR for a 1-year increase in age was 1.009 (95% CI 1.005–1.013). Table 3 also shows that patients who were prioritized did not seem to have statistically significant differences from patients who were deprioritized in terms of sex and ethnicity. Similar relationships with increased ORs for certain chief complaints were observed in this model including general/environmental, neurological, trauma, and ophthalmology when compared to gastrointestinal chief complaints.

We performed a sensitivity analysis around the margin of 15 min used in our definition of violation of FCFS. Specifically, we repeated the statistical analysis with margins of 10 and 20 min and observed similar results. There were 1776 (11.3%) prioritized ED encounters when using a margin of 10 min and 1474 (9.3%) when using a margin of 20 min. Additionally, to test the robustness of our results that were obtained under the assumption that age is a continuous variable, we repeated our analysis by using age as a categorical variable. The aOR and p-values remained comparable to the case where age was modeled as a continuous variable. The results from these two sensitivity analyses are provided in the Supplemental Material Tables S1 through S7.

TABLE 2 Coefficients, aOR, and LRT p-values for the weighted logistic regression model 3

Predictor	aOR	95% CI	LRT p-values	Two-sided p-values
Age	1.005	(1.002–1.007)	<0.001*	<0.001*
Sex (baseline: female)			0.072	
Male	1.072	(0.994–1.156)		0.072
Race (baseline: Caucasian)			<0.001*	
African American	0.751	(0.688–0.818)		<0.001*
Asian	0.715	(0.538–0.951)		0.021
Other	0.782	(0.648–0.942)		0.010
Ethnicity (baseline: not Hispanic or Latino)			0.341	
Hispanic or Latino	0.879	(0.723–1.069)		0.197
Other	1.099	(0.724–1.669)		0.656
Complaint category (baseline: gastrointestinal)			<0.001*	
Cardiovascular	1.247	(1.102–1.410)		<0.001*
Ear, nose, throat	1.231	(1.006–1.507)		0.044
General/environmental	1.546	(1.341–1.783)		<0.001*
Genitourinary	0.830	(0.693–0.993)		0.042
Neurologic	1.377	(1.190–1.593)		<0.001*
Obstetrics/gynecology	1.168	(0.941–1.450)		0.159
Ophthalmology	3.605	(2.838–4.579)		<0.001*
Orthopedic	0.989	(0.858–1.139)		0.877
Respiratory	1.273	(1.085–1.493)		0.003
Skin	1.166	(1.003–1.355)		0.046
Substance abuse	0.944	(0.678–1.313)		0.731
Trauma	1.434	(1.169–1.759)		0.001*
Weighted Elixhauser score	1.014	(1.006–1.020)	<0.001*	<0.001*
Day of week (baseline: Monday)			<0.001*	
Tuesday	1.125	(0.989–1.280)		0.073
Wednesday	0.987	(0.864–1.127)		0.846
Thursday	1.269	(1.113–1.447)		<0.001*
Friday	1.187	(1.042–1.353)		0.010
Saturday	0.623	(0.538–0.723)		<0.001*
Sunday	0.654	(0.564–0.760)		<0.001*
Time of day (baseline: 12 p.m. to 4 p.m.)			<0.001*	
12 a.m. to 4 a.m.	0.801	(0.705–0.911)		0.001*
4 a.m. to 8 a.m.	0.057	(0.041–0.080)		<0.001*
8 a.m. to 12 p.m.	0.271	(0.233–0.315)		<0.001*
4 p.m. to 8 p.m.	0.981	(0.878–1.097)		0.739
8 p.m. to 12 a.m.	1.207	(1.083–1.346)		0.001*
Hourly average end of triage to provider	1.017	(1.016–1.018)	<0.001*	<0.001*

Abbreviations: aOR, adjusted odds ratio; LRT, likelihood ratio test.
*Significant at ≤0.001.

DISCUSSION

In our study of a large academic medical center ED, we employed two modeling techniques that independently found patient and ED operational characteristics that were associated with prioritization of rooming decisions among distinct patient groups compared to patients with similar triage acuity scores. Our findings add to the current literature on triage and rooming decisions in the ED by notably using robust modeling techniques that adjust for both patient-level characteristics and department-level characteristics that may

TABLE 3 Coefficients, aOR, and LRT results for the matched 1:M logistic regression model

Predictor	aOR	95% CI	LRT p-values	Two-sided p-values
Age	1.009	(1.005–1.013)	<0.001*	<0.001*
Sex (baseline: female)			0.640	
Male	1.032	(0.903–1.180)		0.640
Race (baseline: Caucasian)			<0.001*	
African American	0.636	(0.545–0.743)		<0.001*
Asian	0.702	(0.419–1.175)		0.178
Other	0.561	(0.401–0.784)		<0.001*
Ethnicity (baseline: not Hispanic or Latino)			0.394	
Hispanic or Latino	1.075	(0.760–1.520)		0.683
Other	1.632	(0.814–3.271)		0.167
Complaint category (baseline: gastrointestinal)			<0.001*	
Cardiovascular	1.311	(1.059–1.623)		0.013
Ear, nose, throat	1.259	(0.876–1.809)		0.213
General/environmental	1.583	(1.235–2.028)		<0.001*
Genitourinary	0.938	(0.677–1.300)		0.701
Neurologic	1.591	(1.221–2.073)		<0.001*
Obstetrics/gynecology	1.292	(0.897–1.862)		0.168
Ophthalmology	4.695	(3.115–7.079)		<0.001*
Orthopedic	1.096	(0.850–1.413)		0.479
Respiratory	1.445	(1.075–1.942)		0.015
Skin	1.358	(1.038–1.777)		0.025
Substance abuse	0.314	(0.177–0.557)		<0.001*
Trauma	1.444	(1.002–2.081)		0.049
Weighted Elixhauser score	1.017	(1.005–1.029)	0.004	0.004

Abbreviations: aOR, adjusted odds ratio; LRT, likelihood ratio test.

*Significant at ≤0.001.

influence rooming decisions of patients with a similar ESI triage acuity. To the best of our knowledge, this is the first study that specifically examines demographic disparities in rooming decisions. Prior work on disparities in EDs has been restricted to specific types of patients or applications. For instance, Tamayo-Sarver et al.,[17] Heins et al.,[18] Singhal et al.[19] found that ED opioid prescriptions were influenced by race. Chest pain patients have been found to be treated differently based on their race.[20,21] Lastly, Schrader and Lewis[22] and Vigil et al.[23] found that there have been significant differences in the triage acuity scores assigned to similar patients of different races and ethnicities.

There also exist a few papers in the literature that studied prioritization in rooming decisions in EDs. Ashour and Okudan[24] and Claudio and Okudan[25] use multiattribute utility theory to help nurses decide prioritization and select the next patient to be roomed. However, in both papers, the authors study subjective assessment made by a triage nurse about various criteria including patient vital signs or demographics which helped them determine the relative importance of these criteria and cutoffs used to make decisions. In such situations, triage nurses may be unaware of biases or tendencies to prioritize particular groups of patients. Our models use empirical data of how patients were triaged and roomed in a busy academic ED, and all data were retrieved from the EHR in a manner that captures real-world practice patterns and limits the possibility of decision making being influenced by the knowledge of the topic under study. Ding et al.[26] and Li et al.[27] both examined prioritization of patients using the CTAS in Canada, which includes fractile response objectives for each triage level within some target wait time. Both papers placed emphasis on the relation between prioritization and the patient wait time with respect to the target wait time of the associated triage category. Neither paper investigated demographic disparities associated with rooming decisions.

Lastly, Batt and Terwiesch[28] focused on using FCFS violations to determine why some patients leave without being seen rather than investigating disparities in rooming decisions at the ED. They argued that FCFS violations may be due to load balancing for providers in the ED because blocks of rooms are assigned to different doctors and nurses in the study ED, and the nurses in charge of rooming may choose to select patients who require less resources to room in a block that already has more severe patients.

The findings from both of our models suggest that racial disparities in rooming decisions exist in this ED. In particular, the weighted logistic regression model showed that African Americans were less likely to be prioritized in violation of FCFS for rooming when compared to Caucasians. Furthermore, our matched 1:M model found that African Americans and others were less likely to be prioritized compared to Caucasians, with respective aORs of 0.636 and 0.561. In addition, the matched model concluded that African Americans and others were more likely to be deprioritized than Caucasians. We also found that older patients were prioritized more than younger patients. The aOR for a 1-year increase in age were 1.005 and 1.009 for the weighted logistic model and matched model, respectively. Neither model found sex and ethnicity to be significant predictors of prioritization in rooming decisions in this ED. When compared to gastrointestinal chief complaints, certain chief complaints, including general/environmental, neurologic, and trauma, were associated with increased odds of prioritization in both modeling techniques. Of note, ophthalmological chief complaints were much more likely to get prioritized over gastrointestinal complaints, which in part can be explained by having a dedicated eye care room that patients with other chief complaints would not be roomed in. The weighted logistic model also brings up that prioritization may change depending on the ED's operating characteristics. In particular, there was more prioritization during Thursdays but less during the weekends when compared to the reference day of Monday. In addition, there was more prioritization during the evening and less during the morning in comparison to the reference hours of noon to 4 p.m. Lastly, when the ED seemed to be more crowded (as measured by the average time taken to see a provider), the likelihood of prioritization increased. These results suggest that prioritization became more frequent as the ED became more crowded.

It is important to note that violations of FCFS rooming decisions should not be uniformly viewed as problematic, but rather as means to give insight into subtle differences in how patients may experience variations in triage and timeliness of care depending on patient and ED characteristics. Additionally, it is not possible to use our EHR data to definitively assess on a case-by-case basis whether a prioritization was justified based on clinical condition (e.g., age-related frailty). However, the data can identify trends in subgroups of patients who are more likely to be prioritized in aggregate, i.e., sex, race, and ethnicity in this study, which would not be clinically justifiable. As patients are prioritized ahead of patients with similar triage scores, there will be other patients who will face longer wait times, and in some cases this may increase delays in timely diagnosis and treatment. This especially becomes pressing as the ED becomes more crowded, which our results suggest is a scenario where the rate of prioritization in violation of FCFS may also increase.

LIMITATIONS

This study has several limitations that are important to acknowledge. Patient race and ethnicity were abstracted from what was recorded in the EHR during routine clinical care and thus were not prospectively collected for this research purpose. Although this is a limitation, our data set had less than 1% of ED patients with missing race or ethnicity data and at the study ED, patient demographics are collected by ED registration staff who are required to complete training on how to collect demographic information.

Our findings are based on data from a single academic ED and excluded patients arriving to the ED via EMS and, therefore, may not generalize to other settings. To draw firmer conclusions about the existence of disparities, similar models should be generated using data from other EDs and other ED patient groups and with patient demographic data having higher fidelity than routine clinical data captured in the EHR. These additional results would allow us to further generalize our conclusions and to further determine whether a different patient population leads to differences in prioritization in ED rooming.

Additionally, it is possible that our model was not able to account for unmeasured variables that differentially affect the recognized triage acuity of a patient's condition. For example, we do not explicitly adjust for specific comorbidities that differentially affect patients of a given race/ethnicity including end-stage renal disease or sickle cell disease. In our study we utilized a weighted Elixhauser score; however, this only captures the likelihood of a patient's mortality across common comorbidities but does not assess specific individual comorbidities in isolation. Some insight from the models could also be possibly explained by the layout of the ED rather than bias toward a particular type of patient. Some patients, by nature of their complaint, cannot be roomed in certain care areas such as those with chief complaints that require private rooms for adequate evaluation. Additionally, even though ophthalmology-related patients were prioritized more, this is readily explained by the specialized care areas only suited for eye complaints. To ensure robustness, we conducted a sensitivity analysis by excluding the eye complaints and observed that our main conclusions have not changed (Tables S8 and S9 in the Supplementary Material). Lastly, our data did not account for individual patient triage vital signs and other nondiscrete data such as free-text triage nursing notes to further assess the potential severity of a patient's condition that is more easily appreciated in real time by triage staff.

CONCLUSIONS

Using a statistical modeling approach, we identified that patient age and race were statistically associated with prioritization in rooming decisions among patients with similar triage acuity score at an ED of a large academic medical center in the Southeastern United States. The findings from our two statistical models highlight that differences in patient race and age are vulnerable to deviations from a first-come-first-served prioritization scheme, even after accounting for other differences in patient-level and ED-level characteristics. Future study is needed in ways to mitigate disparities in rooming decisions across different patient groups.

AUTHOR CONTRIBUTIONS

Peter Lin conceived and designed the study, managed the data, analyzed numerical results, constructed the statistical models, and drafted the manuscript. Nilay T. Argon conceived and designed the study, analyzed numerical results, provided statistical expertise, acquired funding, and revised the manuscript. Qian Cheng conceived and designed the study, managed the data, analyzed numerical results, and reviewed the manuscript. Christopher S. Evans conceived and designed the study, provided clinical interpretations of the results, provided insights into the operational management of emergency department, and revised the manuscript. Benjamin Linthicum conceived and designed the study, acquired data, provided clinical expertise, and reviewed the manuscript. Yufeng Liu conceived and designed the study, analyzed numerical results, provided statistical expertise, and revised the manuscript. Abhishek Mehrotra conceived and designed the study, provided clinical interpretations of the results, provided insights into the operational management of emergency department, and reviewed the manuscript. Mehul D. Patel conceived and designed the study, analyzed numerical results, provided statistical expertise, and revised the manuscript. Serhan Ziya conceived and designed the study, analyzed numerical results, provided statistical expertise, acquired funding, and revised the manuscript.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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ORIGINAL CONTRIBUTION

Does the definition of preventable emergency department visit matter? An empirical analysis using 20 million visits in Ontario and Alberta

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Abstract

Objectives: This study had two objectives: (1) to estimate the prevalence of preventable emergency department (ED) visits during the 2016–2020 time period among those living in 19 large urban centers in Alberta and Ontario, Canada, and (2) to assess if the definition of preventable ED visits matters in estimating the prevalence.

Methods: A retrospective, population-based study of ED visits that were reported to the National Ambulatory Care Reporting System from April 1, 2016, to March 31, 2020, was conducted. Preventable ED visits were operationalized based on the following approaches: (1) Canadian Triage and Acuity Scale (CTAS), (2) ambulatory care–sensitive conditions (ACSC), (3) family practice–sensitive conditions (FPSC), and (4) sentinel nonurgent conditions (SNC). The overall proportion of ED visits that were preventable was estimated. We also estimated the adjusted relative risks of preventable ED visits by patients' sex and age, fiscal year, province of residence, and census metropolitan area (CMA) of residence.

Results: There were 20,171,319 ED visits made by 8,919,618 patients ages 1 to 74 who resided in one of the 19 CMAs in Alberta or Ontario. On average, there were 2.26 visits per patient over the period of 4 fiscal years; most patients made one (44.22%) or two ED visits (20.72%). The overall unadjusted prevalence of preventable ED visits varied by definition; 35.33% of ED visits were defined as preventable based on CTAS, 12.88% based on FPSC, 3.41% based on SNC, and 2.33% based on ACSC.

Conclusions: There is a substantial level of variation in prevalence estimates across definitions of preventable ED visits, and care should be taken when interpreting these estimates as each has a different meaning and may lead to different conclusions. The conceptualization and measurement of preventable ED visits is complex and multifaceted and may not be adequately captured by a single definition.

KEYWORDS
Canada, emergency department, preventable, urban

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INTRODUCTION

Emergency departments (EDs) are an essential component of emergency care systems and play a key role in the delivery of health care.[1] While they are intended to provide immediate care for acute injuries and illnesses,[1] a considerable proportion of ED visits are for nonemergent reasons or conditions that could be addressed in non-ED settings.[2,3] These preventable ED visits place a burden on EDs and health care systems due to the misallocation of services and resources as these patients could be otherwise treated or managed in primary health care settings.[4,5] High volumes of preventable ED visits are also indicative of inadequate access to and quality of primary health care.[6,7] While not all ED visits can be prevented or avoided, high-quality, effective, and appropriate primary health care can help reduce the use of EDs and acute health services through the provision of preventive care; earlier detection and treatment of disease; and ongoing care, management, and follow-up of health conditions.[8,9]

Despite the widespread attention that preventable ED visits have received, researchers and health care providers differ in their definition and measurement of preventable ED visits, which has resulted in a great deal of variation within the literature on the prevalence of these visits.[10–13] For instance, in an international systematic review, Durand et al.[11] found that among studies published between 1980 and 2008, the prevalence of preventable ED visits ranged from 4.8% to 90.0% and attributed this wide range to the heterogeneity in the methods and criteria used to define and measure these visits. Specifically, they reported 51 methods of categorization of ED visits as preventable ranging from implicit (expert opinion, patients' self-assessment) to explicit (chief complaint, duration of complaint, vital signs and physiological cues, triage score, type of diagnosis, referral to the ED, diagnostic tests and treatments performed at the ED, hospitalizations).[11] Similarly, Uscher-Pines et al.[13] found that among studies published between 1990 and 2010, 8.0% to 62.0% of ED visits in the United States were categorized as nonurgent and that no studies used the same definition.

In Canada, the Canadian Triage and Acuity Scale (CTAS)[14–18] and ambulatory care–sensitive conditions (ACSC) have been used in previous studies to identify preventable ED visits.[15,19,20] In addition, Alberta and Ontario have developed two provincial measures of preventable ED visits: family practice–sensitive conditions (FPSC)[21–24] and emergency visits for conditions that could be treated in alternative primary care settings (hereafter called sentinel nonurgent conditions [SNC]).[25,26] The Canadian Institute for Health Information (CIHI) reported that, based on the FPSC definition, 21.0% of nonadmitted ED visits in 2013–2014 were preventable ED visits,[23] while other studies have reported estimates ranging from 7.2% in 2002–2003 (using the SNC definition)[26] to 59.1% in 2000–2001 (using the CTAS definition).[27]

While these four definitions of preventable ED visits have been independently applied to divergent subpopulations of patients, there have been no studies that have simultaneously applied all these definitions to obtain population-level estimates of preventable ED visits that can be compared with each other. To facilitate proper interpretation of the estimates, there is a need to assess how the prevalence of ED visits differs based on the type of definition used. Furthermore, with the majority of Canadians currently living in large urban centers[28] and the high demands and pressures that are experienced by urban EDs,[18,29] it is important to gain further insight into preventable ED visits in the urban context and the extent to which ED visits made by urban residents—who have comparatively better access to and availability of primary healthcare options[30,31]—are preventable.

Therefore, the objectives of this study were to (1) estimate the prevalence of preventable ED visits during the 2016–2020 time period among those ages 1 to 74 years living in 19 large urban centers in Alberta and Ontario, Canada, and (2) assess if the definition of preventable ED visits matters in estimating the prevalence. Specifically, we aimed to explore how the prevalence of preventable ED visits differed across four definitions of preventable ED visits used in Canada: (1) CTAS, (2) ACSC, (3) FPSC, and (4) SNC. Assessing these estimates simultaneously provides a more comprehensive depiction of preventable ED visits in urban settings in Canada. We also estimated the sex-, age-, time- (by fiscal year [FY]), province-, and urban center–specific prevalence to assess how these group-specific estimates differ across the four definitions.

MATERIALS AND METHODS

Study design and setting

We conducted a retrospective, population-based study of ED visits in Ontario and Alberta that were reported to CIHI's National Ambulatory Care Reporting System (NACRS) from April 1, 2016, to March 31, 2020 (i.e., 4 consecutive FYs). The NACRS is a population-based health administrative database that contains administrative, clinical, and demographic data on emergency and ambulatory care, which includes ED visits, day surgeries, and outpatient clinic visits.

Ontario and Alberta are the largest and fourth-largest provinces in Canada with a population sizes 2016 of 13,448,494 and 4,067,175, respectively.[32] We restricted our analysis to ED visits from residents of Alberta and Ontario because these two provinces had complete ED coverage for all years of our study period and two of our definitions of preventable ED visits (FPSC and SNC) were developed in these provinces. Ethical approval was not required as this study used anonymous secondary data from CIHI.

Study population

All unscheduled ED visits made during the study period by patients (1) ages 1 to 74 years, (2) living in Alberta and Ontario's large urban centers, (3) who had a valid health care number (HCN), and (4) whose ED visits did not result in inpatient admissions were included in the study. Scheduled ED visits, duplicate ED visit records, and visits

by patients with missing or invalid HCNs were excluded from the analysis.

We used census metropolitan areas (CMAs) as a proxy measure of Canada's largest urban centers. A CMA is formed by one or more adjacent municipalities centred around a large urban core with a total population of at least 100,000, of which at least 50,000 must live in the urban core.[33] There are 16 CMAs in Ontario and three in Alberta; as of 2020, there were 12,091,336 people in Ontario and 3,141,060 people in Alberta who resided in CMAs.[34] The patients' place of residence at the time of their ED visit was recorded in NACRS as their forward sortation area (FSA), which are geographic areas defined by the first three characters of the Canadian postal code.[35] Statistics Canada's Postal Code Conversion File Plus (PCCF+) was used to match patients' FSA to their corresponding CMAs.[36]

Study outcome

Following previous Canadian research, preventable ED visits were operationalized as: (1) CTAS, (2) ACSC, (3) FPSC, and (4) SNC. Each outcome measure was treated as a categorical binary variable.

Canadian Triage and Acuity Scale

The CTAS is a five-level triage system (I = resuscitation, II = emergent, III = urgent, IV = less urgent, and V = nonurgent) used in Canadian EDs.[37] Its primary objective is to provide benchmark target times to physician assessment as well as quickly and accurately assess patients' severity and need for medical attention, prioritize and stream patients to appropriate treatment areas, and allow for more efficient allocation and use of ED resources.[37–39] The CTAS has been extensively studied across different populations and is a valid and reliable measure of patient acuity, resource utilization, and ED performance.[40–45] Preventable ED visits were defined as visits that had a triage level of CTAS IV or V; this definition has been used elsewhere.[16,27,46,47]

ACSC

ACSC are conditions for which timely and effective primary health care could prevent or reduce the risk of hospitalization by preventing the onset of the illness, controlling the acute illness episode, or managing a chronic condition or disease.[48] Although they were originally developed as a measure of preventable hospitalizations, they have also been adapted and utilized in ED settings.[49] While there are varying definitions of ASCS, for this study we used the ACSC definition from CIHI, which includes the following seven chronic conditions (with some exclusions for certain cardiac procedures) that were identified based on the most clinically significant reason for the patient's ED visit: angina, asthma, chronic obstructive pulmonary disease, congestive heart failure and pulmonary edema, diabetes, grand mal status and other epileptic convulsions, and hypertension.[50]

FPSC

FPSC visits are ED visits for conditions that may be appropriately managed at a family physician (FP)'s office, as treating these conditions at a FP's office would allow for proper follow-up and would lead to better patient outcomes.[21,51] FPSCs were developed by the Health Quality Council of Alberta, based on conditions or diseases for which the probability of admission as an inpatient was less than 1%.[21,51] Examples of FPSCs include migraine, chronic sinusitis, and scabies; the full list of FPSCs is available from Alberta Health.[21]

SNC

SNC visits are ED visits for conditions that could be managed in nonhospital, alternative primary health care settings.[25,52] This indicator was developed by the Ontario District Health Councils' Local Health System Monitoring Technical Working Group and includes visits that were triaged as CTAS IV or V with an SNC as the most clinically significant reason for the patient's ED visit.[25,52] The included conditions were selected by ED physicians and public health experts and are considered as high-volume conditions that are important to track in assessing and monitoring how clinical alternatives could potentially reduce the burden of these visits on EDs.[52] Examples of SNCs include conjunctivitis, cystitis, and upper respiratory tract infection; the full list of SNCs is available from the Health Analytics Branch, Ministry of Health and Long-Term Care.[25]

Statistical analysis

Univariate descriptive statistics (frequencies and proportions) were produced to describe the sex, age, temporal, and geographic (province and CMA of residence) distribution of the ED visits in our sample. To address our first objective, we estimated the overall proportion of ED visits that were preventable using the four definitions of preventable ED visits (CTAS, ACSC, FPSC, and SNC). We also estimated the adjusted relative risks (RRs) of preventable ED visits by patients' sex (male or female), age (ages 1–4, 5–9, 10–14, 15–17, 18–24, 25–44, 45–64, 65–74), over time (by FY), by province of residence (Alberta or Ontario), and by CMA of residence. The adjusted estimates for RR at the individual level for each definition were computed using a Poisson regression model for binary data with a robust error variance to account for multiple visits by the same patient.[53] These adjusted models included all above-mentioned covariates. All statistical analyses were conducted using SAS 9.4 (SAS Institute Inc.), with statistical significance at the level of $p < 0.05$.

RESULTS

Between April 1, 2016, and March 31, 2020, there were 20,454,138 unscheduled ED visits made by patients ages 1 to 74 who resided in one of the 19 CMAs in Alberta or Ontario. After ED visits from patients with missing or invalid HCNs (282,819 visits) were removed, there were 20,171,319 ED visits made by 8,919,618 patients available for the analysis. On average, there were 2.26 visits per patient over the period of four FYs; the majority of patients had one (44.22%) or two ED visits (20.72%).

The univariate descriptive statistics for the ED visits included in our study are presented in Table 1. The overall mean (±SD) patient age at the time of each visit was 36.19 (±20.54) years and 52.41% of visits were made by females. The annual number of ED visits was stable across the study period (4,981,225 in 2016–2017 FY, 5,094,652 in 2017–2018 FY, 5,066,083 in 2018–2019 FY, and 5,029,359 in 2019–2020 FY, respectively), with the majority of visits reported in Ontario (75.19%). The number of ED visits made across residents of the 19 CMAs in Ontario and Alberta ranged from 184,259 (0.91%) visits in Guelph, Ontario, to 6,594,160 (32.69%) visits in Toronto, Ontario.

The overall prevalence of preventable ED visits for all patients residing in one of the 19 CMAs in Alberta or Ontario ranged from 2.33% to 35.33% (see Table 2). Specifically, 35.33% (95% confidence interval [CI] 35.31%–35.35%) of ED visits were defined as preventable based on the CTAS definition, 12.88% (95% CI 12.86%–12.89%) based on the FPSC definition, 3.41% (95% CI 3.41%–3.42%) based on the SNC definition, and 2.33% (95% CI 2.33%–2.34%) based on the ACSC definition.

The adjusted estimates for RR of having a preventable ED visit with their 95% CI by sex, age, FY, province of residence, and CMA of residence are presented in Table 3. Based on the CTAS and ACSC definitions, across all CMAs, males had 1.10 (95% CI 1.10–1.10) and 1.14 (95% CI 1.13–1.15) times higher risks of having a preventable ED visit, respectively, compared to females and controlling for other covariates. The opposite findings were reported for the FPSC and SNC definitions, however, where males had 0.90 (95% CI 0.90–0.90) and 0.66 (95% CI 0.66–0.67) times lower risks of preventable ED visits, respectively, compared to females. The risk of a CTAS visit increased and peaked at ages 10–14 (RR 1.22, 95% CI 1.21–1.22, compared to those ages 1–4) and then decreased with older age. The age profiles for the risk of FPSC and SNC visits were similar; the RRs of these visits were highest among ages 1–4 (the reference group) and then decreased with older age to 0.27 (95% CI 0.27–0.27) and 0.28 (95% CI 0.28–0.29), respectively, for those ages 65–74. The RRs for ACSC visits were relatively stable until ages 45–64 (1.56, 95% CI 1.54–1.58) and 65–74 (2.55, 95% CI 2.52–2.58). When assessing changes in the risk of ED visits over time, there was a pronounced decrease in RR for the CTAS and SNC definitions, with the RR at 0.85 (95% CI 0.85–0.86) in 2017–2018 FY and 0.81 (95% CI 0.80–0.81) in 2019–2020 FY, compared to the 2016–2017 FY. In comparison, there were no substantial trends across FYs observed for the ACSC and FPSC definitions. Residents of Alberta had substantially greater RRs of CTAS (1.37, 95% CI 1.37–1.38) and SNC (1.50, 95% CI 1.49–1.51) visits than residents of Ontario; for ACSC (RR 1.05, 95% CI 1.04–1.05) and FPSC (RR 1.05, 95% CI 1.05–1.06), differences in the RRs were also statistically significant but less pronounced. In terms of the differences in RR across CMAs, for CTAS, Lethbridge, Alberta, had 2.11 (95% CI 2.10–2.12) times the risk of having a preventable ED visit compared to Toronto, Ontario, while Windsor, Ontario, had the highest RR for ACSC visits (1.35, 95% CI 1.33–1.38), controlling for other covariates. For FPSC, Belleville, Ontario, had 1.49 (95% CI 1.48–1.50) times the risk of preventable ED visits compared to Toronto. Lastly, for SNC visits, Kingston, Ontario, had the highest RR (3.16, 95% CI 3.11–3.20).

DISCUSSION

Using the four definitions of preventable ED visits that have been employed in previous Canadian research, the objective of this study was to estimate the proportion of preventable ED visits and to assess if the adjusted RRs of these visits differ by sex, age, time, and place of residence. The results of our analysis involving a population-based health administrative database indicate that, depending on the adopted definition, there was a substantial variation in the proportion of preventable ED visits, ranging from 2.33% (ACSC) to 35.33% (CTAS), with 12.88% of visits for an FPSC and 3.41% for an SNC. These findings are consistent with previous research that reported that 35.1% of ED visits in 16 of Alberta's high-volume EDs[18] and 33.4% of ED visits in Ontario[17] were triaged as CTAS IV or V. While there are limited Canadian studies on preventable ED visits that have used the CIHI definition of ACSC, McAlister et al.[20] found that approximately 2% of ED visits made by patients in Alberta who had previously seen a primary care physician at least once during the study period were for a patient medical home indicator condition, which are similar to the CIHI definition of ACSC. Our findings on the proportions of FPSC and SNC visits were lower than estimates reported in previous studies; Altmayer et al.[26] found that 7.2% of ED visits in Ontario were for an SNC, while Alsabbagh and Houle[22] and a CIHI report found that 19.3% of ED visits in Ontario and 21% of ED visits in Canada,[23] respectively, were for an FPSC. A potential explanation for these differences may be due to our exclusion of rural residents, as Altmayer et al.[26] noted that rural areas had substantially higher rates of SNC visits whereas urban areas had rates that were much lower. Similarly, the CIHI report also noted that FPSC visits were more common in rural areas, with 32% of FPSC ED visits made by rural patients compared to 17% made by urban patients.[23]

The results from the adjusted models suggest that, controlling for other covariates, all four measures of preventable ED visits were significantly associated with sex and age, although there were some important differences in the nature of these associations. Males were more likely to have a CTAS or an ACSC visit and less likely to have an FPSC or SNC visit. FPSC and SNC visits had a similar pattern of distribution across age groups with the risks being relatively high for children ages 1 to 9 and then declining gradually for older age groups.

TABLE 1 Descriptive statistics for study variables

Variable	Category	Population size	Frequency (n)	Percentage (%)
Sex	Female		10,570,185	52.41
	Male		9,598,972	47.59
	Unknown		2162	
Age (years)	1–4		1,518,962	7.53
	5–9		1,046,941	5.19
	10–14		981,463	4.87
	15–17		736,013	3.65
	18–24		2,219,630	11
	25–44		6,121,047	30.35
	45–64		5,514,715	27.34
	65–74		2,032,548	10.08
Fiscal year	2016–2017		4,981,225	24.69
	2017–2018		5,094,652	25.26
	2018–2019		5,066,083	25.12
	2019–2020		5,029,359	24.93
Province	Ontario	14,223,942	15,166,145	75.19
	Alberta	4,262,635	5,005,174	24.81
CMAs in Ontario	Ottawa	1,125,306	1,520,615	7.54
	Kingston	176,467	375,574	1.86
	Belleville	113,729	392,397	1.95
	Peterborough	131,608	350,797	1.74
	Oshawa	434,736	537,573	2.67
	Toronto	6,572,524	6,594,160	32.69
	Hamilton	812,528	1,086,136	5.38
	St. Catharines–Niagara	439,777	723,504	3.59
	Kitchener–Cambridge–Waterloo	600,304	633,856	3.14
	Brantford	154,483	336,481	1.67
	Guelph	169,674	184,259	0.91
	London	556,397	986,485	4.89
	Windsor	351,116	424,234	2.10
	Barrie	221,576	304,458	1.51
	Greater Sudbury	172,781	320,061	1.59
	Thunder Bay	125,247	395,555	1.96
CMAs in Alberta	Lethbridge	130,027	338,310	1.68
	Calgary	1,559,284	2,108,226	10.45
	Edmonton	1,480,754	2,558,638	12.68

Abbreviation: CMA, census metropolitan area.

A similar pattern of gradual decline was observed for CTAS visits for those ages 10 to 74; however, there was a noticeable increase between ages 1 and 9. For the ASCS visits, there was a U-shape relationship between age and risk of preventable ED visits with the risk being highest among those ages 65–74. Thus, CTAS, FPSC, and SNC visits were more likely to occur among younger patients, whereas ACSC visits were more likely to occur among older patients.

These results may reflect potential sex differences in health services and ED utilization and the differential burden and impact of illnesses and diseases across different age groups and stages of the life course which, in turn, may affect an individual's heath status and their subsequent use of health services and EDs. Older patients—in particular, those ages 45 and older—were more likely to have an ACSC visit and less likely to have a CTAS visit. A potential

TABLE 2 Prevalence of preventable ED visits in Alberta and Ontario by definition

Definition	Prevalence	95% lower CL	95% upper CL
CTAS	35.33	35.31	35.35
ACSC	2.33	2.33	2.34
FPSC	12.88	12.86	12.89
SNC	3.41	3.41	3.42

Abbreviations: ACSC, ambulatory care–sensitive conditions; CL, confidence limit; CTAS, Canadian Triage and Acuity Scale; FPSC, family practice–sensitive conditions; SNC, sentinel nonurgent conditions.

explanation for this may be that the CIHI's definition of ACSC only includes chronic conditions, which are more prevalent among older adults.[54] Previous research has also found that older adults use ED services at higher rates and their visits are more likely to be of greater urgency and complexity as they often visit with atypical presentations of medical illnesses or complaints, cognitive impairment, polypharmacy, and comorbidities.[55,56] We also found that the likelihood of having an FPSC or SNC visit decreased with older age, which aligns with previous studies that have found that older age was associated with lower odds of having an FPSC visit.[22,24] FPSCs and SNCs are primarily composed of acute minor medical complaints that may be more reflective of timely access to and availability of primary health care during the illness episode itself, thus representing different dimensions of access to primary health care. Specifically, younger patients are less likely to have regular access to a FP and therefore need to seek care elsewhere, such as at the ED.[24,57]

Two definitions, CTAS and SNC, showed a decrease in risk across the four FYs (2017–2020) whereas ACSC and FPSC remained stable. SNC visits have an additional criterion of only including visits that were triaged as CTAS IV or V, which may explain why the prevalence of preventable ED visits based on this definition also declined across time. Decreases in CTAS IV and V have been observed in previous studies in Ontario, British Columbia,[58] and Nova Scotia.[59] There were also geographic differences in the RRs of preventable ED visit. Compared to Ontario, residents in Alberta had a substantially greater risk of CTAS and SNC visits. Differences in risk were also found across CMAs in Ontario and Alberta; Lethbridge, Alberta, had the highest risk of having a CTAS ED visit compared to Toronto, Ontario, whereas Windsor, Ontario, had the highest risk for ACSC visits. Belleville, Ontario, had a higher risk of having a FPSC visit than Toronto. Lastly, for SNC visits, Kingston, Ontario, had the highest risk.

Overall, there is a substantial level of variation in prevalence across definitions of preventable ED visits, and researchers and health policy makers should be mindful about interpreting these estimates as each of them has a different meaning and may lead to different conclusions. Moreover, depending on the definition used, preventable ED visits may be impacted by a multitude of factors. Ultimately, the conceptualization and measurement of preventable ED visits is complex, multifaceted, and may not be adequately captured by a single measure. Future research that incorporates factors related to the distribution and geographic accessibility to primary health care services in CMAs would further our understanding of the associations between access to primary health care and preventable ED visits in urban settings. Additionally, further research is warranted that explores how other individual- and area-level factors (e.g., race, ethnicity, income, education) are associated with different risks of preventable ED visits across the definitions.

STRENGTHS AND LIMITATIONS

Our study was strengthened by the use of a population-based health administrative database with complete ED coverage for the two selected provinces. This allowed us to compute and compare the estimates for the four measures of preventable ED visits. Our focus on preventable ED visits by urban residents removed variability in ED utilization that may arise from urban–rural differences and allowed us to uniquely explore the extent to which urban residents visit the ED for low-acuity, primary health care–treatable conditions. There are, however, several limitations that should be noted. As the aim of our study was to broadly explore and quantify the prevalence of preventable ED visits and the relative risk of having these visits, we limited our analyses to the patient demographic characteristics that are available in the NACRS database. There is also potential for nondifferential misclassification due to coding errors in data elements such as the visit's triage level or main diagnosis, which would bias our estimates toward the null.

CONCLUSIONS

We demonstrated the applicability of four different definitions of preventable ED visits to a national health administrative database, which can be used for future research in monitoring and assessing the magnitude and burden of preventable ED visits at the population level. In the context of low-acuity visits or visits that are amenable to treatment and care from primary health care, between 2.3% and 35.3% of ED visits made by urban residents of Alberta and Ontario were preventable. Thus, despite living in large urban centers with comparatively better access to and availability of primary health care than rural and remote areas, a sizable proportion of ED visits were amenable to care and treatment in primary health care settings or of low acuity. Future studies should look not only at interurban but also intraurban differences in preventable ED visits and what role neighborhood characteristics play.

Using various types of definitions in conjunction with each other would provide a more holistic understanding of the pathways through which preventable ED visits occur and how they can be addressed and reduced through more targeted interventions in improving and strengthening the delivery of health care. Thus, further research is required to better understand the associations between

TABLE 3 RRs (95% CI) of preventable ED visit in Alberta and Ontario by definition and selected correlates

Variable	Category	CTAS	ACSC	FPSC	SNC
Sex	Female (REF)				
	Male	1.10 (1.10–1.10)	1.14 (1.13–1.15)	0.90 (0.90–0.90)	0.66 (0.66–0.67)
Age (years)	1–4 (REF)				
	5–9	1.21 (1.20–1.21)	1.10 (1.08–1.12)	0.77 (0.77–0.78)	0.92 (0.91–0.93)
	10–14	1.22 (1.21–1.22)	0.81 (0.79–0.83)	0.48 (0.48–0.48)	0.50 (0.49–0.51)
	15–17	1.08 (1.07–1.08)	0.64 (0.63–0.66)	0.43 (0.43–0.43)	0.49 (0.49–0.50)
	18–24	1.05 (1.05–1.05)	0.64 (0.63–0.65)	0.44 (0.44–0.44)	0.49 (0.49–0.50)
	25–44	0.96 (0.96–0.96)	0.72 (0.71–0.73)	0.40 (0.40–0.41)	0.38 (0.38–0.38)
	45–64	0.92 (0.91–0.92)	1.56 (1.54–1.58)	0.34 (0.34–0.35)	0.31 (0.31–0.32)
	65–74	0.84 (0.84–0.84)	2.55 (2.52–2.58)	0.27 (0.27–0.27)	0.28 (0.28–0.29)
Fiscal year	2016–2017 (REF)				
	2017–2018	0.98 (0.97–0.98)	1.02 (1.01–1.03)	1.01 (1.01–1.01)	0.97 (0.97–0.98)
	2018–2019	0.93 (0.93–0.93)	1.01 (1.00–1.02)	0.97 (0.96–0.97)	0.84 (0.83–0.84)
	2019–2020	0.85 (0.85–0.86)	1.01 (1.00–1.02)	1.00 (0.99–1.00)	0.81 (0.80–0.81)
Province	Ontario (REF)				
	Alberta	1.37 (1.37–1.38)	1.05 (1.04–1.05)	1.05 (1.05–1.06)	1.50 (1.49–1.51)
CMAs in Ontario	Toronto (REF)				
	Ottawa–Gatineau	1.34 (1.34–1.35)	1.21 (1.20–1.23)	1.18 (1.17–1.18)	2.06 (2.04–2.08)
	Kingston	1.91 (1.90–1.92)	1.18 (1.15–1.20)	1.43 (1.42–1.44)	3.16 (3.11–3.20)
	Belleville	1.48 (1.47–1.49)	1.33 (1.30–1.35)	1.49 (1.48–1.50)	2.75 (2.71–2.79)
	Peterborough	1.46 (1.45–1.47)	1.23 (1.20–1.25)	1.38 (1.37–1.39)	2.62 (2.58–2.66)
	Oshawa	1.38 (1.37–1.39)	1.13 (1.11–1.15)	0.87 (0.86–0.88)	1.23 (1.21–1.25)
	Hamilton	1.22 (1.22–1.22)	0.94 (0.93–0.95)	1.12 (1.11–1.13)	1.76 (1.74–1.78)
	St. Catharines–Niagara	1.14 (1.14–1.15)	1.18 (1.16–1.20)	1.38 (1.37–1.39)	2.28 (2.26–2.31)
	Kitchener–Cambridge–Waterloo	1.05 (1.04–1.05)	1.04 (1.02–1.05)	0.91 (0.91–0.92)	1.18 (1.16–1.20)
	Brantford	1.43 (1.42–1.44)	1.24 (1.21–1.26)	1.45 (1.44–1.46)	3.05 (3.00–3.09)
	Guelph	0.98 (0.97–0.99)	0.91 (0.88–0.94)	1.04 (1.03–1.05)	1.17 (1.14–1.21)
	London	1.44 (1.44–1.45)	1.07 (1.05–1.08)	1.32 (1.31–1.32)	2.34 (2.31–2.37)
	Windsor	0.87 (0.86–0.87)	1.35 (1.33–1.38)	0.87 (0.86–0.87)	1.18 (1.16–1.21)
	Barrie	1.27 (1.26–1.28)	1.06 (1.04–1.09)	1.11 (1.10–1.12)	1.72 (1.69–1.76)
	Greater Sudbury	1.47 (1.46–1.48)	1.28 (1.26–1.31)	1.07 (1.06–1.09)	1.87 (1.83–1.90)
	Thunder Bay	1.29 (1.29–1.30)	1.03 (1.01–1.06)	1.30 (1.29–1.31)	1.70 (1.67–1.74)
CMAs in Alberta	Lethbridge	2.11 (2.10–2.12)	0.94 (0.92–0.97)	1.30 (1.29–1.31)	3.00 (2.95–3.04)
	Calgary	1.50 (1.50–1.50)	1.12 (1.11–1.13)	1.14 (1.13–1.14)	2.11 (2.10–2.13)
	Edmonton	1.65 (1.65–1.65)	1.16 (1.15–1.17)	1.18 (1.17–1.18)	2.45 (2.43–2.47)

Abbreviations: ACSC, ambulatory care–sensitive conditions; CMA, census metropolitan area; CTAS, Canadian Triage and Acuity Scale; FPSC, family practice–sensitive conditions; REF, reference category; RR, relative risk; SNC, sentinel nonurgent conditions.

preventable ED visits and individual and geographic correlates of these visits. Such research, for instance, may focus on different dimensions of access to primary health care to develop more effective health care policies and strategies to reduce these visits and enhance the delivery of primary health care.

AUTHOR CONTRIBUTIONS

The first draft of the manuscript was prepared by Tammy Lau, Alana Maltby, Valérie Moran, and Piotr Wilk. Statistical analyses were performed by Tammy Lau and PW. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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ORIGINAL CONTRIBUTION

Establishing the international research priorities for pediatric emergency medicine point-of-care ultrasound: A modified Delphi study

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Abstract

Background: The Pediatric Emergency Medicine (PEM) Point-of-care Ultrasound (POCUS) Network (P2Network) was established in 2014 to provide a platform for international collaboration among experts, including multicenter research. The objective of this study was to use expert consensus to identify and prioritize PEM POCUS topics, to inform future collaborative multicenter research.

Presented at the Pediatric Emergency Medicine Point-of-Care Ultrasound Network (P2Network) Annual Meeting, New Orleans, LA, May 10, 2022.

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Methods: Online surveys were administered in a two-stage, modified Delphi study. A steering committee of 16 PEM POCUS experts was identified within the P2Network, with representation from the United States, Canada, Italy, and Australia. We solicited the participation of international PEM POCUS experts through professional society mailing lists, research networks, social media, and "word of mouth." After each round, responses were refined by the steering committee before being reissued to participants to determine the ranking of all the research questions based on means and to identify the high-level consensus topics. The final stage was a modified Hanlon process of prioritization round (HPP), which emphasized relevance, impact, and feasibility.

Results: Fifty-four eligible participants (16.6%) provided 191 items to Survey 1 (Round 1). These were refined and consolidated into 52 research questions by the steering committee. These were issued for rating in Survey 2 (Round 2), which had 45 participants. At the completion of Round 2, all questions were ranked with six research questions reaching high-level consensus. Thirty-one research questions with mean ratings above neutral were selected for the HPP round. Highly ranked topics included clinical applications of POCUS to evaluate and manage children with shock, cardiac arrest, thoracoabdominal trauma, suspected cardiac failure, atraumatic limp, and intussusception.

Conclusions: This consensus study has established a research agenda to inform future international multicenter PEM POCUS trials. This study has highlighted the ongoing need for high-quality evidence for PEM POCUS applications to guide clinical practice.

INTRODUCTION

Over the past two decades, the use of point-of-care ultrasound (POCUS) in pediatric emergency medicine (PEM) has increased exponentially. Currently there are no mandatory requirements that POCUS should form part of PEM fellowship training, but there are growing recommendations.[1,2] Consequently, an increasing number of articles have been published on PEM POCUS clinical applications, education, and credentialing standards.[1–4] However, despite the increasing use of POCUS, high-quality evidence for PEM POCUS is still lacking. A recent study identified an upward growth and globalization of POCUS-related publications, but almost half of the publications were case-based reports.[5]

Multiple PEM research networks worldwide have identified POCUS as a research priority.[6–10] Most recently, an international group of PEM network research leaders was assembled to develop a list of research priorities for future collaborative endeavors among pediatric emergency research networks using a modified Delphi methodology.[11] They identified the need for more POCUS research within PEM, particularly since indications for its use and application differed between centers. Despite this, to date there has been no dedicated PEM POCUS consensus study for research priorities.

The PEM POCUS Network (P2Network) is a nonprofit, multinational organization that was formed in 2014, with the goal for enabling international collaboration in the emerging field.[12] One of its objectives was to provide a platform for PEM POCUS experts worldwide to collaborate on multicenter research, with the goal of informing clinical practice. To date, the P2Network's research priorities have stemmed from the research interests of individual members.[13,14]

Given the continued growth of POCUS within PEM and recognition of the need for high-quality evidence, there is a need to develop an agenda to guide global research priorities. Establishing a research agenda helps to streamline prioritization and planning of studies, guide allocation of resources, and avoid potential duplication of efforts. It also serves to inform and identify areas of high impact for stakeholders and potential grant funders and importantly aims to provide a high-quality evidence base to inform clinical practice and improve patient care.

The objective of this study was to use expert consensus to identify and prioritize PEM POCUS research topics, to inform future international collaborative multicenter studies or trials. We also aimed to identify evidence gaps for current POCUS applications used in clinical practice.

METHODS

Study design

We conducted a two-stage modified Delphi survey, which included the Delphi method and a modified Hanlon process of prioritization (HPP). This study design was chosen given the large group of geographically dispersed participants and research topics.[15] Additionally, anonymity could be maintained to reduce any effect

of dominant individuals with an iterative process, which included controlled feedback of responses.[15,16] Our methodology was modeled on similar emergency research networks consensus studies.[6,8,9] An ethics waiver for this study was approved by the Gold Coast Hospital and Health Service Human Research Ethics Committee, Queensland, Australia (EX/2021/QGC/76409).

Study setting and population

This was an international study, with experts in PEM POCUS tasked with identifying and ranking priority research topics.

Steering committee selection

A steering committee of 16 PEM POCUS experts was identified within the P2Network, with representation from the United States, Canada, Italy, and Australia. Within this group, four lead authors acted as conveners (PJS, AES, MMM, SHFL), responsible for coordinating the study. The steering committee members were not precluded from taking part in the survey rounds, provided they fulfilled the expert criteria.

Participant selection

Although more fellowship training positions are becoming available, no data currently exists for the number of PEM POCUS-trained physicians internationally.[17,18] Therefore, the P2Network was used as a surrogate starting point, with 315 members from North America, South America, Europe, and Asia at the time of this study.[12] The survey link was distributed via email to all P2Network members on September 6, 2021. Additional participants were further solicited by advertisement via professional society mailing lists, research networks, social media, and "word of mouth."

Survey participants self-identified as meeting all the following eligibility criteria, consistent with prior literature that defined a PEM POCUS expert[4]: (1) Completion of formal PEM training (including a fellowship or equivalent training) *and* (2) completion of more than 1500 POCUS scans *and* (3) have PEM POCUS leadership positions or training. PEM POCUS leadership or training was defined as meeting one of the following criteria: (a) completion of a PEM POCUS/emergency ultrasound (EUS) fellowship *or* (b) has served as a PEM POCUS lead or director *or* (c) has served as a PEM POCUS fellowship director *or* (d) has served as a general emergency medicine (EM) POCUS fellowship director and teaches PEM POCUS skills as a part of this role. Consent was implied when a participant responded to the survey.

Study protocol

The modified Delphi method consisted of two survey rounds and a HPP round. Surveys were administered via email using REDCap (Research Electronic Data Capture), a secure, Web-based platform for data collection.

In the survey rounds, participants were initially asked to identify topics under the broad categories of "clinical application," "education," "administration," or "other," with no requirement for a prerequisite number in each category. Participants were then asked to rate these research questions using a 5-point Likert scale. High-level consensus for a research question was defined as having >80% proportion of high priority rating scores (4s and 5s) from participants. Within each of these rounds, refinement of responses was conducted by the steering committee before being reissued to participants. The HPP round was then conducted using the research questions that had a mean rating greater than neutral (i.e., >3.0).

Round 1 (Part A): Survey 1

In this initial survey, eligible participants were asked the open-ended question, "What are the most important research questions in PEM POCUS that need addressing, which may include clinical applications, education, administration, or other aspects?" Participants were tasked to submit up to 10 research topics, preferably worded in the PICO (population, intervention, comparison, outcome) format, with an example provided that illustrated this structure. Non-PICO questions were still reviewed for suitability. Participants were also asked to sort the topic into the best related category for the research question, which included "clinical application," "education," "administration," or "other."

Survey 1 was open for 4 weeks beginning September 6, 2021, during which additional participants could be invited. Invited participants who had not already responded were sent reminder emails at weekly intervals and then at 48 hours remaining, to improve completion rates. Participants were also asked to provide baseline demographic data including geographical location, hospital/practice description, specialist qualifications, and POCUS experience.

Round 1 (Part B): Refinement of research topics

All research questions generated from Survey 1 were collated and then grouped into one of the predetermined categories (clinical application, education, administration, other) by members of the steering committee. These members then independently reviewed each question in relation to the eligibility criteria with the following actions taken: (1) Duplications of research questions were removed. (2) Topics only relevant to single-center studies were removed. (3) Research questions were excluded if they had already been adequately answered through current existing evidence. (4) Research topics were removed if deemed they did not have sufficient detail to be answered in a study or trial. Following review of responses by the steering committee digitally, and then via teleconference, eligible research questions were collated into a list, grouped into the categories.

Round 2 (Part A): Survey 2

The refined list of proposed research questions compiled at the completion of Round 1 formed the basis of Survey 2. Participants were asked, "Thinking about the field of PEM POCUS, how important are the following questions to you in terms of the need for future multicenter research?" Participants from Round 1 were asked to rate each research question on a 5-point Likert scale (1 = not a priority, 2 = low priority, 3 = neutral, 4 = high priority, 5 = essential priority). "Survey fatigue," the assumption that early questions are better answered than later questions, was addressed using the allocation of five different random orders of the research questions.

Survey 2 was open for 4 weeks beginning October 25, 2021. As in Round 1, participants who had not already responded were sent reminder emails at weekly intervals then at 48 hours remaining, to improve completion rates.

Round 2 (Part B): Survey 2 reevaluation

Survey 2 results were collated, and Likert scores for each question in Survey 2 were combined. Mean scores were used to rank the list of research questions. Additionally, high-level consensus for a research question was determined.

Survey 2 was revisited, with the goal to reevaluate the number of high-level consensus questions. Participants of the original Survey 2 were provided with the list of research questions with mean rating scores, along with the definition for a high-level consensus rating. These participants were invited to rerate topics using the identical Likert scale as before, for questions that had not already met high-level consensus, for an additional 4-week period beginning November 29, 2021. The list of priority research questions, with ranking by mean and high-level consensus, was then finalized at the closure of Round 2.

Modified HPP

Questions at the end of Round 2 with a mean rating score > 3.0 (i.e., greater than neutral rating) were further prioritized using a modified HPP.[6,7,9,19] Typically, the HPP weighs the prevalence, seriousness, and feasibility of a given research question. However, this was adapted by the steering committee to suit PEM POCUS. The existing HPP questions were circulated to the steering committee, who put forward the three main elements of feasibility of performing POCUS research, were discussed and then ratified by the steering committee. Therefore, participants were asked to independently rate each research question on a scale of 1–10 in relation to three domains: (A) relevance—"How likely will you adopt this in your everyday practice?"; (B) impact factor—"How likely will this improve the care of children internationally?"; and (C) feasibility—"Considering your setting, costs involved, and training required, how feasible is this topic for international multicenter research?"

Participants from Round 2 were invited to participate electronically in the HPP for a 4-week period beginning January 10, 2022. Again, reminder emails were sent at weekly intervals then at 48 hours remaining, to improve completion rates.

Key outcome measures

The Delphi ranking was based on the mean rating score for each question from Round 2. Additionally, research questions with >80% proportion of scores being 4 or 5 were identified as being high-level consensus topics. Final HPP scores were calculated using the formula HPP = (A + 2B) x C.[6,7,9,19] This weighed the HPP toward feasibility, with a final ranking based on the overall score for each research question. Although high-level consensus topics were identified in the modified Delphi rounds, the final overall ranking was based on the HPP, in keeping with other consensus studies.[6,9]

Data analysis

Aggregate data were downloaded from REDCap in a spreadsheet format at completion of the study. Answers to survey questions were expressed as frequencies and proportions for categorical variables. Means and medians were then calculated for these variables. Statistical analyses and HPP score calculations were performed using Microsoft Excel.

RESULTS

Survey 1 was distributed via email to 326 potentially eligible individuals, obtained from the initial solicitation process. There were 54 participants (16.6%) who met eligibility criteria and completed Round 1. Participant demographics are summarized in Table 1. The majority were based in North America (49, 90.1%), worked in a pediatric ED (46, 85.2%), and worked in an academic setting (50, 92.6%). Almost all were PEM qualified (52, 96.3%). Most had completed either a general EM POCUS/EUS fellowship (20, 37.0%) or PEM POCUS fellowship (18, 33.3%). Almost two-thirds (35, 64.8%) had greater than 5 years of POCUS experience. Figure 1 illustrates the stages and outcomes of the study.

A total of 191 items were submitted by Survey 1 participants. These were refined and consolidated into 52 research questions, with exclusions of 86 (61.2%) duplicates, 24 (17.3%) lacking detail, 18 (12.9%) not amenable to multicenter research, and 11 (7.9%) with adequate existing evidence. Forty-five (83.3%) participants completed Round 2. Mean scores for the 52 research questions in the Delphi process ranged from 2.82 to 4.43 in Round 2 (Part A; Table S1). Only six of the research questions reached high-level consensus at the completion of Round 2 (Table 2). These included topics of shock (undifferentiated and septic), cardiac arrest, thoracoabdominal trauma, and cardiac failure.

TABLE 1 Participant baseline demographics

Age (years)	41.2 (32–52)
Sex	
Male	32 (59.3)
Female	22 (40.7)
Country of practice	
United States	45 (83.3)
Canada	4 (7.4)
Australia	1 (1.9)
Italy	1 (1.9)
United Kingdom	1 (1.9)
Israel	1 (1.9)
Mexico	1 (1.9)
Board certifications[a]	
PEM	53 (98.1)
EM	5 (9.3)
Pediatrics	14 (25.9)
Ultrasound training/qualifications[a]	
EM POCUS/EUS fellowship	20 (37.0)
Pediatric POCUS fellowship	18 (33.3)
RDMS	4 (7.4)
DDU	1 (1.9)
Other (courses, certificates, etc.)	23 (42.6)
PEM POCUS roles[a]	
Director	32 (59.3)
Fellowship director	14 (25.9)
Administration	32 (59.3)
Education	41 (75.9)
Research	35 (64.8)
Organizational leadership	20 (37.0)
Years of POCUS practice	
0–2	1 (1.9)
3–5	17 (31.5)
6–10	22 (40.7)
11–20	14 (25.9)

Note: Data are reported as mean (range) or *n* (%).

Abbreviations: DDU, diploma of diagnostic ultrasound; EUS, emergency ultrasound; PEM, pediatric emergency medicine; POCUS, point-of-care ultrasound; RDMS, registered diagnostic medical sonographer.

[a]Participants could indicate more than one response.

Thirty-one research questions were selected for HPP rating. Thirty-nine participants (72.2% from Round 1, 86.7% from Round 2) provided valid responses for this round. Mean scores using the HPP ranged from 132.2 to 197.0 (Table S2). The top 20 ranked research questions are provided in Table 2. Top ranked priorities included shock (undifferentiated and septic), atraumatic limp, intussusception, thoracoabdominal trauma, lung pathology, PEM POCUS competency, and peripheral intravenous access.

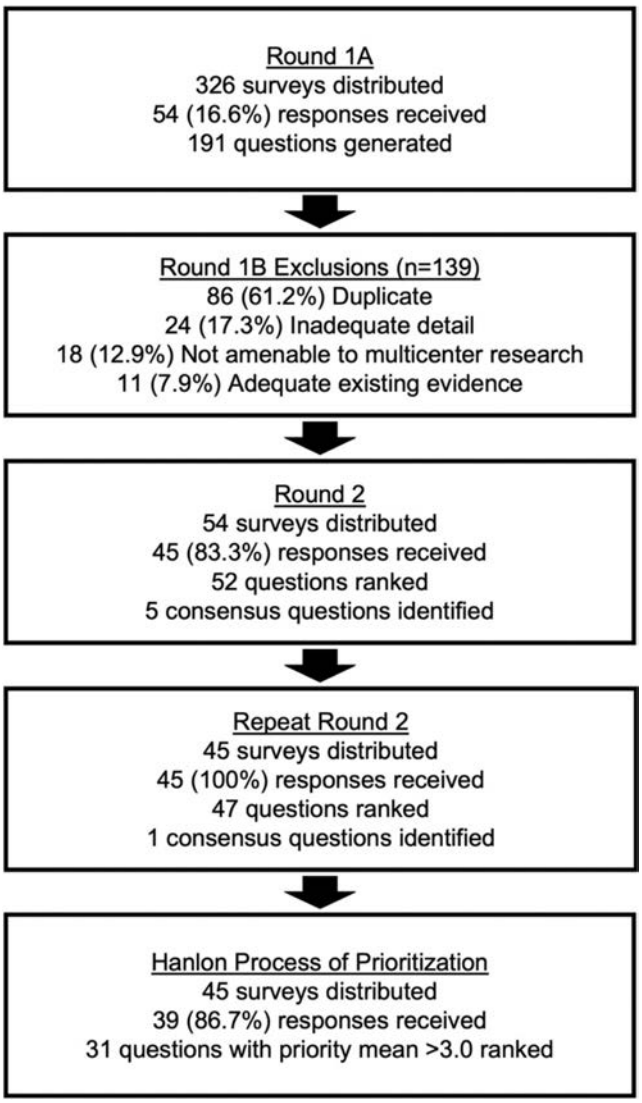


FIGURE 1 Study stages and outcomes

DISCUSSION

This study identified and prioritized PEM POCUS research topics by international expert consensus. The list of research questions was ranked via modified Delphi and HPP processes, which provided both a desired list of topics as well as a pragmatic list weighted toward feasibility. The generated lists provide an agenda for future international collaborative multicenter research. Top ranking consensus topics in this study included clinical applications of POCUS to evaluate and manage children with shock, cardiac arrest, thoracoabdominal trauma, suspected cardiac failure, atraumatic limp, and intussusception. Notably, no educational or administrative POCUS research topics were identified as high consensus, with only even questions from these categories featuring in the HPP.

The modified HPP was effective in identifying POCUS research topics that were relevant, impactful, and feasible to research in the PEM department. Although the topics of cardiac failure and cardiac

TABLE 2 Summary of the top 20 ranked PEM POCUS research questions

HPP priority (HPP score)	Research question	Delphi priority (Delphi score)
1 (197.0)	What is the role of POCUS (cardiac/IVC/lungs/other) in children with undifferentiated shock, in terms of diagnosis and management?[a]	4 (4.32[b])
2 (196.5)	In children presenting to the ED with atraumatic limp, is POCUS noninferior to RADUS for the detection of hip effusion and can it expedite their disposition and/or management (e.g., arthrocentesis)?	19 (3.40)
3 (195.2)	In children presenting to the ED with suspected intussusception, is POCUS noninferior to RADUS for the diagnosis of clinically important intussusception (randomized controlled trial)?	22 (3.36)
4 (193.1)	In children presenting to the ED with atraumatic limp, can POCUS findings be incorporated into a diagnostic algorithm, in conjunction with clinical findings/investigations, to improve diagnosis and management?	11 (3.62)
5 (187.1)	What is the role of POCUS (cardiac/IVC/lungs/other) in children with septic shock, in terms of guiding resuscitation and management?[a]	1 (4.47)
6 (186.1)	In children with shock, can POCUS (cardiac/IVC/lungs) guide fluid resuscitation and administration of inotropes/vasopressors, compared with standard assessment, with improvement of patient-centered outcomes?[a]	2 (4.43[b])
7 (184.3)	In children presenting with thoracoabdominal trauma, can e-FAST performed by expert/trained sonologists: (a) Decrease the utilization of CT imaging without missing any clinically important injuries? (b) Expedite the care of children with clinically important injuries? (c) Be integrated with clinical features and other investigations into an algorithm that benefits patients?[a]	4 (4.32[b])
8 (182.3)	In children, is a dedicated pediatric lung ultrasound diagnostic protocol noninferior to conventional radiography for the diagnosis of pulmonary pathology?	16 (3.49)
9 (180.3)	What are the current consensus guidelines for attaining and maintaining competency in PEM POCUS?	9 (3.69)
10 (178.6)	In children with difficult peripheral intravenous access, does POCUS improve rates of successful insertion and avoidance of central access (intraosseous, central venous line, etc.)?	19 (3.4)
11 (174.8)	In children with suspected cardiac failure, can POCUS accurately diagnose cardiac failure compared to echocardiography, and what is the best measure (EPSS vs. visual estimation, etc.)?[a]	6 (4.25[b])
12 (171.9)	How does POCUS compare to validated scores for diagnosis of appendicitis and can POCUS findings be incorporated into a decision-making algorithm/score, along with clinical findings and other investigations (e.g., pathology)?	19 (3.40)
13 (168.3)	In pediatric sickle cell patients who present with suspected acute chest crisis, what is the role of lung POCUS for the detection of infiltrates compared with x-ray imaging?	24 (3.33)
14 (167.8)	In pediatric patients presenting to the ED with clinical suspicion of lower respiratory tract infection, can POCUS differentiate bacterial from viral pneumonia to guide management? Can it reduce x-ray imaging and length of stay, without missing any clinically important infections?	9 (3.69)
15 (162.9)	In children requiring cardiac evaluation, is POCUS noninferior to echocardiography for the diagnosis of clinically important cardiac pathology (e.g., pericardial effusions, HOCM)?	7 (3.91)
16 (161.3)	In children who present to the ED with suspected appendicitis, does POCUS: (a) Accurately diagnose clinically important appendicitis? (b) Predict the need for operative management? (c) Expedite disposition?	18 (3.44)
17 (159.4)	In children with cardiac arrest, can POCUS guide management (e.g., identification of reversible causes, improve pulse checks) and prognosticate outcomes (e.g., ROSC/survival)?[a]	3 (4.36[b])
18 (157.9)	What training (number of studies/evaluation tools) is required to achieve and maintain competence in PEM POCUS applications and how does it differ for various levels of training/experience?	12 (3.60)
19 (156.2)	What are the perceptions and attitudes of subspecialists/inpatient teams toward POCUS being performed for children in the ED, and what factors might influence their acceptance of images over RADUS for clinical decisions and informing management?	31 (3.04)
20 (154.7)	What should comprise the standard curriculum for PEM POCUS education (applications, delivery, evaluation) for various levels of learners?	12 (3.60)

Abbreviations: eFAST, extended focused assessment with sonography for trauma; EPSS, E-point septal separation; HPP, Hanlon process of prioritization; HOCM, hypertrophic obstructive cardiomyopathy; IVC, inferior vena cava; PEM, pediatric emergency medicine; POCUS, point-of-care ultrasound; RADUS, radiology ultrasound.

[a]High-level consensus-rated questions.

[b]Ranking as per Round 2A mean score.

arrest were ranked as high-level consensus priority topics in the Delphi, these ranked far lower in the HPP, likely due to being rare presentations and being less feasible to study. This is a key distinction, which relates to the FINER (feasible, interesting, novel, ethical, and relevant) framework used for formulating research questions, rather than simply choosing topics of importance alone.[20]

The role of POCUS in children with undifferentiated shock and sepsis ranked highly in both the Delphi and the HPP. The use of POCUS for undifferentiated shock in adults has been established[21,22] but high-quality evidence in pediatrics is still lacking.[23,24] The pathophysiology of shock in children is different from that of adults, which can lead to difficulties with early recognition and management.[25] POCUS holds great potential in aiding the recognition of shock, defining the etiology, and guiding management, such as fluid resuscitation, administration of vasoactive medications, or procedural intervention.[23,26,27]

Cardiac failure in children is an infrequent presentation but can be mistaken for other pathologies, such as bronchiolitis or sepsis, given that it can be difficult to distinguish clinically.[28] POCUS is a way to directly visualize cardiac structure and function and has been demonstrated to be useful in diagnosing cardiac failure in the emergency department (ED) but large-scale studies are still required.[29] Cardiac arrest in children is uncommon but generally has poor outcomes.[30] The etiology of cardiac arrest in children is usually secondary to respiratory failure but other reversible causes, albeit rarer, may be identifiable using POCUS, such as cardiac tamponade,[31] tension pneumothorax,[32] and pulmonary embolism.[33] Although there is growing evidence in the adult population supporting the routine use of POCUS in cardiac arrest,[34] its utility in children remains unclear.

The use of POCUS in thoracoabdominal trauma has come under scrutiny, particularly given that children with visceral injury do not always have free fluid and rarely require operative management.[35] However, many of these studies were conducted in single institutes on stable children with blunt abdominal trauma with an emphasis on POCUS findings in isolation.[36,37] No large multicenter international studies have been performed to date, particularly with expert PEM POCUS sonologists and the incorporation of clinical findings into a pragmatic algorithm, with the inclusion of cardiothoracic injuries.[38] Under these conditions, POCUS may have a defined role in the reduction of unnecessary CT imaging or to rapidly delineate injuries in an unstable patient to aid critical decision making. Furthermore, the use of contrast-enhanced ultrasound holds great promise in pediatric blunt abdominal trauma, but access in the ED remains a barrier.[39]

Atraumatic limp is a frequent presentation to the pediatric ED, often due to hip effusion. POCUS is superior to x-ray in detecting a hip effusion and can guide arthrocentesis but cannot readily determine etiology.[40–42] Therefore, larger trials are required to validate an algorithm incorporating POCUS with clinical and laboratory findings to differentiate transient synovitis from septic arthritis.[43]

Ileocolic intussusception can be a life-threatening condition in infants and young children that can be elusive to diagnose on clinical grounds alone.[44] POCUS has been demonstrated to be noninferior to radiology performed ultrasound in a large multicenter prospective trial but was limited by convenience sampling, which could be mitigated by consecutive recruitment in a randomized controlled trial.[13]

Finally, unsurprisingly many of the identified PEM POCUS research topics in this consensus study align with those identified in international PEM research network consensus studies.[6–10] The Pediatric Emergency Care Applied Research Network (PECARN; United States) group listed respiratory illness and pain management as priority topics, which relates to lung ultrasound and nerve blocks identified in our priority list.[6] The Pediatric Emergency Research in the United Kingdom and Ireland (PERUKI) group identified the need for further research into children with atraumatic limp, imaging in trauma, and management of sepsis, which interface with several of our POCUS priority research questions.[8] The Research in Pediatric Emergency Medicine (REPEM; Europe) and the Pediatric Emergency Research Canada (PERC; Canada) networks both identified POCUS as a priority theme and general topics that relate to our priority list, including trauma, respiratory illness, sepsis, and cardiopulmonary resuscitation.[7,10] The Pediatric Research in Emergency Departments International Collaborative (PREDICT; Australia and New Zealand) network specifically listed POCUS for intussusception, pneumonia, appendicitis, or hip pain in their agenda.[9] Finally, an international PEM research network study identified the need to investigate the impact of POCUS on clinical outcomes of specific diseases, such as blunt abdominal trauma and resuscitation for intravascular volume status, with the overall general top clinical conditions listing sepsis, trauma, and respiratory conditions, all of which are relevant to POCUS as identified in our consensus study.[11]

LIMITATIONS

Although we solicited PEM POCUS experts worldwide as broadly as possible, there was underrepresentation from multiple countries. The participant group likely reflects where PEM POCUS training and research are more embedded, but we only solicited in the English language, which limited its reach. The majority of participants were from North America, which may limit generalizability of the findings.

Our response rate was lower than other PEM research network Delphi studies but our strict criteria of a PEM POCUS expert would have precluded many from participating, and an overall number of eligible participants remains unknown to determine an accurate proportion.[6–10] The benefit of restricting the study to PEM POCUS experts is that they arguably have the best knowledge and experience to guide research. However, the identified topics may not be relatable to general users of POCUS.

Only six questions reached high-level consensus, which may have been reflected both by the definition used and by having international participants, with heterogeneity in settings and resources. This was in part mitigated by the HPP round. There was also a trend toward repeat surveys yielding lower scores, such as one participant scoring all topics as 2s in Round 2 (Part B), likely due to survey fatigue. Although, we did attempt to control for survey fatigue

effects on individual questions by having different random ordering of questions.

Although the HPP identifies topics that are feasible, this consensus study did not specifically address the logistics or barriers associated with conducting multicenter research, including funding, approvals, or collaboration with other specialty teams and stakeholders. Although the research questions were framed around patient-centered outcomes, the actual design of high-quality studies or trials to answer these was not covered. This international PEM POCUS consensus study provides a starting point to start to try and address these issues.

Finally, education and administration topics did not feature strongly, with clinical applications overshadowing the priority list. This may have been due to the majority participants being interested in or more familiar with researching clinical applications or being already highly trained or that the topics were overlooked due to having overlap with a previous study.[4] Many of the high-ranking topics were applications for unstable patients with high risk diagnoses that cannot be readily transported from the ED. Future studies could include a broader cohort of participants, such as the participation of nonexpert users, and separate ranking of topics within main categories, such as education.

CONCLUSIONS

This was the first research consensus study conducted by pediatric emergency medicine point-of-care ultrasound experts worldwide. With the use of a modified Delphi and Hanlon process of prioritization methodology, a ranked list of priority pediatric emergency medicine point-of-care ultrasound research topics was generated and could be used to inform future international multicenter studies and trials. Key research areas included the use of point-of-care ultrasound to evaluate and inform management for shock, thoracoabdominal trauma, cardiac pathology, atraumatic limp, and intussusception. High-quality evidence is currently lacking for pediatric emergency medicine point-of-care ultrasound and the results of this study would hopefully guide future endeavors with the design and implementation of high-quality multicenter international research studies and trials.

AUTHOR CONTRIBUTIONS

Concept and design: all authors. Acquisition of the data: all authors. Analysis and interpretation of the data: all authors. Drafting of the manuscript: Peter J. Snelling (initial), Allan E. Shefrin, Matthew M. Moake, Samuel H. F. Lam. Critical revision of the manuscript for important intellectual content: all authors. Statistical expertise: Matthew M. Moake, Samuel H. F. Lam. Database construction and management: Matthew M. Moake.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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SYSTEMATIC REVIEWS

Clinical Frailty Scale as a predictor of short-term mortality: A systematic review and meta-analysis of studies on diagnostic test accuracy

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Abstract

Background: The Clinical Frailty Scale (CFS) is a representative frailty assessment tool in medicine. This systematic review and meta-analysis aimed to examine whether frailty defined based on the CFS could adequately predict short-term mortality in emergency department (ED) patients.

Methods: The PubMed, EMBASE, and Cochrane libraries were searched for eligible studies until December 23, 2021. We included studies in which frailty was measured by the CFS and short-term mortality was reported for ED patients. All studies were screened by two independent researchers. Sensitivity, specificity, positive likelihood ratio (PLR), and negative likelihood ratio (NLR) values were calculated based on the data extracted from each study. Additionally, the diagnostic odds ratio (DOR) was calculated for effect size analysis, and the area under the curve (AUC) of summary receiver operating characteristics was calculated. Outcomes were in-hospital and 1-month mortality rate for patients with the CFS scores of ≥5, ≥6, and ≥7.

Results: Overall, 17 studies (n = 45,022) were included. Although there was no evidence of publication bias, a high degree of heterogeneity was observed. For the CFS score of ≥5, the PLR, NLR, and DOR values for in-hospital mortality were 1.446 (95% confidence interval [CI] 1.325–1.578), 0.563 (95% CI 0.355–0.893), and 2.728 (95% CI 1.872–3.976), respectively. In addition, the pooled statistics for 1-month mortality were 1.566 (95% CI 1.241–1.976), 0.582 (95% CI 0.430–0.789), and 2.696 (95% CI 1.673–4.345), respectively. Subgroup analysis of trauma patients revealed that the CFS score of ≥5 could adequately predict in-hospital mortality (PLR 1.641, 95% CI 1.242–2.170; NLR 0.580, 95% CI 0.461–0.729; DOR 2.883, 95% CI 1.994–4.168). The AUC values represented sufficient to good diagnostic accuracy.

Conclusions: Evidence that is published to date suggests that the CFS is an accurate and reliable tool for predicting short-term mortality in emergency patients.

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INTRODUCTION

According to the United Nations, the number of people aged ≥ 65 years is increasing rapidly and is expected to be more than double worldwide from 703 million in 2019 to 1.5 billion in 2050.[1] Aging is a normal physiological process that reduces cellular homeostasis and the body's functional reserve, resulting in reduced ability to cope with disease states.[2] Traditionally, old age had been defined as the chronological age of ≥65 years.[3] However, deterioration of the body's functional reserve is influenced by various environmental factors.[2] Therefore, the degree of frailty experienced by individuals in the same age group varies, and determining it based on age alone is inadequate.

Two representative hypotheses that define frailty are the cumulative deficit model and the phenotypical model.[4] Despite the lack of a consensus definition, frailty remains conceptualized as a having high vulnerability to stressors because of the significant depletion of physiological reserves.[5] Identifying emergency department (ED) patients affected by frailty is required to support early treatment decisions, prescribe appropriate medications, and implement risk management at discharge.[6] The need for a tool that supports frailty assessments remains unaddressed. In 2003, the American Geriatrics Society proposed future studies to develop appropriate screening tools for recognizing high-risk older patients.[7] Subsequent efforts aimed at identifying reliable frailty screening tools suitable for the ED context; currently, several such tools are available and their effectiveness is evaluated based on the rates of ED revisit, hospitalization, and mortality.[8,9] In addition, previous studies have compared diagnostic accuracy and ease of use of different frailty screening tools.[10,11] However, the most appropriate tool remains unclear.

The Clinical Frailty Scale (CFS) is a frailty assessment tool developed by Rockwood et al. in 2005.[12] The CFS, originally developed as a 7-point scale, was revised to a 9-point scale in 2008, allowing for a more detailed evaluation of frailty. The CFS is a validated tool that can used be prospectively and retrospectively, based on medical record data.[13,14] The CFS is used in hospitals, outpatient clinics, long-term care facilities, and the community.[15] The CFS is a key triage factor in the Canadian ED Triage and Acuity Scale and a widely used patient classification tool in emergency care with increasing popularity.[16]

There are previous meta-analysis studies using the CFS. Fehlmann et al.[9] conducted a meta-analysis of studies involving older adults who underwent emergency surgery and reported that the 30-day mortality rate increased as the CFS score increased. In addition, Leahy et al.[17] examined the diagnostic accuracy of the CFS score in hospitalized older adults. However, no previous meta-analysis had examined the association between the CFS scores and mortality rates in ED patients. Therefore, this meta-analysis aimed to examine whether frailty defined by the CFS could predict short-term mortality in ED patients.

METHODS

This meta-analysis aimed to examine whether frailty defined by the CFS could predict short-term mortality in ED patients. This study was conducted according to the PRISMA guidelines for diagnostic test accuracy.[18]

Search strategy

Eligible studies were retrieved from the PubMed, EMBASE, and Cochrane libraries. The search was conducted systematically with the assistance of a medical librarian, and the search strategy summary is presented in Supplementary data sheet 1. No language restriction was imposed in this study. Studies were searched from 2005 when the CFS was introduced and the final search was conducted on December 23, 2021. In addition, we scanned the reference lists of included studies to identify other potentially eligible studies. Data retrieved from each database were inputted into EndNote 20 reference management software (Clarivate Analytics) for screening; duplicate entries were removed.

Eligibility criteria

After duplicates were removed, articles were screened by two independent reviewers (J.H.L. and S.P.C.). Any discrepancies between reviewers were resolved by consensus. If a consensus could not be reached, the decision was made by a third reviewer (Y.S.P.). We included studies in which frailty was measured by the CFS and short-term mortality rates were reported for patients treated in the ED. In this study, short-term mortality was defined as death within 3 months of admission to the ED.

To be eligible for the present review, studies had to be original studies reporting on cohort or observational studies and presenting the number of patients and deaths per CFS group. Studies in which uncommon CFS cutoff values were used (e.g., CFS ≥ 4 vs. CFS < 4) were excluded because their results could not be combined with those of other studies.

Data extraction and quality assessment

Data on the following variables were independently extracted by two researchers: author name, publication year, country, number of patients, average age of patients, study eligibility criteria, type and timing of the CFS assessment, and time of death. The participants' age was reported as the median (interquartile range [IQR]) or mean ± standard deviation, as presented in the original article. Outcomes of interest were in-hospital and 1-month mortality rates.

Two authors (J.H.L. and S.P.C.) independently evaluated the risk of bias in the collected studies by using the Quality Assessment of Diagnostic Accuracy Studies-2 (QUADAS-2) scale,[19] blinded to the other author's assessment. Any discrepancies between the two authors were resolved by consensus or arbitration by a third author (Y.S.P.), as required.

The ideal study is one that evaluates the CFS score at the beginning of the initial evaluation in the ED for all adult patients and then

measures the mortality rate. However, during the study selection process, it was predicted that most of the eligible studies did not satisfy this criterion. Therefore, by consensus among the authors, the following conditions were used to evaluate the risk of bias.

Ideally, included studies would evaluate CFS scores at baseline and report mortality rates as an endpoint. However, few studies had this design. Therefore, the following criteria were used to evaluate the risk of bias. CFS data reported after ED admission were unlikely to reflect their status at the time of ED treatment; therefore, for the CFS scores reported more than 72 h after admission, the concern regarding the applicability of the index test was evaluated as high.

This study aimed to investigate the usefulness of the CFS in general ED patients. Therefore, studies that included selected patients group based on criteria other than age were considered at high risk of concerns regarding the applicability of patient selection.

Since the cutoff of the CFS score will be analyzed as the cutoff set by the authors, the appropriateness of the cutoff value suggested in each study was not evaluated.

Because the outcome variable, i.e., mortality, itself corresponds to the criterion standard, concerns regarding the applicability of the reference standard were considered as low for all included studies.

Data analysis

Previous studies used the 7- and 9-point versions of the CFS. The 9-point scale was developed by subdividing the maximum CFS score of 7 points (severe frail) into scores of 7 (severe frail), 8 (very severe frail), and 9 (terminally ill) points. For both scales, scores in the range of 1–6 points represent the same categories of very fit to moderately frail.[12] In this study, frailty was defined as a CFS score of ≥5 points. Further analysis was performed based on the CFS scores of ≥6 and ≥7 points. The present frailty cutoff score included the category of frailty defined by both versions of the CFS, allowing findings from both tools to be used as equivalents.

The included studies categorized patients based on a different range of CFS values. The time of death also differed among the studies. Consequently, in our meta-analysis, we included only those studies that provided data that allowed us to categorize patients based on the CFS scores of ≥5, ≥6, or ≥7 points.

The risk of publication bias was examined using Egger's, and Deek's tests. Deek's test is the recommended statistical method for the analysis of publication bias in a meta-analysis of diagnostic test accuracy.[20] When deciding whether to pool studies, decisions are made based on patients, interventions, outcomes, and study methods.[21] The included studies have the following in common: ED patients, assessment of frailty using the CFS, short-term mortality as an outcome, and observational studies. However, each study was conducted on patients with different disease groups. Therefore, although the included studies could be pooled, they could not be considered homogeneous. Consequently, although Q-test and I^2 methods were used to assess the heterogeneity of the studies used in each analysis and provided relevant estimates, all analyses were performed using the random effect model.

Sensitivity, specificity, positive likelihood ratio (PLR), and negative likelihood ratio (NLR) values were calculated based on the data extracted from each study. The diagnostic odds ratio (DOR) was calculated for effect size analysis, and a forest plot was drawn. In addition, the summary receiver operating characteristic curve (SROC) was drawn and the area under the curve (AUC) was estimated. All statistical results are presented in the form of coefficients (95% confidence interval [CI]). A subgroup analysis was performed with trauma patients for in-hospital mortality. All analyses were performed in R package, version 4.0.4 (http://www.R-project.org).

RESULTS

A total of 722 articles were identified through database searches and four articles were identified through reference review. Overall, 168, 277, and 204 studies were duplicates, articles other than original studies, and ineligible articles, respectively, based on title and abstract screening. Finally, 77 articles underwent a full-text review. Of these, studies that did not use the CFS or did not involve ED patients were also excluded; finally, 17 studies were included. The study selection process, including reasons for study exclusion, is presented in Figure 1.

A total of 17 studies (n = 45,022) were included in the final analysis. Excluding the study by Bastoni et al.[22] (n = 272), which reported only the number of persons with the CFS score of ≥6, the proportion of people living with frailty (CFS ≥ 5) was 50.4%. Three studies used the 7-point CFS, and 14 studies used the 9-point CFS. Study characteristics are presented in Supplementary data sheet 2. Supplementary data sheet 3 presents the number of patients per CFS score category. Supplementary data sheet 4 lists the studies included in each analysis. The results of publication bias analyses are presented in Table 1. For all seven meta-analyses conducted in this study, p-values of the Deek's test and Egger's test were ≥0.05, suggesting no publication bias.

Quality assessment of included studies

Table 2 presents the results of the quality assessment conducted using the QUADAS-2. Three studies involved the general ED patients; however, other studies involved specific patient groups such as trauma patients and patients with suspected infection; therefore, risk of bias and concerns regarding the applicability of patient selection criteria were considered as high. Most of the studies evaluated the CFS score within 72 h, but in three studies, the evaluation period was not described; therefore, concern regarding the applicability of the index test was unclear. Goeteyn

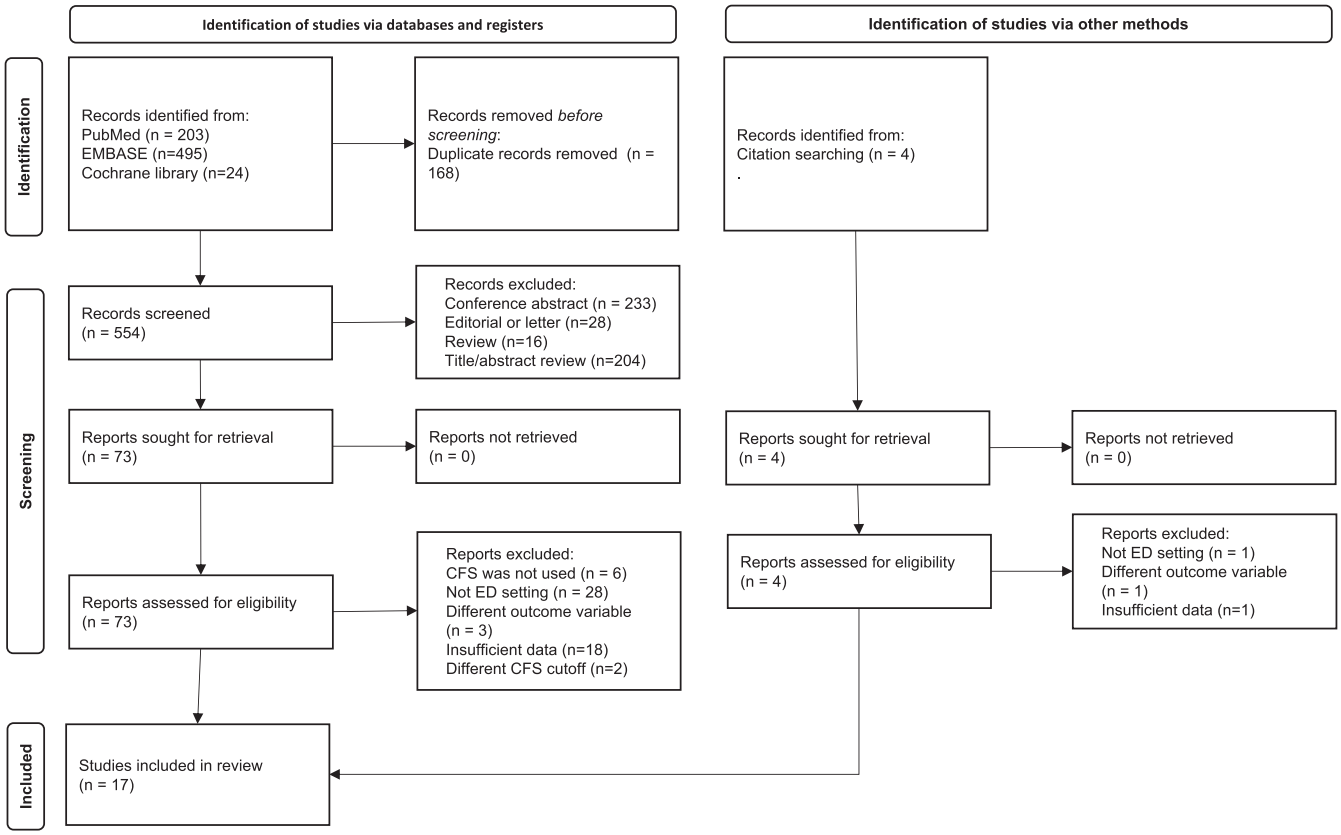


FIGURE 1 Flow diagram of study search and selection. CFS, Clinical Frailty Scale

TABLE 1 Results of publication bias analysis

Mortality	Cutoff of for frailty	p-value	
		Deek's test	Egger's test
In-hospital	CFS ≥ 5	0.7619	0.8861
	CFS ≥ 6	0.6254	0.6552
	CFS ≥ 7	0.5587	0.5429
1-month	CFS ≥ 5	0.7259	0.567
	CFS ≥ 6	0.8845	0.7787
	CFS ≥ 7	0.6695	0.8379
In-hospital for trauma subgroup	CFS ≥ 5	0.8093	0.6298

Abbreviation: CFS, Clinical Frailty Scale.

et al. evaluated the CFS score retrospectively based on medical records, and the concern regarding the applicability of the index test was high. In the flow and timing category, three studies did not report the number of excluded patients and the risk of bias was evaluated as unclear. Seven studies excluded a high proportion of patients and the risk of bias was evaluated as high. With the exception of the study by Goeteyn et al., which retrospectively evaluated the CFS scores, most studies evaluated the CFS scores at the beginning of treatment; hence, the CFS scores would have been evaluated blindly to death. However, no studies reported whether these CFS results were blinded to the doctor who cared for the patient after the ED. Therefore, the risk of incorporation bias was evaluated as high.[23]

Correlations between frailty assessed by the CFS and short-term mortality

Correlations among the CFS cutoff scores and mortality rates are summarized in Table 3. The DOR of the three different CFS cutoffs ranged from 2.633 to 2.847 for in-hospital mortality and 2.696 to 3.056 for 1-month mortality. For both in-hospital and 1-month mortality rates, as the cutoff value of the CFS score increased from 5 to 7 points, specificity, PLR/NLR, and DOR values tended to increase, whereas sensitivity values tended to decrease.

Associations between frailty, defined as the CFS scores ≥5, and in-hospital mortality are presented in Table 4. Both the Q-test and the I^2 tests indicated high heterogeneity among the included studies.

TABLE 2 Quality assessment of the included studies using the QUADAS-2

	Risk of bias				Concerns regarding applicability		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Arjan 2021[24]	Low	Unclear	Low	High	Low	Unclear	Low
Bastoni 2019[22]	High	Unclear	Low	Unclear	High	Unclear	Low
Cheung 2017[25]	High	Low	Low	High	High	Low	Low
Fernando 2020[26]	High	Low	Low	Low	High	Low	Low
Goeteyn 2017[27]	High	High	Low	Unclear	High	High	Low
Hamidi 2019[28]	High	Low	Low	Low	High	Low	Low
Ishikawa 2021[29]	High	Low	Low	Low	High	Low	Low
Jarman 2021[30]	High	Low	Low	High	High	Low	Low
Kaeppeli 2020[13]	Low	Low	Low	Low	Low	Low	Low
Owen 2020[31]	High	Low	Low	High	High	Low	Low
Rickard 2020[32]	High	Low	Low	Unclear	High	Low	Low
Romero-Ortuno 2016[33]	High	Low	Low	Low	Unclear	Low	Low
Shrier 2020[34]	High	Low	Low	High	High	Low	Low
Takauji 2021[35]	High	Unclear	Low	Low	High	Unclear	Low
Thompson 2021[36]	High	Low	Low	High	High	Low	Low
Ticinesi 2021[37]	High	Low	Low	High	High	Low	Low
Wallis 2015[38]	Low	Low	Low	Low	Low	Low	Low

Abbreviation: QUADAS-2, Quality Assessment of Diagnostic Accuracy Studies-2.

TABLE 3 Pooled summary statistics of the association between each CFS cutoff value and mortality rates

Mortality	Cutoff for frailty	Number of included studies	Sensitivity (95% CI)	Specificity (95% CI)	PLR (95% CI)	NLR (95% CI)	DOR (95% CI)
In-hospital	CFS ≥ 5	8	0.738(0.721–0.755)	0.506(0.500–0.511)	1.446(1.325–1.578)	0.563(0.355–0.893)	2.728(1.872–3.976)
	CFS ≥ 6	5	0.603(0.583–0.622)	0.668(0.662–0.673)	1.654(1.439–1.901)	0.637(0.389–1.043)	2.633(1.445–4.797)
	CFS ≥ 7	3	0.387(0.367–0.407)	0.850(0.846–0.854)	2.201(1.704–2.843)	0.748(0.506–1.105)	2.847(1.431–5.663)
1-month	CFS ≥ 5	8	0.640(0.610–0.669)	0.537(0.527–0.547)	1.566(1.241–1.976)	0.582(0.430–0.789)	2.696(1.673–4.345)
	CFS ≥ 6	4	0.602(0.567–0.637)	0.669(0.659–0.678)	1.827(1.214–2.750)	0.615(0.452–0.835)	2.984(1.412–6.306)
	CFS ≥ 7	5	0.365(0.331–0.400)	0.857(0.849–0.864)	2.314(1.550–3.455)	0.769(0.666–0.888)	3.050(1.765–5.271)
Subgroup analysis for trauma patients							
In-hospital	CFS ≥ 5	4	0.675(0.595–0.749)	0.570(0.545–0.595)	1.641(1.242–2.170)	0.580(0.461–0.729)	2.883(1.994–4.168)

Abbreviations: CFS, Clinical Frailty Scale; DOR, diagnostic odds ratio; NLR, negative likelihood ratio; PLR, positive likelihood ratio.

The values of PLR, NLR, and DOR of the individual studies were in the range of 1.250–2.074, 0.375–0.925, and 1.238–4.025, respectively. The pooled statistics were 1.446 (95% CI 1.325–1.578), 0.563 (95% CI 0.355–0.893), and 2.728 (95% CI 1.872–3.976), respectively (Figure 2). The AUC value of SROC was 0.633, indicating sufficient diagnostic accuracy (Figure 3). Supplementary data sheets 5 and 6 present detailed results for the CFS scores of ≥6 or ≥7 and in-hospital mortality rates. The DOR and AUC of SROC values were the highest for the CFS score of ≥7 (DOR 2.847, 95% CI 1.431–5.663, AUC 0.776, good diagnostic accuracy).

Table 5 presents the associations between the CFS scores of ≥5 and 1-month mortality. The values of PLR, NLR, and DOR were in the range of 1.087–3.016, 0.261–0.862, and 1.261–9.282, respectively. The pooled statistics were 1.566 (95% CI 1.241–1.976), 0.582 (95% CI 0.430–0.789), and 2.696 (95% CI 1.673–4.345), respectively (Figure 4). The AUC value of SROC was 0.657, indicating sufficient diagnostic accuracy (Figure 5). Findings for the CFS scores ≥6 and ≥7 are presented in Supplementary data sheets 8 and 9. The DOR and AUC of SROC values were the highest for the CFS scores of ≥7 (DOR 3.050, 95% CI 1.765–5.271, AUC 0.667, sufficient diagnostic accuracy).

Most included studies involved older adults. However, two studies included patients aged ≥16 and ≥18 years. This younger patient group was included in the analysis of 1-month mortality. Excluding these two studies, the results of analyses of studies with older adults are presented in Supplementary data sheets 7, 8-1, and 9-1. Except

TABLE 4 Results of meta-analysis of the association between frailty defined as CFS of ≥5 and in-hospital mortality rates

	Sensitivity(95% CI)	Specificity(95% CI)	PLR(95% CI)	NLR(95% CI)	DOR(95% CI)
Wallis 2015[38]	0.831(0.787–0.870)	0.450(0.436–0.463)	1.510(1.431–1.594)	0.375(0.295–0.477)	4.025(3.005–5.391)
Cheung 2017[25]	0.455(0.167–0.766)	0.636(0.572–0.697)	1.250(0.641–2.439)	0.857(0.496–1.482)	1.458(0.433–4.917)
Hamidi 2019[28]	0.606(0.421–0.771)	0.708(0.654–0.758)	2.074(1.498–2.872)	0.557(0.362–0.855)	3.726(1.778–7.812)
Shrier 2020[34]	0.388(0.344–0.434)	0.661(0.651–0.672)	1.146(1.019–1.288)	0.925(0.860–0.996)	1.238(1.024–1.498)
Arjan 2021[24]	0.832(0.813–0.851)	0.440(0.432–0.447)	1.485(1.446–1.524)	0.382(0.341–0.427)	3.890(3.391–4.463)
Jarman 2021[30]	0.571(0.394–0.737)	0.709(0.657–0.757)	1.962(1.407–2.735)	0.605(0.410–0.892)	3.244(1.595–6.598)
Thompson 2021[36]	0.792(0.680–0.878)	0.411(0.373–0.450)	1.344(1.175–1.538)	0.507(0.320–0.803)	2.651(1.470–4.781)
Ticinesi 2021[37]	0.727(0.390–0.940)	0.510(0.447–0.572)	1.483(1.012–2.175)	0.535(0.202–1.415)	2.772(0.719–10.687)
Q-test p-value	<0.001	<0.001	<0.001	<0.001	<0.001
I^2	98.1%	99.5%	77.1%	97.3%	93.1%
Pooled statistic	0.738(0.721–0.755)	0.506(0.500–0.511)	1.446(1.325–1.578)	0.563(0.355–0.893)	2.728(1.872–3.976)

Abbreviations: CFS, Clinical Frailty Scale; DOR, diagnostic odds ratio; NLR, negative likelihood ratio; PLR, positive likelihood ratio.

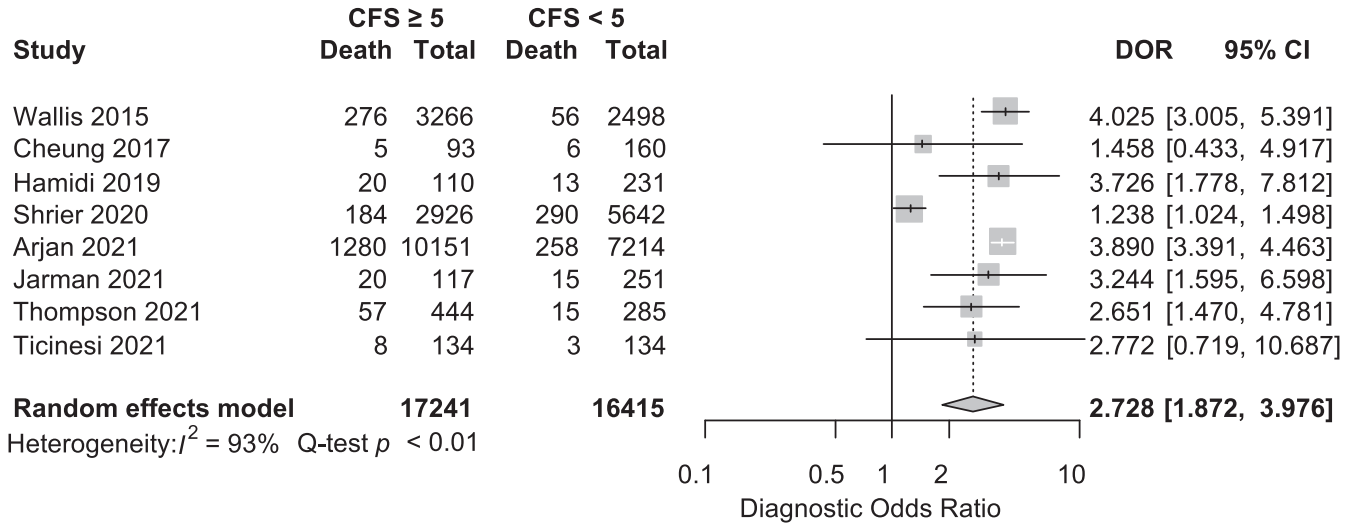


FIGURE 2 Forest plot for the effect of the CFS scores on in-hospital mortality rates, cutoff CFS 5 or higher. CFS, Clinical Frailty Scale; DOR, diagnostic odds ratio

for the young patient group, the DOR and AUC of SROC values increased for the CFS score of ≥5 (for studies on older adults only: DOR 3.091, 95% CI 1.065–5.953, AUC 0.745, showing good diagnostic accuracy). However, for the CFS score of ≥6 or ≥7, the results did not change significantly, with the exception of young patients.

The results of subgroup analysis of studies involving trauma patients are presented in Supplementary data sheet 10. For in-hospital mortality and the CFS score of ≥5, PLR, NLR, and DOR values were 1.641 (95% CI 1.242–2.170), 0.580 (95% CI 0.461–0.729), and 2.883 (95% CI 1.994–4.168), respectively. The AUC of SROC was 0.670, showing sufficient diagnostic accuracy.

DISCUSSION

To the best of our knowledge, this is the first systematic review and meta-analysis to demonstrate an association between frailty assessed by the CFS and mortality rates in ED patients. This study revealed that the CFS score adequately predicted in-hospital and 1-month mortality in ED patients. In addition, the CFS score showed good predictive power in the subgroup analysis of trauma patients. Overall, the AUC value of SROC showed sufficient to good diagnostic accuracy.

Different medical subspecialties, depending on their interests, have different understandings of the effects of frailty on the body with a variety of specific frailty assessment tools used. In transplantation medicine, frailty may delay the function of grafted organs and tolerance to immunosuppression.[5] In HIV treatment, the Veterans Aging Cohort Study index is used to assess physical frailty and predict the 5-year mortality.[5] Accurate and reliable frailty instruments that are feasible to use in ED settings are an important component of baseline risk stratification.[39] Frailty may negatively affect not only long-term prognosis but also short-term treatment response in acutely ill patients.[40,41] We, as emergency physicians who treat

acutely ill patients, recognize that frailty adversely affects the recovery of ED patients and should be accounted for in emergency care, starting with identifying a tool that can help predict outcomes, including mortality. Therefore, we initiated this study because we were interested in determining whether the CFS, which was recommended by Lewis et al.[11] as an appropriate tool for use in ED, could predict short-term mortality. Therefore, we aimed to evaluate whether frailty, based on the CFS, could adequately predict short-term mortality.

In this study, when only studies with older adults were considered, the CFS score of ≥5 showed a good predictive value for 1-month mortality; however, higher cutoff values did not affect this result. This means, when the generally used CFS score of ≥5 cutoff is applied, the predictability of mortality for young patients is lower than that for older patients. A previous study has shown that as the Frailty index increases, the mortality rates also increase; however, the strength of this association was lower in younger than in older people.[42] Older adults experiencing a change in their health status are less likely than young adults to recover their baseline health status; consequently, younger patients are more likely to recover than older patients. Therefore, caution is required in interpretation for young patients assessed as CFS of 5 when evaluating prognosis based on the CFS score.

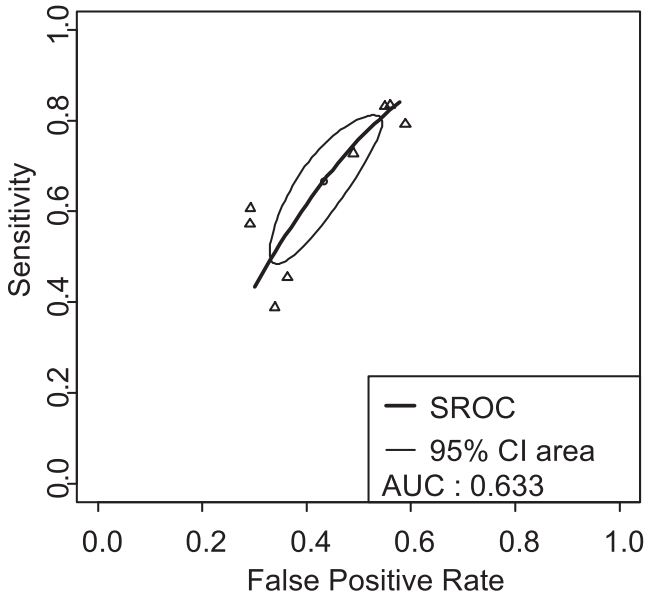


FIGURE 3 Summary receiver operating characteristic curve for correlation between CFS scores of ≥5 and in-hospital mortality rates. Diagnostic accuracy for in-hospital mortality is considered as good. △, included study; ○, pooled statistics; AUC, the area under the curve; CI, confidence interval; SROC, Summary receiver operating characteristic curve

Frailty is associated with various outcomes, which were assessed in the included studies alongside mortality. Two studies reported a correlation between the CFS and hospitalization. For the CFS score of ≥5, the PLR and NLR for hospitalization were 2.17 (95% CI 2.02–2.33) and 0.71 (95% CI 0.69–0.73) in a study by Shrier et al.[34] and 2.24 (95% CI 1.95–2.58) and 0.68 (95% CI 0.64–0.72) in a study by Kaeppeli et al., respectively[13] Although, this PLR was higher than the PLR for mortality obtained in this study, the NLR was also higher than that in this study. For 30-day readmission, the PLR and NLR were 1.12 (95% CI 1.06–1.19) and 0.84 (95% CI 0.77–0.93) in a study by Wallis et al.[38] and 1.66 (95% CI 1.22–2.25) and 0.74 (95% CI 0.59–0.93) in a study by Hamidi et al., respectively.[28] In a study by Braude et al.[43] on 1-year mortality in trauma patients, the PLR and NLR were 1.74 (95% CI 1.51–2.00) and 0.43 (95% CI 0.32–0.58), respectively. The predictability of the 1-year mortality presented by the study by Braude et al. was better than the predictability of the in-hospital mortality obtained from the trauma subgroup analysis of this study.

The CFS has adequate accuracy for various frailty indicators in addition to short-term mortality. However, when evaluating the effectiveness of diagnostic tools, reliability as well as accuracy are important aspects. Among the included studies, four studies evaluated kappa coefficients for inter-rater reliability during the study period. Shrier et al.[34,44] reported a kappa coefficient of 0.21 (95%

TABLE 5 Results of meta-analysis of the association between frailty defined as CFS of ≥5 and 1-month mortality rates

	Sensitivity(95% CI)	Specificity(95% CI)	PLR(95% CI)	NLR(95% CI)	DOR(95% CI)
Romero-Ortuno 2016[33]	0.768(0.718–0.811)	0.454(0.441–0.468)	1.406(1.316–1.502)	0.511(0.417–0.628)	2.750(2.101–3.599)
Goeteyn 2017[27]	0.667(0.208–0.939)	0.779(0.686–0.851)	3.016(1.245–7.305)	0.428(0.086–2.128)	7.048(0.609–81.579)
Fernando 2020[26]	0.731(0.539–0.863)	0.446(0.375–0.520)	1.320(1.009–1.726)	0.603(0.314–1.160)	2.188(0.876–5.468)
Kaeppeli 2020[13]	0.828(0.753–0.884)	0.658(0.638–0.678)	2.423(2.198–2.671)	0.261(0.178–0.382)	9.282(5.817–14.811)
Ishikawa 2021[29]	0.585(0.499–0.666)	0.609(0.574–0.642)	1.494(1.261–1.769)	0.682(0.552–0.843)	2.189(1.501–3.191)
Owen 2021[31]	0.667(0.597–0.730)	0.387(0.348–0.427)	1.087(0.964–1.226)	0.862(0.687–1.081)	1.261(0.892–1.782)
Rickard 2021[32]	0.731(0.539–0.863)	0.536(0.477–0.595)	1.577(1.209–2.057)	0.502(0.264–0.954)	3.142(1.279–7.716)
Takauji 2021[35]	0.333(0.274–0.399)	0.788(0.757–0.817)	1.575(1.243–1.995)	0.846(0.764–0.936)	1.862(1.331–2.606)
Q-test *p*-value	<0.001	<0.001	<0.001	<0.001	<0.001
I^2	94.8%	98.8%	94.6%	89.6%	86.1%
Pooled statistic	0.640(0.610–0.669)	0.537(0.527–0.547)	1.566(1.241–1.976)	0.582(0.430–0.789)	2.696(1.673–4.345)

Abbreviations: CFS, clinical frailty scale; DOR, diagnostic odds ratio; NLR, negative likelihood ratio; PLR, positive likelihood ratio.

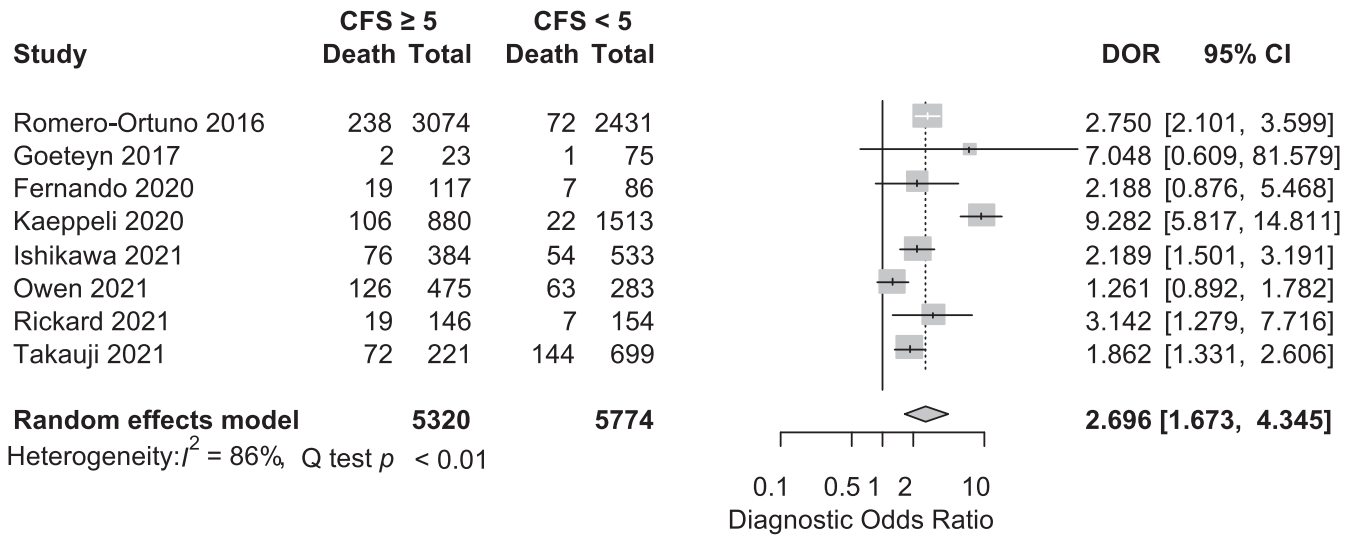


FIGURE 4 Forest plot for the effect of the CFS scores on 1-month mortality, cut-off CFS 5 or higher. CFS, Clinical Frailty Scale; DOR, diagnostic odds ratio

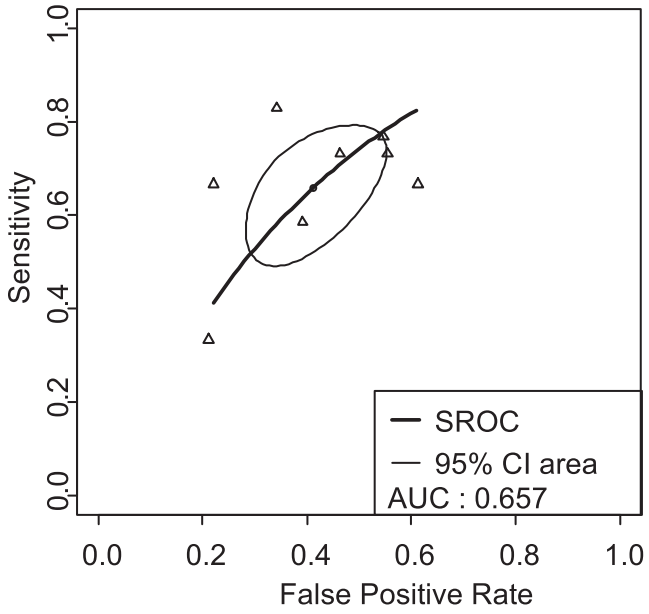


FIGURE 5 Summary receiver operating characteristic curve for correlation CFS scores of ≥5 and 1-month mortality rates. Diagnostic accuracy for 1-month mortality is considered as good. △, included study; ○, pooled statistics; AUC, the area under the curve; SROC, Summary receiver operating characteristic curve

CI 0.19–0.22, fair agreement), which was very low. The authors speculated that this discrepancy may be due to the differences in CFS evaluation timing. The first CFS was evaluated during the triage period when sufficient information about the patient could not be obtained, but the second CFS was evaluated after hospitalization. Meanwhile, Hamidi et al.,[28] Kaeppeli et al.,[13] and Owen et al.[31] reported estimates obtained approximately at the same time during the ED staying, with the corresponding kappa values in the range of 0.70–0.83, representing substantial to almost perfect agreement.[44] Given these results, the CFS can be considered a reliable tool.

Previous studies have shown that older adult patients are undertriaged in the triage stage, which is the starting point of emergency treatment.[45,46] In one study, educational interventions were attempted to solve the undertriage of older adults, without any effect, suggesting a need for a new triage tool.[47] In a recent study, when the emergency triage tool and the frailty assessment tool were used together, the predictability of 1-month mortality was improved.[48] This study suggests the possibility that the emergency triage tool and the frailty assessment tool can play complementary roles. Many triage tools determine treatment priorities based on the current disease status, such as vital signs, level of consciousness, and expected number of medical resources. However, because frailty is associated with poor treatment outcomes, frailty should be considered in addition to their current disease status when determining treatment priorities. This approach aligns with the aims of emergency medicine: treating more severe patients first, and this will result in the creation of a patient-centered care environment that prioritizes frail patients, who may find waiting times difficult because of poor health status, among patients with the same level of severity of the disease. However, if the assessment of frailty takes a lot of time, this approach will act as another barrier to the treatment of emergency patients. According to Elliott et al.,[49] since the median time of 44 s is required to evaluate the CFS, the effect on treatment delay is not expected to be significant. The advantage of quick evaluation makes the CFS an appropriate tool for use in busy EDs.

Although the CFS classifies frailty into a 9-point scale, a dichotomous criterion that defines frailty as ≥5 is currently used. However, a recently published study by Rueegg et al.[50] found that the 1-year survival rate decreased with each increase in the CFS grade. According to the results of their study, the restricted mean survival times of the CFS scores of 5 and 8 were 311 and 219 days, respectively; however, they are equally classified as just frail according to the current dichotomous interpretation. This means that depending on the interpretation method, the CFS score has the potential to

provide more in-depth information about the prognosis of emergency patients. In the future, studies will hopefully be conducted to maximize the potential of the CFS and to find the best combination with emergency triage tools. This will contribute to improving the safety of older emergency patients.

LIMITATIONS

This study has several limitations. First, despite our efforts to identify all eligible studies, some studies may have been missed. Second, this meta-analysis included only studies that reported the number of frail patients and deaths. Third, although all included studies were conducted in the ED setting, they involved different patient groups. Heterogeneity was high among the included studies, and the results should be approached with caution. Finally, although this study included ED patients, in several included studies, the CFS might have been evaluated outside the ED, which may have affected the assessment.

CONCLUSIONS

The present systematic review and meta-analysis results suggest that the Clinical Frailty Scale is a reliable frailty assessment tool that can predict short-term mortality rates among emergency patients. The Clinical Frailty Scale score of ≥5, the generally accepted cutoff for frailty, predicted short-term mortality more accurately in older patients than in younger patients. However, even when younger patients were included, it showed reliability in predicting short-term mortality. Therefore, the Clinical Frailty Scale may be used as a frailty assessment tool in ED settings.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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SYSTEMATIC REVIEW

Palliative care interventions for adults in the emergency department: A review of components, delivery models, and outcomes

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Abstract

Background: Existing evidence suggest the emergence of palliative care (PC) services in the emergency department (ED). To gain insight into the nature of these services and provide direction to future actions, there is a need for a comprehensive review that ascertains the components of these services, integration models, and outcomes.

Methods: A scoping review design was employed and reported according to the PRISMA extension guidelines for scoping reviews. Extensive searches in peer-reviewed databases (CINAHL, EMBASE, PubMed, Cochrane Library, and Medline) and gray literature sources (Trove, MedNar, OpenGrey, and the Agency for Healthcare Research and Quality) were undertaken and supplemented with hand searching. Titles, abstracts, and full text were reviewed in duplicate. Studies were eligible for inclusion if they reported on a PC intervention implemented in the ED for adults. Codes were formulated across the included studies, which facilitated the conduct of a narrative synthesis.

Results: Twenty-three studies were retained with the majority ($n = 15$) emerging from the United States. The components of PC interventions in the ED were categorized as: (1) screening, (2) goals of care discussion and communication, (3) managing pain and other distressing symptoms in the ED, (4) transitions across care settings, (5) end-of-life (EoL) care, (6) family/caregiver support, and (7) ED staff education. Traditional PC consultations and integrated ED–PC services were the main modes of delivery. PC in the ED can potentially improve patient symptoms, facilitate access to relevant services, reduce length of stay, improve care at the EoL, facilitate bereavement and postbereavement support for family members, and improve ED staff confidence in delivering PC.

Conclusions: PC implementation in the ED may potentially improve patient and family outcomes. More studies are needed, however, to standardize trigger or screening tools. More prospective studies are also needed to test PC interventions in the ED.

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KEYWORDS
emergency department, models of care, palliative care

INTRODUCTION

The aging trend across the globe along with medical advances have resulted in a growing number of older persons living with complex comorbidities such as congestive heart failure, advanced cancer, and chronic lung disease who may utilize the emergency department (ED) throughout their illness trajectory and at the end of life (EoL).[1,2] In fact, several patients with serious illnesses are treated in the ED in the last month of life[3,4] and approximately 1% of persons attending the ED die there, which makes it important to provide palliative/EoL care service when needed.[5,6]

The focus of care in the ED is rapid assessment and acute clinical care to stabilize and transfer the patient in a timely and efficient manner.[7] Discussing palliative/EoL care in the chaotic, fast-paced ED environment characterized by acute care and resuscitation may therefore appear as an oxymoron.[8] However, it has been argued that palliative care (PC) and emergency medicine should be considered synergistic as they evolve to achieve a common purpose of providing comprehensive and compassionate care.[9]

Delivering PC in the ED has the potential to promote patient-centered care at the end of life, decrease the intensity and invasiveness of care, promote quality of life, and reduce costs.[10–12] PC in the ED remains a priority across groups such as the Royal College of Emergency Medicine[13,14] and the American College of Emergency Physicians (ACEP).[15] Also, in 2006, the American Board of Emergency Medicine cosponsored palliative medicine as a recognized subspecialty.[16] Although these demonstrate an interest in incorporating PC principles in the ED, its implementation has various challenges: the busy nature of the ED, lack of guidelines, and lack of PC training.[8,17–19] Besides, the ED has not been the focus of PC research, leading to a call for more research in this regard.[20]

Although there are varied models of implementing PC in the ED, none is presented as the most effective and efficient. In spite of the challenges, there is evidence suggesting that PC interventions in the ED are emerging.[21] Existing reviews have, however, either focused on the types of trigger tools used for PC consultations[2,22] or EoL care in the ED.[23] To the authors' knowledge, there is currently no comprehensive review that ascertains the components of existing interventions (beyond the trigger tools), delivery models, and outcomes. Such knowledge can potentially offer insights into the nature of existing programs and provide direction to future actions. This study therefore sought to scope existing literature to map the components, models of integration, and outcomes associated with PC interventions for adults in the ED. Additionally, we sought to identify gaps in existing studies. The review question posed was "what is known about the components, models of integration, and outcomes associated with palliative care interventions for adults in the ED"?

METHODS

Review design

A scoping review was performed following the methodological guidance of Arksey and O'Malley.[24] The PRISMA Extension Guidelines for Scoping Reviews were followed in reporting this review.[25] Although a review protocol was developed by the team, it was not published.

Data sources, searches, and eligibility criteria

Extensive searches were conducted by two members (J.B. and H.A.O.) of the research team independently with the assistance of a librarian in the following databases: (1) CINAHL, (2) EMBASE, (3) PubMed, (4) Cochrane Library, and (5) Medline. Trove, MedNar, OpenGrey, and the Agency for Healthcare Research and Quality were searched for gray literature. All literature sources were searched from inception to March 31, 2021, by two team members and repeated in December 2021 by a third independent member (E.K.A.) with ongoing wider team consultation. For clarity, the consensus-based definition of PC, which refers to the active holistic care of persons with serious health-related suffering due to severe illness, was used in this study.[26] The search terms included "palliative" *or* "palliate" *or* "palliation" *or* "palliative care" *or* "comfort care" *or* "end of life care" *or* "terminal care" *or* "hospice care" *and* "emergency department" *or* "emergency room" *or* "accident and emergency" *or* "accident & emergency" *or* "a&e" OR "a & e" *and* "interventions" *or* "strategies" *or* "best practices" *or* "treatment" *or* "therapy" *or* "program" *or* "programme" *or* "management" *and* "adults" *or* "adult" *or* "aged" *or* "elderly." All studies published in English that reported the implementation or evaluation of a PC program for adults in the ED, irrespective of the study design, were eligible for inclusion. To fully scope, PC programs in this study was broadly defined in line with the hospice and palliative medicine (HPM) components relevant to the ED formulated by the palliative medicine section of the ACEP.[27] This includes communication, goals of care (GoC) discussion, prognostication, screening for PC needs, and transitions across settings.[27] Studies were considered ineligible if they reported PC interventions for pediatric patients in the ED, did not provide the ED–PC program details, or reported educational programs targeting ED staff.

Study selection

Studies retrieved from all search rounds were pooled to EndNote X9.2 and duplicates were removed by the same team members who

conducted the search (J.B. and H.A.O.). Titles and abstracts and then full texts were screened as per the eligibility criteria by two members of the team independently (J.B. and H.A.O.). In case of disagreement, the reviewers either discussed it or consulted two independent members of the team (A.E.A. and J.D.) to reach a consensus (see Figure 1 and for Table 1 the study selection process).

Data charting process and synthesis

Standardized data extracted each study included the author(s), setting, and study aims/objectives by two members (see Table 2). Based on the study aim, we extracted the PC intervention reported in each study (content, delivery, and outcomes; see Table 2). All extracted data were reviewed by the team to attain consensus if all required data had been retrieved from the primary studies and congruent with the focus of the study. Following team consensus, J.B. and H.A.O. independently undertook data synthesis with ongoing wider team consultation. To undertake the synthesis, the review aim was used as a heuristic guide to extract and formulate codes iteratively and inductively across the retained studies. In this regard, codes representing components, models of integration, or outcomes of PC interventions in the ED were extracted from the included studies. To ensure rigor, the formulated codes were reviewed by the team. Disagreements were discussed to attain consensus. The codes were rereviewed, and similar codes were aggregated to formulate categories based on the ACEP HPM framework where applicable.[27] These categories were then aligned to the study aim as domains (see Table 3). Using the codes as a guide, the authors re-reviewed each study iteratively and continuously refined the codes to reflect the content of the primary studies. The codes, categories, and domains facilitated the conduct of a narrative synthesis.

RESULTS

Study characteristics

Twenty-three studies were retained in the review.[28–50] Fifteen studies emerged from the United States[29–33,35,39–46,50]; two each from France[38,48] and Singapore[28,36]; and one each from Finland,[34] Ireland,[47] Canada,[37] and Taiwan.[49] The study designs employed by the included studies were retrospective (n = 11),[28,29,34,38–43,46,50] prospective cohort (n = 5),[31,33,36,37,48] randomized controlled trial (n = 2),[22,32] quasi-experimental (n = 2),[47,49] pilot (n = 1),[44] and cross-sectional (n = 1).[45] One study employed a program development approach with no outcomes assessed.[30] Six studies focused specifically on persons with advanced cancer.[22,29,32,34,36,45] Four studies also focused on persons with advanced illness[28,37,38,42] with three studies focusing on frail elderly participants.[31,43,44] The concepts formulated based on the review aim are: (1) components of PC in the ED, (2) models of delivery, and (3) outcomes.

Components of PC in the ED

The components of PC in the ED as reported were categorized as: (1) screening, (2) GoC discussion and communication, (3) managing

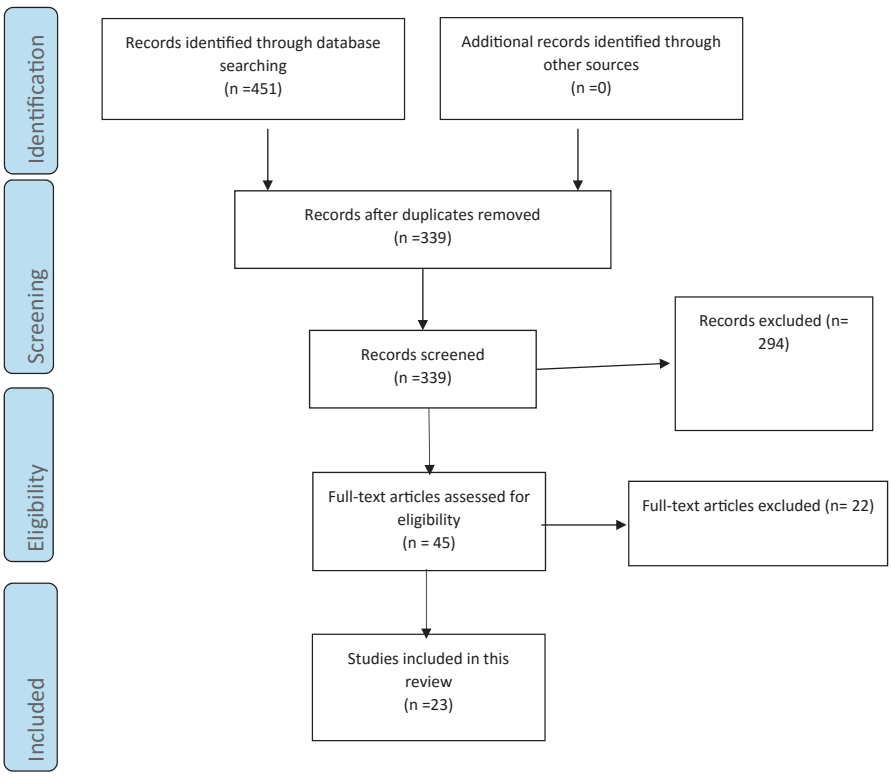


FIGURE 1 PRISMA flowchart of study selection

TABLE 1 Summary of included studies

Authors/year	Study setting	Study aims	Study design/participants
Chor et al., 2019[28]	Singapore	To describe the epidemiological characteristics, symptom burden, and management of patients using a protocolized management care bundle.	Retrospective study ($n = 205$)
Delgado-Guay et al., 2016[29]	United States	To compare symptom control and health utilization outcomes of advanced cancerpatients seen in the emergency center vs. patients seen as inpatients consults.	Retrospective study ($n = 400$)
Fausto et al., 2020[30]	United States	To implement a PC response for a multihospital health care system that incorporates conventional capacity, contingency capacity, and crises capacity in the ED, ICU, and medical and surgical acute care.	Program development
Glajchen et al., 2011[31]	United States	To implement a rapid two-stage screening protocol that was developed to improve referral for PC needs among frail elderly in the ED.	Prospective study ($n = 51$) Received PC consultation ($n = 20$) PC consultation not pursued ($n = 26$) Referred to hospice ($n = 5$)
Grudzen et al., 2016[32]	United States	To compare quality of life, depression, health care utilization, and survival in ED patients with advanced cancer randomized to ED-initiated PC consultation vs. care as usual.	RCT ($n = 136$)
Highet et al., 2016[33]	United States	To evaluate the feasibility of an ED–PC intervention to identify hospice-eligible patients to accelerate PC consultation and hospice enrollment.	Prospective pilot study ($n = 88$)
Hirvonen et al., 2018[34]	Finland	To explore the effect of the project and the PC clinic on the management practices of EoL cancer patients attending the ED of Turku University Hospital from 2013 to 2016.	Retrospective cohort study (2013, $n = 529$; 2016, $n = 432$)
Kistler et al., 2015[35]	United States	The objectives were to assess the process of early referral from the ED to PC for patients with advanced, incurable cancer as part of a RCT and to compare the proportion and timing of consultation to a care as usual group.	Single-blind RCT ($n = 134$)
Koh et al., 2019[36]	Singapore	To study the feasibility of a new three-way model of care between ED, hospital PC department, and inpatient/home hospice for persons with cancer.	Prospective, observational study ($n = 340$)
Kruhlak et al., 2021[37]	Canada	To identify and describe the ED management across presentations to the ED for EoL conditions.	Prospective cohort study ($n = 663$)
Lafond et al., 2016[38]	France	To improve the quality of both PC and the EoL conditions of patients at the terminal stage of a chronic disease sent to the ED.	Retrospective study ($n = 342$)
Lamba et al., 2012[39]	United States	To delineate the most requested ED–PC services and understand why ED clinicians currently request PCC.	Retrospective study
Lee et al., 2020[40]	United States	To examine the clinical characteristics and outcomes of patients who received ED-based COVID-19 PC.	Retrospective study ($n = 110$)
Leith et al., 2020[41]	United States	To descriptively analyze patients receiving EoL care in an ED-ICU.	Retrospective study ($n = 218$)
Liberman et al., 2018[42]	United States	To investigate the effectiveness of our AI management program in the ED on key outcomes.	Pre-post study with a retrospective chart review ($n = 82$)
Mogul et al., 2019[43]	United States	To ascertain if patients aged 65 years and above who present to the ED as a Level 1 ESI from an long-term care facility have prolonged hospitalizations with high resource utilization and significant mortality and therefore may be a population for whom early PC involvement should be considered.	Retrospective study ($n = 198$)
O'Mahony et al., 2008[44]	United States	To identify chronically ill older adults in need of PC, home care, and hospice services and to link such patients with these services.	Pilot study ($n = 291$)
Reuter et al., 2019[45]	United States	To assess the feasibility and reach of an EPI program.	Cross-sectional study of ED patients with active cancer ($n = 1278$)

TABLE 1 (Continued)

Authors/year	Study setting	Study aims	Study design/participants
Rosenberg and Rosenberg, 2013[46]	United States	To describe one hospital's approach in expanding the role of the ED staff into palliative and EoL care.	Retrospective review ($n = 131$)
Tiernan et al., 2019[47]	Ireland	To evaluate a new intervention intended to increase referral rates from the ED to the PMS in acute hospitals.	Quasi-experimental study over two 8-week periods Preintervention ($n = 57$) Postintervention ($n = 84$)
Van Tricht et al., 2012[48]	France	To assess the incidence of PC and to describe this population.	Cohort study ($n = 2420$) Of these, 1246 patients (51.5%) died in the observation unit of the ED, and the remaining 1174 (49.5%) died in examination rooms.
Weng et al., 2017[49]	Taiwan	To improve the quality of care of EoL ED patients and popularize this important issue.	Quasi-experimental study
Wu et al., 2013[50]	United States	To examine whether inpatient admissions after PC consultation initiated in the ED were associated with decreased LOS, compared with those in which consultations were initiated after hospital admission.	Retrospective study ($n = 1435$)

Abbreviations: AI, advanced illness; ED-ICU, emergency department–based ICU; EoL, end of life; EPI, ED-based palliative intervention; ESI, Emergency Severity Index; PC, palliative care; PCC, palliative care consult; PMS, palliative medicine service; RCT, randomized controlled trial.

pain and other distressing symptoms ED, (4) transitions across care settings, (5) end-of-life care, (6) family/caregiver support, and (7) ED staff education.

Screening

Screening for the presence of advanced illness or unmet PC needs emerged as a major component of PC in the ED. Several studies screened for the presence of advanced or terminal illness[28,30,31,36–38,42,49] or the presence of unresolved PC needs[32] as triggers to initiate PC in the ED. The screening tools/protocols are heterogenous across the included studies and context-specific (see Table 4). For instance in two studies, the screening process proceeded in two stages: first, identifying or diagnosing a life-limiting condition, and second, screening for PC needs.[31,37] In other studies, however, the screening focused on identifying the presence of advanced illness, multimorbidity or terminal stage of a chronic illness or actively dying patients to trigger the PC pathway in the ED.[28,30,38,42] In three studies, symptom assessment tools were used to screen for the presence of unmet needs and to make recommendations for symptom management among persons with cancer[32,35] and chronically ill elderly patients.[44]

Similarly, the studies that evaluated for the presence of PC needs also employed structured questionnaires. The abbreviated five-question version of the screen for palliative and EoL care needs in the ED (5-SPEED) was used by Reuter et al.[45] while Koh et al.,[36] developed a context-specific one based existing literature and agreed upon by the ED and PC staff. The screening tool of the latter study focused on persons with metastatic cancer with any one of the following conditions: 1) repeat ED visit within a month of hospital discharge, 2) difficulty in controlling symptoms, and 3) potential care difficulties. Grudzen et al.[32] assessed ongoing PC needs following discharge as the basis to refer a patient to the outpatient PC clinic. Yet in another study, the screening was in the form of flagging the patients to indicate there were previously known to the PC team which prompted an action to invite the PC team.[47]

GoC discussions and communication

GoC discussion and communication also emerged as components of PC in the ED in across various studies.[28,32,37,40–43] However, the studies did not report the duration of these GoC discussions although they centered on exploring the patients' goals and values and making care recommendations. ED staff, led primarily by a physician, conducted GoC discussions.[42] Grudzen et al.[32] reported the involvement of the PC team in identifying GoC and advance directives in the ED with ongoing support as GoC changed during admission. Although communication was evident across all the included studies, six studies reported on structures/content employed when communicating with patients and families in the ED.[28,32,39,42,46,51] This included communicating difficult news using standardized communication protocols delivered by the PC team either in the ED or following admission to another clinical unit[32]; communicating advance directives including "do not attempt resuscitation" orders and treatment plans[30,34,40,46,49]; GoC communication, conveying prognosis in a clear and simple way[37,42]; and other end-of-life issues.[30,34,37,39,49]

Managing pain and other distressing symptoms

PC in the ED also involved managing pain and other distressing symptoms. This included physical care measures to alleviate pain and

TABLE 2 ED–PC intervention content, delivery, and outcomes

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Chor et al., 2019[28] Singapore	The EoL pathway was developed by the ED–PC workgroup in collaboration with the hospital's inpatient PC team, which consists of palliative medicine specialists, nurses, and medical social workers. The pathway comprises a care bundle with clearly stated clinical management guidelines for ED doctors and nurses, a private room (designated as quiet room) for the patients and their family, and initiatives for EoL care education for ED staff to facilitate the delivery of EoL care at the ED. Members of the PC workgroup also provided on-call advice during the initial implementation of the EoL pathway. Criteria for initiating the ED EoL pathway (the following five criteria had to be met before transfer to the quiet room): 1. Actively dying patient/high likelihood of mortality within hours to a few days. 2. Family accepts that the GoC are provision of comfort, symptom relief, and dignity. 3. Limitations on extent of care established and patient is not for CPR/intubation/ICU transfer. 4. Family members want to stay by patient's bedside. 5. Serious life-limiting illness with poor prognosis: • Chronic severe illness (terminal cancer, end-stage renal failure (refused/withdrawing dialysis), Stage 4 COPD (not for intubation/noninvasive ventilation), end-stage cardiac disease, end-stage liver disease, advanced neurological disease—dementia/Parkinson's disease/cerebrovascular accident, chronic frailty with poor functional state. • Acute catastrophic illness (e.g., massive subarachnoid hemorrhage) patient/family communication guidelines: Explain that the quiet room is to provide privacy and for family to spend time with their loved one (limited to five visitors, until inpatient bed is available). • Reassure that doctors and nurses will review regularly, continue to provide care and administer medications in case of any pain, dyspnea etc. (*not* "abandonment"). • Prepare the family for possible demise of patient and the process of deterioration (exact timing difficult to predict, few hours to few days, not for CPR if heart stops naturally). Provide the family with the "last journey" resource booklet (booklet guide on what to do after a patient's demise) if deemed suitable. Management of terminal symptoms (pain, dyspnea, nausea/vomiting, terminal agitation, and terminal rattling).	The three most commonly experienced symptoms were drowsiness (66.3%), dyspnea (61.5%), and fever (29.7%). Through the protocolized management care bundle, 74.1% of patients with dyspnea and/or pain received opiates while 59.5% with copious secretions received hyoscine butylbromide for symptomatic relief. The institution of a protocolized care bundle is feasible and provides ED physicians with a guide in managing EoL patients. Though still suboptimal, considerable advances in EoL care at the ED have been achieved and may be further improved through continual education and enhancements in the care bundle.
Delgado-Guay et al., 2016[29] United States	A PC consultation service was provided. This service consists of a PC specialist, PC and oncology fellows, advanced practice nurses, a social worker, a case manager, a child life specialist, a chaplain, and a psychological counselor. These providers consult with patients in all areas of the institution about symptom control and PC issues via a mobile team an outpatient PC clinic and an inpatient PC unit where patients with distressing symptoms can be admitted controlling their physical and psychosocial symptoms and to prepare them for the transition to home and/or hospice care.	Symptoms at presentation for PC consultation included uncontrolled pain, nausea/vomiting/constipation, and dyspnea. The medians (interquartile ranges) of baseline symptom intensities for emergency center patients and inpatients, respectively, were as follows: pain, 7 (5–9) and 5 (2–8) ($p < 0.0001$); fatigue, 7 (4–8) and 6 (4–8) ($p = 0.0517$); and sleep, 6 (0–8) and 4 (1–7) ($p = 0.1064$). At follow-up, improvement was observed in pain (125/238 [53%]), sleep (59/131 [45%]), well-being (32/82 [39%]), fatigue (53/139 [38%]), anxiety (51/132 [39%]), appetite (46/132 [35%]), dyspnea (49/160 [31%]), nausea (52/170 [31%]), depression (36/123 [29%]), and drowsiness (37/126 [29%]). After PC consultations, discharge/admission destinations for emergency center patients were as follows: home, 65 (33%); home hospice, 13 (7%); inpatient hospice, 8 (4%); regular hospital floor, 65 (33%); and PC unit, 46 (23%). The median duration of hospitalization was 92 (range, 69–114) h for hospitalized emergency center patients and 125 (range, 108–142) h for inpatients ($p < 0.0001$).

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Fausto et al., 2020[30] United States	ED can access onsite specialty PC 7 days/week from 9 a.m. to 6 p.m. by consult request. In addition, PC telephonic coaching and support is available 24 h a day, 7 days/week. PC interventions in the ED: • Consults for patients with poor prognosis and at risk of intubation or resuscitation prioritized. • Patients admitted to the hospital followed daily through check-in with primary team. • Support for implementing DNAR orders using informed assent or based on medical futility when appropriate. • Chart review results and brief or full consults documented. Embed a PC specialist in ED to assist and address high volumes of patients and screen patients based on following criteria • COVID-19 +/− patient under investigation with respiratory distress. • Multimorbidity, severity of illness, and high oxygen requirement. • Clinical status: symptom burden, frailty (using Clinical Frailty • Scale), and baseline functional status. • Code status: DNAR/DNI, DNAR intubation okay, and full code with high intubation risk. Based on screening, the following will happen: 1. Meet or call with family/legal surrogate to address GoC and code status. 2. Coach ED team on GoC and code status discussion. 3. Assist with documentation of discussions and transitions of care. After hours, PC on-call provider can assist with telephone support and coaching.	No outcomes reported.
Glajchen et al., 2011[31] United States	The BriefPal Project composed of two stages implemented over an 8-month period. In Stage 1, elderly patients with specific life-limiting conditions were identified by the project social worker, who was stationed full time in the ED. In Stage 2, subgroups with recent losses in ADLs, high symptom distress, poor functional status, and high levels of caregiver burden were identified. The social worker administered the tools face to face during regular weekday daytime hours and identified appropriate patients to the ED resident or attending. Referrals for PC or hospice were made by the ED physicians from the subgroup of patients identified in Stage 2. PC training was concurrently provided to 79 physicians, physician assistants, nurses, and social workers, and local ED champions were identified.	Over 8 months, 1587 patients were screened, representing 22% of ED visits made by patients older than 65 years during this time. Of these, 140 met functional decline criteria, and 51 of these needed PC consultations. Five patients were referred to hospice, 20 received PC, and 26 received no further service. Follow-up telephone calls were made to 112 patients who were referred, and their medical records were reviewed. Based on this follow-up, those patients who had received PC services reported symptom reduction in pain, shortness of breath, nausea, and anxiety. Forty-one patients (80%) from the referral group died during the intervention period, mostly in the hospital ($n = 25$), but also on hospice ($n = 8$), on hospice home care ($n = 5$), and in a nursing home ($n = 3$).

(Continues)

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Grudzen et al., 2016 United States	If the participant was assigned to the intervention arm, the PC team was consulted within a few hours. Intervention participants received a comprehensive PC consultation by the inpatient team on the same or following day. Inpatient comprehensive PC consultation consists of three components: (1) symptom assessment and treatment, (2) GoC and advance care plans, and (3) transition planning. The team used validated symptom assessments to make recommendations for symptom management using NCCN guidelines. They communicate these recommendations to consulting physicians (in this case, the oncologist or hospitalist) verbally, either in person or by telephone, and electronically through standardized PC team medical chart notes. The PC team meets with patients, families, and care teams to identify GoC, complete advance directives, and communicate difficult news (if requested) using standardized communication protocols. If admitted, the team sees patients daily to monitor implementation and results of treatment recommendations and to assess for new and ongoing symptoms. Reassessment and treatment modifications occur as needed to achieve GoC. The PC team conducts or assists with discussions about new or changing GoC, communicates bad news, and adjusts treatments accordingly. The team also works with the patients' social workers and family to facilitate transition management consistent with GoC. If the team finds ongoing PC needs that are expected to continue after discharge, they refer patients to the outpatient PC clinic. Participants assigned to the usual care arm completed the same baseline interviews and follow-up as intervention participants. If requested by the admitting team or oncologist of record, usual care participants may also have received a PC consultation.	The primary outcome was quality of life as measured by the change in Functional Assessment of Cancer Therapy–General Measure (FACT-G) score at 12 weeks. Secondary outcomes included major depressive disorder as measured by the Patient Health Questionnaire-9 (PHQ-9), health care utilization at 180 days, and survival at 1 year. Quality of life, as measured by a change in FACT-G score from enrollment to 12 weeks, was significantly higher in patients randomized to the intervention group, who demonstrated a mean (±SD) increases of 5.91 (±16.65) points compared with 1.08 (±16.00) in controls ($p = 0.03$ using the nonparametric Wilcoxon test). Median estimates of survival were longer in the intervention group than the control group: 289 (95% CI 128–453) days vs. 132 (95% CI 80–302) days, although this did not reach statistical significance ($p = 0.20$). There were no statistically significant differences in depression, admission to the ICU, and discharge to hospice.
Highet et al., 2016[33] United States	The study team members involved in this project included an ED resident physician, a PC attending physician, and a NP. The ED residents and faculty were given a 1-h lecture on hospice care, disease trajectory, and prognostication at the EoL, with content derived from the Medicare-suggested hospice guidelines. The study team ED resident gave this lecture. Medicare guidelines were made available to ED providers, and the "Hospice in a Minute" smartphone app was publicized as a resource. Subsequently, ED providers were asked to consult the PC team by pager if they estimated the patient had a 6-month prognosis or if they "would not be surprised" if the patient died in the next 6 months. At our institution, a formal physician-to-physician consult is required for any specialty service such as PC to see a patient; this effectively moved the PC consultation to the time of ED recognition. Informed consent for inclusion was not obtained, as PC consultation and hospice referral are accepted as standard of care. If available during usual business hours, a PC team member would respond to the consult and discuss whether this patient would be more appropriate for a consultation in the ED or on the inpatient floor. If patients were well enough to be immediately discharged, they were referred at the point of care to a local hospice agency. If ED providers anticipated discharge within 24 h with hospice support, patients were placed in an ED-run observation unit and had PC consultation in the ED, with social work involvement to establish hospice resources. If patients required admission, a study team member acquired permission from the inpatient admitting team for PC consultation on the floor, and the PC team consulted as soon as they were able. To provide feedback, every time an inpatient was discharged with hospice resources by the PC team, an email was sent to ED providers by the study team updating them of the patient's outcome and reinforcing continued use of the PC consultation pager.	In a 6-month period, emergency physicians identified 88 hospice-eligible patients with 91% accuracy. Of the patients identified, 59% died within 3 months of their visit to the ED. Mean (±SD) time to PC consultation was 2.3 (±2.3) days, and 57% of those seen by PC were discharged to hospice vs. 30% of those not consulted ($p = 0.038$). The potential median hospice LOS was 31.5 days, better than for the institution as a whole.

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Hirvonen et al., 2018[34] Finland	It consists of a plan and description of how EoL care should be organized in the hospital district. The guideline for the project states that good care should be organized close to the patients' home with the support of a home care team and a responsible physician; these recommendations follow the ASCO palliative are guidelines. Proactive ACP should be offered to every patient including proper symptom management, the possibility of admission to a primary care ward in the community without a visit to the hospital ED at any time of the day, and the restrictions placed on the care provided (e.g., a DNAR order) accompanied by the patients' own wishes (e.g., living will with a surrogate). As part of the development project, regular regional education and an EoL network for both hospital- and community-based primary care physicians and nurses were established.	In 2016, the number of late palliative and EoL patients admitted to the ED has shown a tendency to decrease. The quality of the documentation for treatment goals, DNAR orders, living wills, and connections to primary care providers has improved since 2013. Prior visits to palliative outpatient clinic correlated well with the more comprehensive ACP information: (i) DNAR order ($p = 0.0001$); (ii) connection to primary care ($p = 0.003$); and (iii) documented ICD-10 code Z51.5 ($p = 0.0001$).
Kistler et al., 2015[35] United States	*Intervention arm* If the patient was assigned to the intervention arm, the PC team was consulted within a few hours. The PC team used validated symptom assessments and made recommendations for symptom management using the NCCN guideline. *Usual care* If requested by the admitting team or oncologist of record, any usual care patient could also receive a PC consultation.	For patients in the intervention group, 88% (60 of 68) had documented PC consultations during their index admissions (95% CI 80.5–95.5), compared to 18% (12 of 66) in the control group (95% CI 8.8–27.5; $p < 0.01$). The 60 intervention patients received PC consultations on average 1.48 days from admission (95% CI 1.19–1.76), compared to 2.9 days from admission in the 12 control patients (95% CI 1.03–4.79; $p = 0.15$).
Koh et al., 2019[36] Singapore	The program comprised a screening checklist that was modified from available literature and agreed upon by both the heads of emergency and palliative medicine departments. The ED physicians would call the PC team directly during office hours from Mondays to Fridays (0800–1700 h). The PC team will review patients in the ED and direct care based on patient evaluation, together with the ED team. Patients who could be discharged would be supported by home hospice or outpatient care. Patients who required inpatient care could be admitted directly to an inpatient PC unit or directly to the inpatient hospice. Patients who were in the actively dying phase (last 48 h of life) were moved to a special comfort care room (single room) in the hospital where families could have the privacy to spend their last moments with the patient. Outside office hours or on weekends, patients who would benefit from PC consults but could be discharged because their symptoms were mild and could be managed at home were reviewed in a PC "Hot Clinic" usually within a week. The PC on-call team were also available for consultation for patients with more complex needs who needed admission, with subsequent reviews by the inpatient PC team. These consultations could be through the phone, but if patients were evaluated to be in need of emergent physical consults, it was not unusual for the on-call PC physician to review after office hours in the ED.	This tripartite model of PC, hospice, and ED collaboration allows earlier access to PC in the ED and direct admissions to the PC unit and comfort care rooms. The ED patients who did not need admission were also attended to in the PC "Hot Clinics" within a week with home hospice help. Patients who required inpatient hospice care were directly admitted there from the ED.

(Continues)

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Kruhlak et al., 2021[37] Canada	Modifications to a preexisting screening tool were completed by a panel of physicians with specialties in emergency medicine, intensive care, nephrology, and internal medicine as well as PC specialists, methodologists, and a clinical epidemiologist. In addition, to gain a better understanding of presentations to the ED for progressive neurological diseases, the screening tool was modified so that physicians could identify patients with advanced dementia separately from patients with other advanced PCNS conditions (e.g., multiple sclerosis, Parkinson's disease, amyotrophic lateral sclerosis). The screening tool was also modified to include additional clinical criteria for several of the eligible EoL conditions to assist physicians. Additional questions were added to the screening tool to explore barriers to providing care, whether the patient presented with GoC documentation, and the opinions of treating physicians on the appropriateness of each patient's current GoC based on their presenting condition. For each presentation with an EoL condition with at least one of the eligible end-stage conditions listed on Step 1 of the screening tool (e.g., cancer, COPD, chronic kidney failure, heart failure, cirrhosis, dementia, and other PCNS conditions), emergency physicians completed Step 2 of the modified screening tool, in which they identified risk factors for unmet palliative needs for each ED presentation. Risk factors for unmet palliative needs included frequent ED visits or hospitalizations in the past 6 months, uncontrolled symptoms, functional decline, uncertainty/distress about GoC and/or caregiver distress, and a response to the surprise question (the physician would not be surprised if the patient died within 12 months). Patients were considered to have unmet palliative needs if they presented with one or more clinical condition, along with two or more risk factors for unmet palliative needs. Physicians completed the screening tool for all presentations they identified with EoL needs regardless of whether or not the patient had previously presented to the ED during the study period.	Physicians identified 663 ED presentations for EoL conditions, with advanced cancer (41%), dementia (23%), and COPD (16%) being the most common EoL conditions. The majority of presentations involved consultations (77%), hospitalization (65%), and numerous investigations (97%), including blood work (97%) and imaging (92%). The majority of patients with EoL conditions had a history of ED visits (68%). Using a modified screening tool, 78% of presentations involved patients with unmet PC needs, but only 1% of presentations involved a palliative consultation or admission to a PC unit.
Lafond et al., 2016[38] France	During the time spent in the ED before admission to the ICU, analgesic medications were prescribed in 100% of patients and initiated in 41.5%; anxiolytic medications were prescribed in 84.7%.	Concerning the outcome, 64.8% (114 of 176) of patients admitted to the ICU for PC died, 14.2%(25 of 176) were subsequently transferred to the PC unit, and 11.4% (20 of 176) were transferred to the medical departments previously in charge of their chronic disease. Seventeen (9.6%) patients were finally discharged back home or to their previous nursing/hospice facility. Since its creation in 2009, the family room was occupied with a rate of 50%. Among them, 176 (51.5%) were admitted to our hospice and PC bed, where 114 died. Besides, 99 (28.9%) of them died on stretchers in the ED. Our intervention led to a significant decrease in the number of terminally ill patients dying on stretchers in the ED. It also allowed both patients and families to have access to a more suitable environment.
Lamba et al., 2012[39] United States	ED-initiated PCC.	In-hospital mortality rate for ED-initiated PCC patients is very high (most die early and in the ED setting), signifying a trend for ED clinicians to request PC consults in those who are imminently dying. PC consult teams called to the ED should expect to provide high-priority, time-sensitive services and anticipate a high level of bereavement/emotional support for distraught and unprepared families, with major discussions around EoL care.

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Lee et al., 2020[40] United States	ED clinicians consulted the PC team for assistance with any PC-related needs, including GoC clarification and cases where stated GoC did not align with expected prognosis. The PC team (one attending physician who was board-certified in HPM, one HPM fellow clinician, and four psychiatry resident physicians and fellow clinicians, all trained in GoC conversations and supervised by the PC attending physician) was available in person 12 h per day and for phone consultation overnight and on weekends. The PC intervention focused on GoC conversations: conveying the prognosis in a clear and simple way, exploring patients' goals and values, and making care recommendations based on elicited goals. GoC were defined as "full code" (pursue all LSTs including intubation and CPR); "DNAR only" (pursue all LSTs excluding CPR); "DNAR/DNI, continue medical treatment" (pursue all LSTs excluding intubation and CPR); and "comfort-directed care" (forgo LSTs, deliver symptom-focused treatment only). The GoC were presumed to be full code if no advance directives or medical orders for LST were found on presentation to the ED.	After initial PC intervention, the number of full code decreased from 91 patients (82.7%) to 20 patients (18.2%). Among these 71 patients (64.5%) in whom CPR was declined, mechanical ventilation was also declined in 61 patients (55.5%; i.e., 32 patients in DNAR/DNI, continue medical treatment, 29 patients in comfort directed care). On discharge, the number of full codes further decreased to nine patients (8.6%), whereas comfort-directed care increased to 54 patients (51.9%). The median(range) LOS was 4 (0–28) days and 71 patients (68.2%) died in the hospital. Among 33 patients (31.7%) who were discharged alive, six patients (5.8%) were discharged with hospice care.
Leith et al., 2020[41] United States	An ED-ICU provides an environment in which critical care interventions can be performed while GoC are further investigated. The interventions included symptomatic treatments for pain, dyspnea, congestion, secretion management, nausea, hiccups, pruritus, and cough along with non–symptom-focused aspects to relieve suffering. The order set also provided optional consults to palliative medicine, social work, and/or spiritual care; assessments of patient and family distress or discomfort; and discontinuation of vital signs, laboratory draws, noise disturbances, and interventions not conducive to patient comfort.	The median ED-ICU LOS was 13.3 h (interquartile range 7.4–20.6). Two patients (0.9%) were admitted to an inpatient ICU, 117 (53.7%) died in the ED-ICU, 77 (35.3%) were admitted to a non–intensive care inpatient service, and 22 (10.1%) were discharged from the ED-ICU. An ED-ICU can be used for ED patients near the EoL. Only 0.9% were subsequently admitted to an ICU, and 10.1% were discharged from the ED-ICU. This practice may benefit patients and families by avoiding costly ICU admissions and benefit health systems by reducing ICU capacity strain.
Liberman et al., 2018[42] United States	The goals of the program were to screen ED patients for AI, provide ED health care providers with training to have GoC discussions, conduct ED-led GoC promptly, and develop a safe discharge to hospice for appropriate patients. An interdisciplinary team consisting of nurses, emergency and physicians, social workers, case management, quality, and administration was formed and met biweekly during the study period. The team utilized the ED (EMR) readmission trigger tool, which is a simple procedure created to facilitate hospice directly from the ED. ED staff, led primarily by a physician, conducted GoC discussions that lasted, on average, 10 min. The interdisciplinary team documented the GoC discussions in the EMR. Case management/social work was available 12 h per day, and PC faculty was available to the ED providers for support. We displayed posters prominently throughout the ED for contact information.	Patients in the intervention, compared with baseline, were significantly more likely to be identified as having AI in the ED (90.2% vs. 0.0%; $p < 0.0001$), to receive an ED-led GoC conversation (83.6% vs. 0.0%; $p < 0.0001$), and to be discharged to home hospice (39.3% vs. 0.0%; $p < 0.0001$).

(Continues)

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Mogul et al., 2019[43] United States	Formal PC involvement was defined as services performed either by an official consult team or by supportive care nurses. These supportive care nurses were embedded in the ICU and saw patients per request from the primary team as well as any patients who were deemed to have a high likelihood of unmet PC needs; in addition, a formal PC consult could occur at the request of the primary team. If the primary team documented a code status discussion or change in code status without official consult, they were considered to have performed a basic palliative intervention, referred to herein as primary team palliative discussion.	80 persons received formal PC involvement, 67 received primary PC discussion, and 51 received no PC. Most patients arrived with full code status (58.6%), despite having a median age of 81 (interquartile range 14) years. Patients arriving with full code status ($n = 116$) were younger than those with advanced directives dictating care limitations. Regarding ED disposition, 13 patients died in the ED, 11 were discharged back to their nursing facility, and 11 patients were transferred to an outside hospice care facility. Of the 198 patients, 163 patients were admitted to the hospital, 44 to a floor bed (27.0% of admissions) with 119 (73.0%) admitted to an ICU. Regarding change in code status, about half (48.5%) of the patients experienced a downgrade in code status to a less-aggressive advanced directive status. Two patients were upgraded to full code status from limited DNAR status. Few formal PC interventions occurred in the ED (9.1%). Elderly patients from long-term care facilities presenting with severe acute illness have high mortality and seldom receive early PC.
O'Mahony et al., 2008[44] United States	A PC trigger tool was used by the NP to determine whether the patient was eligible for the study. The triggers are as follows: (1) "Does this patient have a progressive incurable illness that is in its later stages?" (2) "Do you know if the patient is expected to die on this hospital admission?" (3) "Would you be surprised if this patient were to die in the next year?" This was followed by a series of questions to screen for medical necessity for a PC evaluation including physical symptoms, psychosocial issues, and the need for ACP and PC. If the NP indicated a positive response to any of the triggers, the patient was considered eligible for the study, and a needs assessment questionnaire was completed by the NP with the patient or caregiver. After completion of the needs assessment form, a consultation would be conducted. The NPs provide educational in-services to the ED's staff every 3 to 4 months. In-services focus on indications for referral to PC, hospice eligibility guidelines, and how to access services. The NP confirmed that linkage with home care and hospice had occurred with follow-up of patients who were admitted to the medical center and phone calls to patients and their families once discharged.	For patients who completed the MVQoL scale ($n = 20$) post–discharge from the ED, a clear majority, 69%, expressed satisfaction with control of their physical symptoms and ability to communicate with people close to them (64%). However, similar proportions of patients described a "loss of ability to do many of the things that I like" (60%) and a general sense of loss of life's value (57%). The NPs referred 263 patients (from the 894 consultations) to home care organizations and 287 patients to hospice organizations, of whom 83 received home care and 91 received hospice services. Ninety percent of patients were admitted to the medical center. Of patients admitted to acute care, 41.9% were subsequently discharged to skilled nursing facilities, 24.2% were discharged to home with home care, and 19.1% were discharged without home care. The project did not impact on rates of subsequent use of the ED. Twenty-four percent of patients returned within 1 month and 59% within 6 months of their initial contact with the NPs. There were small reductions in the length of hospital stay compared with the baseline preproject chart review from 7.9 to 7 days. Linkage with hospital-based PC services was enhanced. The median time from admission to Montefiore Medical Center for a consultation by the PC service decreased to 3 days, and the median time from consultation to discharge decreased to 4 days. The number of admissions to the PC unit from the ED increased to between 10 and 15 patients per month during the project. Almost one-third (30.9%) died within a median of 50 days, and 67.8%, within 180 days. Most occurred beyond the medical center (7.7% died in Montefiore Medical Center and 23.3% outside Montefiore Medical Center, $p < 0.001$). Patients who were enrolled on hospice were more likely to die in their own home (skilled nursing facility or community) than in the hospital (Fisher's exact test = 0.023).

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Reuter et al., 2019[45] United States	Patients with PC needs utilizing the ED were identified using an abbreviated five-question version of the screen for palliative and EoL care needs in the ED (5-SPEED). Patients with PC needs were then automatically flagged for an EPI as determined by their identified need.	The primary outcome was the prevalence of PC needs among patients with active cancer. Secondary outcomes were the rate of EPI services successfully delivered to ED patients with unmet PC needs, ED LOS, and repeat ED visits within the next 10 days. Of the 1278 patients with active cancer, 817 (63.9%) completed the 5-SPEED screen. Of the patients who completed the screen, 422 patients (51.7%) had one or more unmet PC needs and 167 (39.6%) received an EPI. There were no differences in ED LOS or 10-day repeat ED visit rates between patients who did or did not receive an EPI.
Rosenberg and Rosenberg, 2013[46] United States	The Life Sustaining Management and Alternatives (LSMA) program includes a core team of one emergency physician and one master's-prepared nurse coordinator for the initial consult. Additional member involvement from the interdisciplinary team is determined by the plan of care. Other key members include nurses, nutritionists, chaplains, psychologists, social workers, physical therapists, occupational therapists, and other disciplines as required meeting the needs of each patient and family. Initial consultations range from a general introduction to in-depth communications regarding advanced directives and treatment plans. Consultation's average 15 to 30 min or longer depending on the patient/family circumstances. During the week, Monday through Friday from 7 a.m. to 6 p.m., consultations are within 30 min. Telephone consultation is available 24/7; the patient is seen the following morning if further follow-up is needed. Of utmost importance is the determination of the patient goals as early as possible, including discussions of DNAR status as appropriate to the individual patient.	An integrated model of PC in the ED of an inner-city academic teaching center utilized existing hospital resources to reduce hospital LOS and reduce overall cost. Benefits related to resuscitation rates, intensity of care, and patient satisfaction are attributed to the ED-based palliative team's ability to provide real-time consults and utilize InterQual criteria to admit to a less costly level of care or transfer directly to home or hospice.
Tiernan et al., 2019[47] Ireland	The PAL.M.ED intervention, whose objective was to increase referral rates to the PMS from the ED, had four components: 1. *"Flagging" system*. Patients referred to the PMS during an admission to SVUH in the 3 years prior to the study period, and then discharged from hospital, had their records in the ED database "flagged" so that should they present to the ED at a later date, an alert would appear indicating that they were previously known to PC. A prompt encouraged the ED physician then to contact a member of the PMS to discuss the appropriateness of a consultation. 2. *Checklist*. A checklist P.A.U.S.E. was developed to identify patients not previously known to the PMS in SVUH, but potentially appropriate for a referral to the service. All ED staff were asked to refer to the checklist when admitting a patient. This tool, based on a synthesis of the key items from other tools, as well as the expert opinion of the project group members, was designed to be brief and easy to administer. 3. *Proactive PMS engagement*. Each morning, a member of the PMS liaised with the ED team to screen for patients registered at the ED in the previous 24 h who might be appropriate for referral to PC. As well as the daily morning visit to the ED, the PMS were available to evaluate patients in the ED weekdays (7.30 a.m. to 5 p.m.) and weekends (9 a.m. to 4 p.m.) and provided telephone consultation outside of those hours. 4. *Education*. Training on PC and the PAL.M.ED project, with particular focus on the introduction of the flagging system and the P.A.U.S.E., was designed and delivered by the PMS to ED doctors and nurses through a series of interactive multidisciplinary 1-h workshops. Topics covered included symptom management, communication and ethical challenges in EoL decision making.	In the preintervention phase, six patients out of 57 (11%) received their first PMS consultation in the ED; in the postintervention phase, this was 43 patients out of 84 (51%). Patients admitted to SVUH through the ED who subsequently received a PC consultation during their hospitalization were 10.5 (95% CI 4–29) times more likely to receive the first consult in the ED after the intervention than beforehand. PMS consult initiated in the ED (vs. later in the hospital stay) is significantly associated with reduced LOS ($p < 0.005$; −10.9 days [95% CI −17.7 to −4.1]), fewer hematology tests ($p < 0.005$; −9.8 [95% CI −15.6 to −4.0]), fewer biochemical tests ($p < 0.005$; −30.0 [95% CI −50.5 to −9.6]), fewer microbiology tests ($p < 0.005$; −3.2 [95% CI −5.0 to −1.4]), and fewer CT scans ($p < 0.03$; −0.4 [95% CI −0.7 to 0]). There is no statistically significant association with number of MRI scans or ultrasounds.

(Continues)

TABLE 2 (Continued)

Authors/year/setting	Description of PC intervention in the ED	Outcomes
Van Tricht et al., 2012[48] France	PC therapies were administered to 1373 patients (56.7%) and consisted of administration of analgesics in 709 (59%), sedation in 442 (37%), mouth care in 449 (37%), repositioning for comfort (as appropriate) in 428 (35%), and provision of emotional support to the patient in 319 (27%) and to his/her relatives in 635 (54%). A proposition to call a religious leader was done for 92 patients (7%). In the population receiving PC, about half of them received few palliative therapies. For 146 patients, no action was recorded, although the physicians had indicated on the form that PC was administered.	The median interval between ED admission and death was longer in patients who received PC (median, 15 h; first quartile, 6 h; third quartile, 34 h) than in those who did not (median, 4 h; first quartile, 1 h; third quartile, 10 h).
Weng et al., 2017[49] Taiwan	Educational programs for hospice and PC in the ED, interdisciplinary meeting with the hospice team every month, sharing information and experience via cell phone communication app, and setting an emergency hospice room for EoL patients in the ED. All ED patients who fulfilled the criteria of signed a DNAR and life expectancy <24 to 48 h were eligible for hospice and PC.	Compared with four in the preintervention period, the cases of DNAR per month increased significantly to 30.1 in the early stage of intervention, 23.9 in late stage of intervention, and 34.6 in the postintervention period (all $p < 0.001$ compared with the preintervention period). Compared with 10.8% in the preintervention period, the ratio of DNAR orders signed in the ED/total DNAR orders signed in the study hospital was increased to 17.1% in early stage of intervention, 12.5% in late stage of intervention, and 22.8% in postintervention. Compared with zero in preintervention and early intervention, the cases of consultation with the hospice team increased significantly to 19 cases per month in the late stage of intervention and postintervention. The ability of nurses in hospice and PC, including knowledge and the timing and method of consultation with the hospice team, was also significantly improved.
Wu et al., 2013[50] United States	Education and training on PC and the consultation service were provided to ED physicians and nurses. The PC service evaluated patients in the ED during weekdays and provided telephone consultation nights and weekends with postadmission follow-up. We compared the outcomes of these patients with those whose PC needs were identified and addressed through consultation postadmission.	Included in the analysis were 1435 PC consultations, 50 of which were initiated in the ED across the 4-year study period. Propensity scores were calculated using patient-level characteristics, including All Patient Refined Diagnostic Related Group (APR DRG) risk of mortality and severity of illness, age, gender, readmission status, facility, and insurance type. Regression results showed that consultation in the ED was associated with a significantly shorter LOS by 3.6 days ($p < 0.01$).

Abbreviations: ACP, advance care planning; ADL, activities of daily living; AI, advanced illness; COPD, chronic obstructive pulmonary disease; DNAR, do not attempt resuscitation; DNI, do not intubate; ED-ICU, emergency department–based ICU; EMR, electronic medical record; EoL, end of life; EPI, ED-based palliative intervention; GoC, goals of care; LOS, length of stay; LST, life-sustaining treatment; NCCN, National Comprehensive Cancer Network; NP, nurse practitioner; PCC, palliative care consult; PCNS, peripheral and central nervous system; PMS, palliative medicine service; SVUH, St. Vincent's University Hospital.

TABLE 3 Data collation and synthesis

Codes/references	Categories	Domain
Screening for the presence of advanced illness, terminal phase of a chronic illness, or multimorbidity[28,30,31,36–38,42,49]	Screening for PC needs	Components of PC in the ED
Screening for unmet PC needs in the ED[32,45,47]	Screening for PC needs	
GoC discussions and advanced care planning in the ED[28,32,37,40–43]	GoC discussions and communication	
Communicating bad news, including prognosis in the ED[28,32,39,42,46,51]	Communication	
Pain management among PC patients in the ED[32,38,44,48,52]	Pain control	
Managing other distressing symptoms in the ED among PC patients[32,38,44,48,52]	Managing other distressing symptoms	
Providing spiritual support to patients[38,41,44]	Managing other distressing symptoms	
Providing transitional support across various settings including hospice, home, skilled nursing facility, and ICU[29,31–33,36,38,42,44,46]	Transitions across settings	
Pain management in the imminently dying patient[33,36,38,39,46,48]	EoL management	
Prognostication[33]	EoL management	
Communicating with family at the EoL[28,30,31,44,48]	GoC discussions and communication at the EoL	
Providing privacy for patient and family at the EoL[28,36]	EoL management	
Psychosocial support for the patient and family at the EoL[31,41]	Family/caregiver support	
Providing information to patient and family members[34,42]	Family/caregiver support	
Practical support for caregivers to ease caregiver burden[34,42]	Family/caregiver support	
Emotional support[39]	Family/caregiver support	
Training ED staff in patient and caregiver screening[31,49]	ED staff education	
Training local ED champions[31]	ED staff education	
Training ED staff to undertake PC consultation[44,50]	ED staff education	
ED staff training on prognostication at the EoL, GoC discussions, and communication[42]	ED staff education	
ED training on delivering EoL care[33]	ED staff education	
Screening patients and undertaking referrals to PC teams[31,33,40,42,44,45,47]	Traditional PC consultations in the ED	Models of PC in the ED
Formal collaboration between ED and PC teams[38,41,46,50,51]	Integrated ED–PC model	
PC delivered either by primary care team, supportive care nurses, or PC teams[43]	Mixed model	
Patient satisfaction with care	Satisfaction	Outcomes
Improved control of symptoms including pain, shortness of breath, secretions, nausea, and vomiting[28,31,44,46]	Symptom control	
Improvement in sleep, general, and psychological well-being[29,32]	Symptom control	
PC in the ED can facilitate GoC discussions[42]	GoC discussions	
No differences in ED LOS between patients who did or did not receive PC in the ED[45]	LOS	
Shorter ED/hospital stay[44,46,50]	LOS	
Cost savings[46]	Cost	
Linkage to other services such as hospice and outpatient services[31–33,38,42,44,46]	Health care service utilization	
Fewer scans and laboratory investigations[40,47]	Decreased frequency of clinical investigations	
Discontinuation of laboratory investigations at the EoL[28,36,41]		
Family satisfaction with care[44]	Family-related outcome	
Receiving support[38]	Family-related outcome	

Abbreviations: EoL, end of life; GoC, goals of care; ICU, intensive care unit; LOS, length of stay; PC, palliative care.

TABLE 4 Summary of PC screening/trigger tools used in the ED

Authors	Nature of screening tool	Screening criteria
Glajchen et al., 2011[31]	Two-staged screening tool performed by the social worker stationed in the ED	Stage 1 involved screening for elderly persons with life-limiting condition in the ED. Stage 2 involved screening for symptom distress, poor functional status, losses in ADLs, and caregiver burden. Persons aged ≥65 years with life-limiting illnesses including advanced dementia, severe congestive heart failure, COPD, advanced malignancy, and AIDS, with at least moderate functional status limitations.
Grudzen et al., 2016[32]	Validated symptom assessment tools used for screening based on the NCCN guideline	Persons with advanced cancer.
Kistler et al., 2015[35]	Validated symptom assessment tools used for screening based on the NCCN guideline	Persons with advanced, incurable cancer.
Koh et al., 2019[36]	Screening checklist developed based on literature and expert review	Persons with metastatic cancer with any one of the following conditions: repeat ED visit within a month of hospital discharge, difficulty in controlling symptoms (pain, dyspnea, nausea and vomiting, delirium, and edema), and potential care difficulties (such as requiring home hospice care).
Kruhlak et al., 2021[37]	Preexisting screening tool modified by a team of experts in emergency medicine, intensive care, nephrology, and internal medicine as well as PC specialists, methodologists, and a clinical epidemiologist; the screening tool was modified so that physicians could identify patients with advanced dementia separately from patients with other advanced PCNS conditions (e.g., multiple sclerosis, Parkinson's disease, amyotrophic lateral sclerosis). Screening completed in two stages.	**First stage (diagnosis)** Cancer • Metastatic or local incurable; • Patient is no longer pursuing therapy; • Patient is told cancer is not curable; or • Home care/palliative home care are involved in patient's care. Chronic pulmonary disease • FEV1 < 30% (consistent with literature); • MRC 4 or 5; • Home oxygen; or • BiPAP at home. CKD • End-stage renal disease on dialysis or refuse dialysis; or • CKD Stage 4/5 (consistent with literature). Heart failure • EF < 35 (consistent with literature); or • Class 3 or 4 heart failure. Cirrhosis • Decompensated cirrhosis (ascites, coagulopathy, encephalopathy, varices, etc.); • MELD > 10 (6% mortality 3 months MELD 10–19); or • Hepatocellular carcinoma. Dementia • Requiring significant support with ADL; or • In long-term care facility. Progressive CNS disease • Requiring significant support with ADL; or • In long-term care facility. **Second stage (unmet PC needs)** *Frequent visits*: Two or more ED visits or hospital admissions in the past 6 months. *Uncontrolled symptoms*: Visit prompted by uncontrolled symptom: pain, dyspnea, depression, fatigue. *Functional decline*: Loss of mobility, frequent falls, decrease PO, skin breakdown, etc. *Uncertainty about GoC and/or caregiver distress*: Caregiver cannot meet long-term needs; uncertainty/distress about GoC. *Surprise question*: You would not be surprised if the patient died within 12 months.
Liberman et al., 2018[42]	ED EMR readmission trigger tool used to screen the patients	Using the ED EMR to facilitate hospice directly from the ED; screening for advanced illness defined as one or more medical conditions, which become severe to the extent that health and functioning worsen and treatments begin to lose their impact; AI with organ failure, advanced or metastatic cancer, more than one readmission in 3 months, weight loss of >10% or albumin <2.5, rapid decline in ADL or other AI such as dementia or COPD with survival <6 months; patients were not expected to survive more than 6 months.

TABLE 4 (Continued)

Authors	Nature of screening tool	Screening criteria
Mogul et al., 2019[43]	Screening for unmet PC needs	ESI from a long-term care facility for persons aged 65 years or older.
O'Mahony et al.,[44]	PC trigger tool covering three questions followed by PC evaluation to ascertain the need for PC (including physical and psychosocial symptoms, need for advanced planning) performed by the NP	Series of questions to screen for medical necessity for a PC evaluation including physical symptoms, psychosocial issues, and the need for advance care planning and PC.
Reuter et al., 2019[45]	Abbreviated five-question version of the palliative and EoL care needs in the ED (5-SPEED)	Patients with PC needs were identified using an abbreviated five-question version of the screen for palliative and EoL care needs in the ED (5-SPEED).
Tiernan et al., 2019[47]	Flagging system based on previous utilization of PC services	Patients referred to the PMS during an admission to SVUH in the 3 years prior to the study period, and then discharged from hospital, had their records in the ED database flagged so that should they present to the ED at a later date, an alert would appear indicating that they were previously known to PC.

Abbreviations: AI, advanced illness; ADL, activities of daily living; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; EF, ejection fraction; EMR, electronic medical record; ESI, Emergency Severity Index; FEV1, forced expiratory volume; GoC, goals of care; MELD, Model for End-stage Liver Disease; MRC, Medical Research Council dyspnea scale; NCCN, National Comprehensive Cancer Network; NP, nurse practitioner; PCNS, peripheral and central nervous system; PMS, palliative medicine service; SVUH, St. Vincent's University Hospital.

promote relaxation. Other care measures included mouth care; repositioning[32,38,44,48,52]; emotional support[48]; managing nausea, congestion, dyspnea, hiccups, pruritus, and cough[28,41]; and psychosocial symptom management.[52] Three studies reported religious support, which included allowing access for visitation by religious leaders and offering spiritual care for PC patients to alleviate spiritual distress.[38,41,44]

Transitions across care settings

Eleven studies reported on varying transitional support as the patient and family transit from the ED to various destinations such as home (with or without home care support), skilled nursing facility, hospice care,[29,31–33,36,38,42,44,46] or admission to other clinical units such as the intensive care unit (ICU)[38,41] or inpatient hospice.[36] The ED–ICU approach is particularly noteworthy as it involved collaboration between ED and ICU staff to provide a conducive environment for EoL care.[38,41] The transitional support activities included peridischarge support,[32,50] follow-up telephone calls to patients who were either referred[31] or discharged from the ED,[44] case management, postdischarge, social support, and EoL care services.[32,33,36,38,41,42] Discharged patients with ongoing PC needs were also referred to outpatient PC clinic for continuity of care.[29,32,36]

EoL care

Six studies reported delivering EoL care in the ED.[33,36,38,39,46,48] This included prognostication at the EoL,[33,46] family discussions regarding EoL issues,[39] symptom management of pain, and other distressing symptoms.[28,38,48] EoL care also involved discontinuation of interventions deemed to be unconducive to the patient's comfort such as laboratory investigations.[28,38,41] In three studies, patients who were actively dying (last 48 h of life) were moved to a special comfort care room in the hospital where families could have the privacy to spend their final moments and prepare for the potential demise of the patient.[28,36,38]

Family/caregiver support

Several studies reported providing family support in the ED. This included emotional, psychosocial, and caregiver support as well as meeting their information needs.[28,30,31,44,48] Two studies evaluated the existence of distress among family caregivers of PC patients in the ED and offered support.[31,41] Three studies also mentioned the provision of private rooms to enable family members to remain with their relatives at the EoL.[28,36,38]

ED staff education

Various PC education programs for ED staff were also identified across the included studies.[31,33,42,44,50] These education programs were not stand-alone; instead, they were a part of the PC interventions reported to improve uptake of PC in the ED. In two studies, the PC training focusing on patient symptom screening and caregiver needs identification were provided to health care staff prior to implementing the PC in the ED.[31,49] Additionally, Glajchen et al.[31] employed the use of local ED champions whose role was to expedite the rate of referrals to PC and hospice from the ED. In another study, the educational programs were undertaken by nurse practitioners

to ED staff every 3 to 4 months focusing on indications for PC referral, hospice eligibility guidelines, and how to access these services.[44] Another study also reported delivering training on PC consultation to ED staff.[50] Liberman et al.[42] also reported a training program focused on having GoC discussions promptly, while Highet et al.[33] focused on education regarding hospice care, disease trajectory, and prognostication at the EoL.

MODELS OF PC DELIVERY

Irrespective of the how PC was delivered in the ED, all studies reported an interdisciplinary team approach. Three categories of PC delivery were identified: (1) traditional PC consultations in the ED, (2) integrated ED–PC services, and (3) mixed model.

Traditional PC consultations in the ED

With this approach, ED staff employed trigger protocols or screening tools to identify persons with PC needs and refer to the PC team. Thus, the PC teams deliver the bulk of supportive care, rather than the ED staff. Seven studies reported the assessment of PC needs in the ED using varied tools and undertaking referrals to the PC team to attend to the patient and family.[31,33,40,42,44,45,47] In six studies the PC teams were consulted within few hours of the patient's entry to the ED to deliver supportive care.[29,32,35,36,39,48]

Integrated ED–PC services

Four studies reported on integrated ED–PC services. This was characterized by a more formal working relationship in which the PC team supported the ED staff beyond just referring or consulting PC services. In two studies that involved collaboration between ED and ICU, the ICU and ED staff provided PC with ongoing support from the PC team.[38,41] In another study, the PC team evaluated patients in the ED during weekdays and provided telephone consultation nights and weekends with postadmission follow-up while the ED staff delivered hands-on/practical care.[50] Two studies reported PC teams providing round-the-clock PC support in the ED via telephone consultation while the ED staff delivered hands-on care.[46,51]

Mixed model

The mixed model reflects the utilization of both integrated ED–PC and traditional PC consultations in the ED. With this approach, patients with unmet PC needs were attended to by the ED team, by supportive care nurses in the ED, or by PC teams following PC based on the decision by the primary care team.[43] The basis for the decision-making was, however, not mentioned.

Outcomes

The outcomes of PC interventions in the ED as reported in the studies were patient, family, and ED physician–related outcomes.

Patient-related outcomes

Symptom relief and patient satisfaction

Screening in the ED was reportedly noted to help identify patients with unmet PC needs.[37] Four studies (two reporting an integrated ED–PC intervention and two reporting the traditional PC consultations in the ED) reported reduction and satisfaction with symptom control including pain, shortness of breath, secretions, nausea, and anxiety.[28,31,44,46] In addition to these symptoms, another study also observed improvement in sleep, well-being, appetite, depression, and drowsiness.[29] Grudzen et al.[32] assessed quality of life used the Functional Assessment of Cancer Therapy–General Measure (FACT-G) and found this to be significantly higher among patients who received ED-initiated PC consultation over a 12-week period than those who did not. They, however, observed no significant difference in depression among participants receiving ED-initiated PC and those who did not using the Patient Health Questionnaire-9 (PHQ-9).

GoC discussion

Several studies implementing both the traditional PC consultations in the ED and the integrated PC–ED mentioned GoC discussion as a component of PC services in the ED. However, only one study that implemented the traditional PC consultations in the ED reported an outcome in this regard.[42] Liberman et al.[42] observed that compared to a baseline group, persons in their ED–PC intervention group were more likely to have ED-led GoC conversations.

Timing and place of death

Eight studies reported on the time and place of death following ED-initiated PC.[31,33,38,40,41,43,44,48]

Length of stay

Seven studies reported on length of stay (LOS) in the ED, hospital/ICU, and hospice PC in the ED.[33,38,41,44–46,50] In the study by Reuter et al.,[45] which involved a PC consultation program in the ED, the authors observed no differences in ED LOS between patients who did or did not receive PC in the ED. The mean LOS of PC patients transferred from the ED to the ICU was 5.3 days in another study that implemented an integrated ED–PC program.[38] Wu et al.[50] found in their integrated ED–PC intervention that PC consultation in the ED significantly reduced LOS by 3.6 days. Similarly, the study by Rosenberg and Rosenberg,[46] which involved an integrated ED–PC intervention, reported a shorter length of hospital stay following integrating PC in the ED. O'Mahony et al.[44] reported a marginal reduction in the length of hospital stay compared with the baseline from 7.9 to 7 days in their study which involved the traditional PC consultations in the ED. In the traditional PC consultation in the ED

study by Highet et al.,[33] patients transferred to a hospice had a median LOS of 31.5 days.

Cost

One study reported on cost. Rosenberg and Rosenberg[46] reported reduced overall costs following the integration of PC in the ED. The authors observed that the cost savings were associated with providing the appropriate level of service for the palliative patient in terms of level of care, support of disease trajectory, and patient/family choices.[46]

Health care service utilization

Eight studies reported outcomes associated with health care service utilization. O'Mahony et al.[44] reported that utilizing PC services in the ED did not impact on rates of subsequent use of the ED. Similarly, Reuter et al.[45] observed that there were no differences in 10-day repeat ED visit rates between patients who did or did not receive the ED-based PC program. Varying numbers of persons who received PC in the ED were discharged to hospice facilities.[31–33,38,42,44,46] Koh et al.[36] observed that collaboration between the ED, PC team, and hospice facilities facilitated earlier access to PC in the ED and direct admissions to the PC unit and comfort care rooms. Furthermore, ED patients who did not need admission were attended to in the PC "hot clinics" within a week with home hospice assistance and patients who required inpatient hospice care were directly admitted there from the ED.[36] O'Mahony et al.[44] also observed that the number of admissions to the PC unit from the ED had increased from four prior to implementing the PC intervention in the ED to between 10 and 15 patients per month over 9 months.

Decreased number of clinical investigations

PC delivery in the ED was observed to be significantly associated with fewer CT scans and hematological, biochemical, and microbiological investigations.[40,47] At the EoL in the ED, these investigations were discontinued altogether.[28,36,41]

Family-related outcomes

Four studies reported on family-related outcomes.[38,39,44,53] O'Mahony et al.[44] reported family satisfaction with physical symptom control. Lafond et al.[38] found that the implementation of a PC program between the ED and ICU allowed both patients and families to have access to a more suitable environment at the EoL, including access to beds instead of stretchers.

ED staff–related outcomes

Although several PC programs in the ED included staff training, no training-related outcomes were reported across these studies.

DISCUSSION

PC delivery has evolved over the decades and is accepted as an important part of care for persons with serious illness. While it is being integrated as a component in certain settings such as cancer care, accessibility is limited in some other medical specialties. Our review sought to map the components, models of integration, and outcomes associated with PC interventions in the ED. The review findings highlight seven components of PC in the ED. The traditional PC consultations in the ED and integrated ED–PC services were the main models of delivering PC in the ED. The outcomes of providing PC in the ED have been reported in different dimensions including those related to patients, their families, and ED physicians. The emerging evidence so far suggests that PC in the ED can improve patient symptoms, facilitate access to relevant services such as hospice, potentially reduce LOS, improve care at the EoL, facilitate bereavement and postbereavement support for family members, and improve ED staff confidence in delivering PC.

PC in its broadest sense involves the active and holistic care of individuals across all age groups with serious health-related suffering and aims to improve the quality of life of these individuals, their families, and their caregivers.[26] Components of PC models employed in acute care settings have been reported to include discussions regarding prognosis and GoC and advance directives, discussion about foregoing specific treatments and/or diagnostic interventions, family and patient support, discharge planning, and symptom management.[54] Congruent with these components, the current review also identified seven components of PC in the ED: decision making, GoC discussion and communication, palliative therapies/strategies, transitional support/linkage to other services, EoL care, family support, and support for ED staff in the form of education. Unlike other settings such as the burn ICU where PC is considered synonymous to EoL care due to the often-brief period from PC initiation to time of death.[55,56] It is not unexpected that persons with serious illness may be presenting to the ED with deteriorations that herald EoL. This review findings, however, highlight that EoL care is only one aspect of PC in the ED, with patients requiring other services such as transitional support and linkage to other services (hospice, home care, and nursing home) and postdischarge support for persons with unresolved needs. This finding may potentially highlight the feasibility of implementing the entire PC package in the ED, rather than just EoL care. However, some concerns are worth mentioning. First, varied tools were employed in the decision-making process to initiate PC in the ED. These tools focused either on specific patient groups such as persons with advanced cancer[36] or on population groups such as frail older adults.[31] These tools and trigger processes are heterogenous and vary across settings that resonate with a previous systematic review that examined triggered PC consults in the ED.[22] Given the varied patient groups utilizing the ED, generic tools that screen for the presence of PC needs may be considered in addition to the disease-specific screening tools to ensure that

adults patients who may require PC are not missed. Such an approach may also help to identify patients who may require a primary level of specialty-level PC in the ED. Second, the identified screening tools seem to focus significantly on chronically ill adults with limited attention to acute illness though PC needs may also exist in the latter group.[57] This potential gap may highlight a need for more work regarding screening for PC needs in adults with acute, life-limiting illnesses.

Two approaches to implementing PC in the ED were identified in this review: traditional PC consultation and integrated ED–PC approach. These approaches have previously been described.[10] The current review makes no attempt to place one approach ahead of the other as the type of integration model employed may be based on available resources and context-specific concerns in each setting. Besides, the evidence base regarding the outcomes is still limited to draw strong conclusions regarding the overall effects of the models of integration. As such the effectiveness of each model may have to evaluated based on the outcomes and not the model itself per se. Also, process and pathway evaluations can be done to assess the unique contextual factors that hinder or facilitate the programs.

Regarding outcomes, the current review observed that delivering PC in the ED may lead to varied patient, family, and ED physician–related outcomes. PC in the ED was observed to improve symptom management, facilitate GoC discussion, potentially lower cost, connect patients to required services such as hospice care, improve family satisfaction, and provide access to quality bereavement and postbereavement support. Similar findings of PC improving quality of life and symptom burden have been reported in a recent systematic review that examined the impact of PC on persons with advanced cardiac failure[58] and cancer in the ICU.[59] Despite these, we observed mixed findings regarding LOS. PC integration in traditionally non-PC setting such as the ICU has been observed to be associated with decreased ICU LOS and overall hospital LOS.[60,61] A previous systematic review that evaluated the effectiveness of ED-based PC for adults with advanced disease also observed that there is yet no evidence that ED-based PC affects patient outcomes except for a possible reduction in LOS if PC is introduced early at the ED rather than after hospital admission.[21] The mixed findings regarding LOS may be related to the fact that LOS was examined across varied areas in the current review: ED, ICU, and hospice. The mixed findings notwithstanding, the positive outcomes are encouraging in advocating for wider access to PC in the ED and more studies are required to develop, implement, and evaluate PC programs in the ED.

LIMITATIONS

Our review offers a comprehensive overview of PC in the ED. Despite this uniqueness, there are some limitations. First, only studies reported in English were considered for inclusion in this review. Second, the review focused only on adults and findings are limited to this population. Also, the emerging evidence is still small in some regards such as the effects of the models of integration which makes it difficult to draw strong conclusions.

CONCLUSION

Implementing comprehensive palliative care interventions for patients and their families in the ED can potentially improve outcomes such as symptom burden and family satisfaction. However, there is a need for more work regarding standardizing trigger or screening tools to ensure that patients with palliative needs are not missed.

AUTHOR CONTRIBUTIONS

Jonathan Bayuo conceived the study; Jonathan Bayuo, Anita Eseenam Agbeko, and Hammoda Abu-Odah designed the review protocol; Jonathan Bayuo, Hammoda Abu-Odah, and Emmanuel Kwasi Acheampong undertook literature search; Jonathan Bayuo and Jephtah Davids were involved in data extraction and synthesis; all authors participated in writing up the manuscript, critically reviewing it, and approving the final version for submission. Jonathan Bayuo takes responsibility for the paper as a whole.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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RESEARCH LETTER

Can point-of-care ultrasound speed up time to diagnosis for small bowel obstruction?

In 2019, Becker and colleagues[1] published a multicenter, observational study in *Academic Emergency Medicine* showing point-of-care ultrasound (POCUS) to be moderately sensitive in diagnosing small bowel obstruction (SBO) when performed by emergency providers (EPs). We performed a similar study with a cohort of 35 patients aimed at answering this same question. Unlike the prior study, we also determined the impact of POCUS on time to diagnosis.

Our primary objective sought to evaluate the accuracy of EP-performed POCUS compared to computed tomography (CT). The diagnostic test characteristics of ED POCUS were compared to the abdominal CT findings as well as a final diagnosis adjudicated by a committee of three physicians blinded to the ED POCUS based on the totality of evidence including clinical, laboratory, imaging, and operative findings when available. Our secondary objective was to compare the time to diagnosis of POCUS versus CT.

Our prospective, observational study from February 2019 to June 2020 included a convenience sample of adult ED patients ages 18 years and older presenting with abdominal pain, with suspected SBO. Written informed consent was obtained for all participants. The study was approved by our institutional review board. SBO on POCUS was defined as dilated (>2.5 cm) loops of small bowel with abnormal peristalsis. Our EPs designated bowel as normal, dilated, or indeterminate. Indeterminate examinations and ileus were considered negative for an SBO, and partial obstruction was included as a SBO.

POCUS images of the small bowel were conducted by one of several emergency medicine residents (PGY-2, PGY-3), fellows, or attendings with prior experience in POCUS (but not POCUS of the small bowel) who received a 15-minute didactic training session on diagnosing SBO by an emergency ultrasound fellowship trained ED sonographer. EPs performed a minimum of five small bowel ultrasound procedures under the supervision of the fellowship-trained sonographer prior to patient enrollment.

The study sonographers imaged the abdomen with a Mindray M9 ultrasound device (Mindray NA, Mahwah, NJ), or SonoSite Edge II (Fujifilm, Bothell, WA) using a 1- to 5-MHz curvilinear transducer and scanned in both the transverse and the longitudinal planes in all four quadrants of the abdomen in whatever order they chose. Six-second clips and still images were saved and stored on QpathE middleware software for quality assurance and blinded review analysis. A 5- to 12-MHz linear array probe could be used if the sonographer wanted to improve visualization of the bowel to aid with measurements.

Of the 35 study patients, 16 had a final diagnosis of SBO (45.7%, 95% confidence interval [CI] 30%–62%). The mean (±SD) age of the study population was 59 (±18) years, 13 (37%) were male. Of the 35 patients who had POCUS, one examination was indeterminate and excluded from analysis of test characteristics. A total of 34 patients had an abdominal CT, of which one was indeterminate and excluded for the purposes of analyzing test characteristics.

Table 1 presents the diagnostic test characteristics of POCUS for diagnosing SBO using the CT results as the criterion standard. POCUS had a sensitivity of 89% (95% CI 64%–98%), a specificity of 67% (95% CI 39%–87%), a positive predictive value (PPV) of 76% (95% CI 52%–91%), and a negative predictive value (NPV) of 83% (95% CI 51%–97%). When POCUS was compared to the final adjudicated diagnosis, we calculated a sensitivity of 100% (95% CI 80%–100%), specificity 93% (95% CI 64%–99%), PPV 95% (95% CI 74%–99%), and NPV 100% (95% CI 72%–100%).

Mean (±SD) time from patient triage to completion of POCUS was significantly shorter than the time from triage to completion of the abdominal CT (130 [±68] vs. 297 [±376] min; mean difference 167 [95% CI 27–306] min). Based on a subset of ultrasounds that were reviewed by two independent ED sonographers, the interobserver agreement for the various sonographic findings was highest for dilated loops of bowel (0.88, 95% CI 0.72–0.99) and overall final impression (0.88, 95% CI 0.71–0.99).

Overall, we found varying accuracy of POCUS, which improved with level of training (data not shown). Of all POCUS findings, presence of dilated loops of bowel was most reliable. We also found that POCUS was completed much earlier than abdominal CT. Though we did not record the exact time required to perform the POCUS examination in the current study, Grunshaw and colleagues[2] reported a mean duration of about 15 min.

Our findings, together with those reported by others, including Becker et.al., suggest that emergency physicians can easily learn how to diagnose SBO based on POCUS.[1–9] Our data suggest that the accuracy of POCUS for diagnosing SBO improves with training. Regardless of specialty, it would seem that with standardized training, even novice or inexperienced providers can become proficient in recognizing signs of SBO on POCUS.[10] These scans may also lead to faster disposition times; however, from anecdotal experience, many surgeons still opt for radiology reviewed "official" studies prior to accepting EP interpretation. Hopefully one day, proof of concept for the EP performed study will be viewed with similar acceptance.

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TABLE 1 Two-by-two tables and diagnostic test characteristics of POCUS using abdominal CT or final diagnosis as the criterion standard

	CT result as criterion standard		
POCUS result	**Non-SBO**	**SBO**	**Total**
Non-SBO	10	2	12
SBO	5	16	21
Total	15	18	33
Sensitivity 89% (95% CI 64%–98%) Specificity 67% (95% CI 39%–87%) PPV 76% (95% CI 52%–91%) NPV 83% (95% CI 51%–97%)			
POCUS result	Final diagnosis as criterion standard		Total
	Non-SBO	SBO	
Non-SBO	13	0	13
SBO	1	20	21
Total	14	20	34
Sensitivity 100% (95% CI 80%–100%) Specificity 93% (95% CI 64%–99%) PPV 95% (95% CI 74%–99%) NPV 100% (95% CI 72%–100%)			

Abbreviations: NPV, negative predictive value; POCUS, point-of-care ultrasound; PPV, positive predictive value; SBO, small bowel obstruction.

A major limitation of our study is the small sample size leading to wide CIs around the point estimates. While we originally planned on enrolling 88 patients, enrollment was stopped prematurely for two reasons. First, during the course of our study, several similar larger and multicenter study results were reported.[1,5] Second, the emergence of the Covid-19 pandemic limited patient enrollment. However, our results are in line with those of larger more adequately powered studies. Our study supports the feasibility of brief training and confirms that POCUS can shorten the time to diagnosis of SBO.

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RESEARCH LETTER

Evaluation of National Institutes of Health cardiac arrest research based on "chain of survival" links

Research discoveries in resuscitation science are critical to improving survival and reducing the public health burden associated with cardiac arrest (CA). Yet, to our knowledge, fewer than five CA randomized control trials have been published yearly throughout the world over the past two decades,[1] and nearly three-quarters of recent American Heart Association/Emergency Cardiovascular Care (AHA/ECC) guidelines were based on a low level of evidence, with only 1% based on high-grade data.[2] Little information is known on the current landscape of CA research funding in the United States, as the National Institutes of Health (NIH), the largest funder of biomedical research in the world, does not specifically report annual funding for CA research.[3] The goals of this study were to characterize recent NIH funding of CA research and evaluate its distribution among links in the chain of survival (Figure 1A).[9]

The NIH-funded CA grants were identified using our previously published methodology.[10] In brief, the NIH RePORTER database (https://projectreporter.nih.gov/reporter) was searched for single common resuscitation terms or combinations therein for the years 2017 to 2021. Data were exported from NIH RePORTER to a Microsoft Excel file, and grants were individually reviewed and categorized as CA research (by author R.A.C.) using predefined criteria: (1) studies designed to improve the treatment/outcomes of prehospital or in-hospital CA; (2) use of a CA model; (3) use of a global ischemic brain injury model; (4) study of the mechanism of ventricular fibrillation (VF), pulseless ventricular tachycardia (pVT), pulseless electrical activity (PEA), or asystole; (5) study of the mechanism of therapeutic hypothermia for CA; or (6) funding for resuscitation centers or group collaborations. Grants were excluded if their focus was: (1) study of channelopathies or arrhythmia research other than VF, pVT, PEA, or asystole; (2) cardioplegia; (3) implantable cardioverter defibrillator research; (4) trauma; or (5) not CA research. Grant study aims for CA research were then reviewed and classified based upon which chain of survival link was studied. Finally, published odds ratios (ORs) for each chain of survival link were used to compare the distribution of research funds (Figure 1B).[4–8] This analysis utilized publicly available grant information and therefore did not require institutional review board approval.

The search yielded 1653 NIH-funded grants, of which 111 (6.7%) were classified as individual CA grants. A total of 26 (23.4%) did not address a specific chain of survival link. The remaining 85 (76.6%) grants addressed the following links: activation of emergency

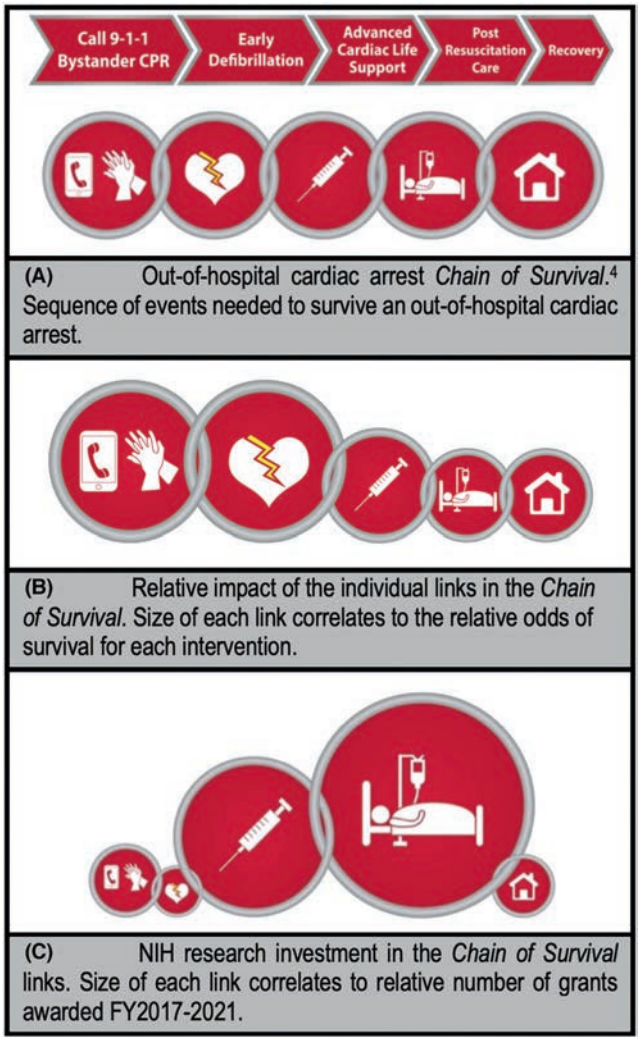


FIGURE 1 (A) Out-of-hospital CA chain of survival. *Activation of emergency response and bystander CPR were combined into a single first link. (B) Relative impact of the individual links in the chain of survival. Size of each link represents the relative odds of survival published for each intervention (i.e., bystander CPR OR ~3;[4] bystander automated external defibrillator [AED] OR ~3;[5] epinephrine/amiodarone/lidocaine OR ~1.5;[6,7] targeted temperature management OR ~1[8]). (C) NIH research investment into chain of survival links. Size of each link correlates to relative number of grants awarded FY2017-2021. CA, cardiac arrest; CPR, cardiopulmonary resuscitation.

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response and bystander CPR (5, 5.9%), rapid defibrillation (1, 1.2%), advanced cardiac life support (24, 28.2%), postresuscitation care (52, 61.2%), and recovery/survivorship (3, 3.5%; Figure 1C).

Total funding of unique grants was $47.4 M. Funding per chain of survival link during the study period was found to be activation of emergency response and bystander CPR ($2.6 M, 5.5%), rapid defibrillation ($0.19 M, 0.4%), advanced cardiac life support ($9.9 M, 20.8%), postresuscitation care ($20.8 M, 43.9%), and recovery/survivorship ($1.8 M, 3.8%). Grants not specifically addressing a chain of survival link accounted for $12.2 M (25.7%).

Our study found that two-thirds of recently funded CA grants have been focused on downstream chain of survival links such as advanced cardiac life support and post-CA care, with a paucity of funding directed toward more proximal links including activation of emergency response and bystander CPR and rapid defibrillation, which have the largest demonstratable impact on CA survival. Three grants were identified as studying recovery and survivorship, which is a new link the chain of survival added in the 2020 guidelines. Nearly one-quarter of CA grants did not directly study a chain of survival link. Examples of such grants included scientific networks (such as SIREN), training programs, and data centers as well as epidemiologic database research.

These results provide and important and much needed overview of the current landscape of NIH research funding of CA but does not include all funding sources including the American Heart Association, Department of Veterans Affairs, or foundational grants. Our findings can be used to inform funding agencies during decision making and distribution of limited funds and also assist emergency physicians and resuscitation scientists in targeting their research efforts toward high-impact, practice-changing gaps in CA care.

In conclusion, there is currently a large disparity between NIH funding among chain of survival links and their demonstrated contributions to overall survival from CA. These findings may be due to an inadequate number of investigators submitting grant proposals directed toward high-yield chain of survival links as well as NIH investing limited resources toward CA research. Additional and more diverse research is needed to promote broader guideline development, improve CA outcomes, and reduce CA disease burden.

AUTHOR CONTRIBUTIONS

Ryan A. Coute, Timothy J. Mader, and Michael C. Kurz designed the study, analyzed the data, and wrote the manuscript. All authors have read and approved of the manuscript.

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CONFLICT OF INTEREST

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CONSENSUS CONFERENCE

Race, racism, and antiracism in emergency medicine: A scoping review of the literature and research agenda for the future

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Abstract

Objectives: The objective was to conduct a scoping review of the literature and develop consensus-derived research priorities for future research inquiry in an effort to (1) identify and summarize existing research related to race, racism, and antiracism in emergency medicine (EM) and adjacent fields and (2) set the agenda for EM research in these topic areas.

Methods: A scoping review of the literature using PubMed and EMBASE databases, as well as review of citations from included articles, formed the basis for discussions with community stakeholders, who in turn helped to inform and shape the discussion and recommendations of participants in the Society for Academic Emergency

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Medicine (SAEM) consensus conference. Through electronic surveys and two virtual meetings held in April 2021, consensus was reached on terminology, language, and priority research questions, which were rated on importance or impact (highest, medium, lower) and feasibility or ease of answering (easiest, moderate, difficult).

Results: A total of 344 articles were identified through the literature search, of which 187 met inclusion criteria; an additional 34 were identified through citation review. Findings of racial inequities in EM and related fields were grouped in 28 topic areas, from which emerged 44 key research questions. A dearth of evidence for interventions to address manifestations of racism in EM was noted throughout.

Conclusions: Evidence of racism in EM emerged in nearly every facet of our literature. Key research priorities identified through consensus processes provide a roadmap for addressing and eliminating racism and other systems of oppression in EM.

INTRODUCTION

In April and May 2021 the Society for Academic Emergency Medicine (SAEM) held a consensus conference, "From Bedside to Policy: Advancing Social Emergency Medicine and Population Health," to identify priority areas for research in these fields. Three major groups within the conference were created, including one focused on identifying priority areas for future research and implementation science related to *race*, *racism*, *and antiracism* in emergency medicine (EM). This article presents a scoping review of the literature and consensus-derived research priorities for future research inquiry in an effort to (1) identify and summarize existing research related to race, racism, and antiracism in EM and adjacent fields and (2) propose an agenda for EM research in these topic areas.

Definitions

To address the issues of race and racism in EM, it is important to begin with a mutual understanding of key terminology. Table 1 outlines definitions of the most important words and concepts on which this work is based, though this list is by no means exhaustive. Throughout this manuscript we have followed guidance from "Advancing Health Equity: Guide to Language, Narrative and Concepts," developed by the American Medical Association's Center for Health Equity and the Association of American Medical Colleges' Center for Health Justice.[1] This has guided our choice of terminology and grammar, including the capitalization of Black and lowercase spelling of white in this context.

BACKGROUND AND FRAMING

Before discussing existing literature and identifying future priorities for research, it is critical to understand the history of medicine in the context of racism and other systems of oppression that remain dominant forces in our society. This history forms the backdrop and foundation for the relationship between Black, Latinx, Indigenous, and other historically minoritized groups and the health care system today. The resultant harms, both historical and contemporary, shape the way in which medical research has been and continues to be developed and carried out.

Structural racism

Structural racism refers to the interwoven political, economic, and social forces grounded in histories of white supremacy that exert and perpetuate harm on communities of color. As opposed to direct interpersonal racism or institutional racism, structural racism is more pernicious, mediating harm through inequitable education, policy, laws, infrastructure, and institutions.

Structural racism affects health and health care through at least two interrelated mechanisms. The first, and most significant, is via the constraints it imposes on the potential for health and wellness of communities of color, which manifests in individual- and community-level structural vulnerabilities. Examples include barriers to wellness-promoting social determinants of health (e.g., stable housing, economic security, community efficacy, access to health care) and disproportionate exposure to detrimental social drivers of health (e.g., policing, toxic environmental exposures, violence). In the United States this differential exposure drives racial inequities in health outcomes even after accounting for income and class.

A second mechanism by which structural racism affects racial health inequities is via constraints on health care practice. Even if interpersonal and institutional racism were addressed, structural racism would lead to differential provision of health care and contribute to racial health inequities. A recent example of this is rationing of services during the COVID-19 pandemic. Situated in the context of a historical abandonment of social services, including closure of health care facilities, in favor of investments in policing and incarceration, health systems serving poor communities and communities of color have been more severely affected and thus compelled to consider rationing of care during the pandemic.[2–5] Individual providers and

TABLE 1 Key terminology and definitions[a]

Race	A socially constructed way of grouping people, based on skin color and other apparent physical differences, which has no genetic or scientific basis. This social construct was created and used to justify social and economic oppression of historically minoritized groups by whites. According to the American Anthropological Association: "… it has become clear that human populations are not unambiguous, clearly demarcated, biologically distinct groups…there is greater variation within 'racial' groups than between them."
Power (in the context of race)	Critical Race Theory explains: "Structural determinism in which systems of power preserve the interests of dominant group members."
Racism/racial discrimination	A system of advantage based on race. A system of power and oppression codified into laws, policies, and institutions, based on the socially constructed concept of race, that advantages the dominant group (white people) while disadvantaging the non-dominant group (historically minoritized groups). Racism takes several forms and works most often in tandem with at least one other form to reinforce racist ideas, behavior, and policy. Types of racism include: • Individual racism: the beliefs, attitudes, and actions of individuals that support or perpetuate racism in conscious and unconscious ways. The U.S. cultural narrative about racism typically focuses on individual racism and fails to recognize systemic racism. • Interpersonal racism: public expressions of racism, often involving slurs, biases, or hateful words or actions occurring between individuals. • Institutional racism: race-based discriminatory treatments, unfair policies, or biased practices occurring in an organization that result in inequitable outcomes for whites over historically minoritized groups and extend considerably beyond prejudice. These institutional policies often do not explicitly mention any racial group, but the intent and effect is to create advantages for privileged groups. • Structural racism: the overarching system of racial bias across institutions and society. These systems give privileges to white people resulting in disadvantages to historically minoritized groups.
Health disparity	Differences between the health of one population and another in measures of who gets disease, who has disease, who dies of disease, and other adverse health conditions.
Health inequity	Differences in health status and mortality rates across population groups that are systemic, avoidable, unfair, and unjust. These differences are related to social and economic injustice and are attributable to social, economic, and environmental conditions in which people live, work, and play.
Antiracist	Antiracist action results from a conscious decision to make frequent, consistent, equitable choices daily. These choices require ongoing self-awareness and self-reflection. In the absence of making antiracist choices, we (un)consciously uphold aspects of white supremacy (the false notion of a hierarchy of human value based on race, with white being supreme), white-dominant culture, and unequal institutions and society.
Race-based medicine	The system by which research characterizing race as an essential, biological variable translates into clinical practice, leading to inequitable care. This is in opposition to race-conscious medicine, which incorporates awareness of race as a societal health influence but does not view it as a genetic or other biologic factor.

[a]Developed with adaptations from Bailey et al., 2017[15]; Wellman, 1993[147]; American Anthropological Association, 1998[148]; Kendi, 2019[149]; Lawrence and Keleher, 2004[150]; Jones, 2000[151]; and Greenwald and Banaji, 1995.[152]

hospital administrators may aim to act equitably in rationing care but are ultimately complicit in structural racism as health systems in more affluent areas are not compelled to make similar decisions. While the COVID-19 pandemic may seem exceptional, structural racism has caused a perpetual crisis in the health care facilities that serve predominantly Black, Latinx, Indigenous, and other historically marginalized communities. The effects manifest as fewer hospital beds per capita,[6] longer emergency department (ED) wait times,[7–9] poorer access to specialty services,[10–12] and staffing models[13] that ultimately constrain practice patterns and perpetuate structural racism in medicine.[14–16]

History and context of racism in medicine

The medical profession has long participated in and perpetuated a culture of racism within and outside the medical sphere and enacted racial violence on individual, institutional, and structural levels.[17] This violence has deep historical roots in the United States. Since the colonial era, people of color were not only subjected to inferior and often segregated health care systems, but their bodies were stolen for "anatomic material" and were experimented on for "medical advancement."[18–20] Black and Indigenous people were also excluded from medical education. In the American Association of Medicine's own words, "for more than 100 years, the AMA actively reinforced or passively accepted racial inequalities and the exclusion of African-American physicians," actions for which they apologized in 2008.[21]

The field of medicine not only perpetuated direct violence against historically minoritized populations; it also constructed institutions that perpetuated structural racism as described above. Racial minorities continue to have worse health outcomes than their white counterparts. For many years, medical institutions and the majority of practitioners supported the idea that these differences were based on genetics, cultural inferiority, or ignorance rather than seeking to identify the structural and infrastructural factors that create and sustain these inequities.[22,23] While more overt forms of racist rhetoric are less likely to be observed in the 21st century, many treatments and guidelines in use

today were developed based on research that conceptualized race as biological rather than a social construct (e.g., eGFR calculations, differential recommendations for antihypertensive medications).[24]

Movement toward antiracism

The path to antiracism in medicine promises to be long and circuitous, but work is already being done that can be built upon. From free clinics set up by the Black Panther Party to more recent efforts to eliminate race-based "corrections" in clinical algorithms, there is an established history of medical antiracism work in the United States. Events in recent years have generated unprecedented interest in achieving equity in medicine. It is our belief that we can use this forum to help inform justice-rooted efforts toward advancing heath equity.

From this history and the burgeoning civil movements around us, researchers should consider (1) how a profession whose history is rooted in racism and other systems of oppression can structure research and enact guidelines that are antiracist; (2) whether current research methodologies, practices, and infrastructures reinforce inequities rather than challenge them and (3) how EM can critically reexamine what is considered to be valuable and valid in advancing our field knowing that current methods and progress derive from this violent history.[22]

METHODS

A scoping review of the literature formed the basis for discussions with community stakeholders and EM physicians to identify key research priorities for addressing racism in EM. These processes informed and shaped the discussion and recommendations of participants in the 2021 SAEM Consensus Conference "From Bedside to Policy: Advancing Social Emergency Medicine and Population Health."

Literature review

An a priori scoping review protocol was developed and conducted. PubMed and EMBASE databases were searched for key terms including those that identify care provided within EDs ("emergency medicine," "emergency medical services," "emergency department," "emergency care,") and terms related to race, racism, and antiracism ("racial bias," "racial discrimination," "racial prejudice," "racism," "antiracism," "racial–ethnic disparities," "racial disparities"). The identified articles were reviewed for relevance; articles were included if they addressed how race and/or racism affect emergency medical care, including access, utilization, treatment, outcomes, patient experience, or provider experience in the ED. Citations from relevant articles were reviewed to identify additional manuscripts for inclusion in the review. All inclusion and exclusion decisions were reviewed by the first three authors (A.D., E.C.M., and H.J.) and any discrepancies were adjudicated by consensus. Data extracted from relevant articles included the relevant category (access to care, prehospital care, in-ED care, in-hospital [but not ED] care with relevance for EM practice, patient outcomes, patient experience of ED care, or provider experience in EM); topic areas (implicit bias, social determinants of health, pediatrics, neurology, etc.); study purpose and design; funding source(s); data source; sample size; how race was defined; whether the study evaluated an intervention; and key findings. Included studies were reviewed by the first three authors and organized by topic area. Topic areas were determined iteratively by authors via review of included studies and discussion. Findings in each topic area were discussed by the authorship team to identify themes and generate a draft list of priority questions for future research.

Community stakeholder consultation

Organizations with a mission and expertise in addressing racism within EM or related fields were invited by the authors to review and comment on research priorities that emerged following the scoping review of the literature. Leaders from three community organizations (Southern Jamaica Plain Health Center's Racial Justice and Health Equity program in Boston, MA; Women of Color Health Equity Collaborative in Springfield, MA; and Frontline Wellness Network in Los Angeles, CA) reviewed drafted content and provided feedback. This input was incorporated into the draft research questions prior to the consensus conference.

Consensus conference

Over the course of two virtual meetings held in April 2021, the findings from the scoping review and drafted research questions were presented to attendees of the race, racism, and antiracism breakout session at the SAEM consensus conference. These were discussed and revised both synchronously and asynchronously. Consensus was reached on terminology, language, and priority research questions through written and oral discussion as well as input via electronic surveys administered to all participants after the two live sessions. The final survey asked participants to rate each research question's importance or impact (highest, medium, lower) and feasibility or ease of answering (easiest, moderate, difficult). The priority research questions developed through the consensus process in collaboration with EM physicians, trainees, and students who attended the 2021 SAEM consensus conference are presented for each topic area, along with the consensus decision regarding priority and feasibility.

RESULTS

Literature review

A total of 344 articles were identified through the literature search. Of these, 187 met inclusion criteria. An additional 34 articles were identified by reviewing citations of articles found in the initial

TABLE 2 Major domains and topic areas

Access to care, including insurance	Pediatrics
Prehospital care	Neurology
Within-ED care	Trauma and injury prevention
In-hospital (but not in ED) care	Anesthesia
Outcomes	Pulmonology
Patient experience of ED care	Dermatology
Provider experience in EM	Utilization
Implicit bias	Substance use disorders
Residency training	Psychiatry
Cardiology	Radiology
Congestive heart failure	ED operations
Social determinants of health and structural racism	Infectious diseases
Structural competency	Orthopedics
EMS	Law enforcement

search. Data on each article including topic area, study design, racial and ethnic groups studied, funding sources, research question, and key findings were abstracted by the working group (all named authors except M.M.). The topic areas into which included articles fell are presented in Table 2; topic areas were not mutually exclusive. Themes that emerged from this scoping review of the literature are discussed below.

Funding

Of the 187 included studies, 83 (44.4%) were unfunded. Seventy-two (38.5%) received federal funding, 20 (10.7%) were supported by foundational grants, eight (4.3%) received departmental or internal funding, and four (2.1%) received pharmaceutical company funding.

Overall findings

EM and adjacent fields have extensively documented racial inequities in access, utilization, diagnosis, treatment, and outcomes over the course of many decades. Despite this, very few studies have explicitly studied racism or antiracism in EM in any capacity. Based on the deficits found in the current literature, Table 3 presents key research and methodologic questions that emerged from the review of the literature and consensus conference proceedings, in addition to the consensus opinions regarding their priority and feasibility.

The majority of included studies were observational. Methods for reporting racial and ethnic inequities varied between studies, and many did not clearly report methods of collecting racial and ethnic data. This finding led to recommendations regarding best practices for collecting and using these data (Table 3, Questions 5 and 6).

Of the 187 included studies, only six evaluated an intervention aimed at reducing racial inequities. Of these, one study evaluated the impact of implementing an equity framework on patient perspectives of discrimination,[25] two evaluated educational interventions to raise awareness about racial bias or discrimination,[26,27] one evaluated a multifaceted intervention to reduce implicit bias,[28] another was a secondary analysis of broad intervention aimed at improving sedation and pain control in the ICU setting,[29] and one described interventions aimed at increasing historically underrepresented in medicine recruitment within a single EM residency.[30] Several other observational cohort studies attempted to explore the impact of policy changes or insurance expansion on racial inequities.[31,32] These findings led to Research Question 7 regarding assessment of interventions for mitigating racism in emergency care (Table 3).

Some studies found that racial inequities reflected differences in where patients access care, while other studies found racial inequities persisted within single centers. This finding led to the development of Research Questions 8 and 9 (Table 3) regarding the impact of patient care location on inequities. The literature review and consensus process also revealed that many other structural forces and health-related social needs are colinear with race and the lived experience of racism. This acknowledgment led to Research Question 10 (Table 3) regarding assessment of structural determinants of health. The finding that racial inequities persist even within care that has been protocolized (e.g., trauma resuscitation, stroke treatment) led to Research Question 11 (Table 3), intended to develop strategies to eliminate inequities in algorithms and pathways.

Specific topic areas

Access to care and ED utilization

The ED is more likely to serve as the entry point into the health care systems for historically minoritized groups than for white populations in the United States.[33,34] Numerous studies have shown that Black and Latinx people are more likely to report ED use than white patients.[10,32,35] Poor health care access has been suggested in multiple studies as a causal factor for racial and ethnic disparities in ED visits and hospitalizations in numerous conditions such as asthma,[36–38] neurologic conditions,[39] gastrointestinal complaints,[35,40] mental health disorders,[41] heart failure,[42] diabetes,[33] dental health conditions,[43] and conditions requiring emergency general surgery.[35] Data exists suggesting that improved insurance coverage mitigates racial inequities in many scenarios.[32,35,44,45] However, expansion of insurance has not revealed a consistent reduction in health care disparities for all conditions or among specific racial and ethnic minorities. Numerous studies have documented racial inequities in morbidity and mortality after traumatic injury among both children[46] and adults[47–50] though these may be mitigated in universal health care systems such as the military.[44] Some of the excess morbidity and mortality among traumatically injured Black individuals may be attributable to being cared for disproportionately at lower quality institutions.[51,52] Key research questions that emerged from these findings are presented in Table 4.

TABLE 3 General recommendations and questions for EM research about race, racism, and antiracism, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
1	EM societies, funding sources at all levels, and institutions should prioritize directing funds toward research, implementation science, interventions of all sizes, education, and advocacy that focus on addressing racism and advancing antiracism at all levels. True, meaningful community participation that goes beyond committee work should be an essential part of funded research efforts.	Highest	Moderate
2	Priority should be given to the creation and testing of interventions that mitigate inequities in patient-centered outcomes, even if they do not conform to the requirements set forth by traditional research, which has its history tied to racist medical and research practices and which has failed to create any substantial changes in care inequities for Black, Indigenous, Latinx, and other historically minoritized groups.	Highest	Moderate
3	What would an ED that centers the needs of our most marginalized and vulnerable community members look like? If an ED were designed to care for a Black or Indigenous, queer, transgender, non–English-speaking woman with a history of trauma, how would it work? How might we transform our system into one that works equitably for all patients?	Medium	Difficult
4	How should EDs be held accountable for the harm done (historically and currently) to Black, Indigenous, Latinx, and other historically minoritized groups? How should these harms be acknowledged and addressed?	Lower	Difficult
5	Priority should be given to creating/identifying and disseminating best practices for the collection of racial and ethnic data used in research and operations. Research studies should be required to report the racial categorization methods that they employ (e.g., self-reported, provider-assigned). What are the best practices for accounting for missing racial and ethnic data in data sets?	Highest	Easiest
6	What outcomes and outcome measures are best suited to studying individual-level risk for experiencing racism and its associated adverse health effects? Is self-reported race the best marker for this risk? What other metrics, e.g., how people are racialized by others, may be missing from our data sets?	Highest	Moderate
7	What are the most effective interventions for mitigating racism in emergency care? Priority should be given to the creation and testing of interventions that directly target the effects of racism, both structural and interpersonal, on patients and providers. Given that the prevalence of racism in medicine is well established and harms all patients (with greatest harm to historically minoritized groups), priority should be given to developing substantive and effective interventions even if precise methodologies for testing are not available.	Highest	Moderate
8	What are best practices, including research methodologies, for determining and addressing between-hospital versus within-hospital racial inequities? Are the inequities that exist in ED access, utilization, and clinical outcomes true between hospitals, within hospitals, or both?	Medium	Moderate
9	If between-hospital differences contribute to inequities, then what factors cause those facilities to provide worse care? And/or what factors lead Black, Latinx, and people from other historically minoritized groups to obtain care at facilities providing lower quality care instead of other facilities?	Medium	Moderate
10	How should researchers disentangle and address the structural determinants and factors that create and perpetuate racist practices in medicine?	Medium	Difficult
11	What strategies can best address and eliminate racial inequities during the development, implementation, and revision of clinical pathways and algorithms? What are current best practices for incorporating equity framework into crisis standards of care and other clinical policies?	Highest	Moderate

ED operations

Most studies examining racial inequities in ED operations focused on ED wait times,[53–56] ED length of stay (LOS)[57,58] and triage acuity scoring.[59,60] Multiple studies showed that overall ED wait times were longer for nonwhite patients, both with any complaint[55] and when examining specific, time-sensitive chief complaints such as chest pain,[53] gastrointestinal illness,[56] and stroke,[54] as well as when stratifying by Emergency Severity Index.[55,56] Black and Latinx patients were given lower acuity scores for similar complaints in

TABLE 4 Key questions for EM research related to access to care and ED utilization, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
12	What are the barriers stopping ED clinicians from championing policy change that would address racial inequities in insurance and health care access?	Medium	Moderate
13	Insurance status is often represented as a proxy for access to health care and should be used to stratify outcome data along with race and social determinants to explore potential health disparities. This is important specifically within like groups. How do inequities in commercial and state-issued health insurance contribute to racism in medicine? What specific programs have found ways to eliminate/mitigate this? Priority should be given to research and advocacy that advances universal health care (as a mediator of disparities).	Highest	Moderate/difficult
14	How can EDs increase insurance coverage in a community? How can an ED affect and improve patients' access to primary care? What new systems might we test to create more equitable access within our own institutions?	Medium	Moderate
15	What are best practices for determining the cause of differential ED utilization and recidivism? Does differential ED utilization suggest system or structural failures and, if so, at what level? What interventions have impacted differential ED utilization and recidivism?	Medium	Moderate
16	How can structural factors, such as geography and environment, be modified, accounted for, and addressed to mitigate racial inequities in ED access and utilization?	Medium	Difficult
17	How do prehospital systems (EMS) and policies exacerbate or mitigate racial inequities within their catchment areas? What policies, strategies, and interventions can be developed or disseminated to increase equity in prehospital care?	Highest	Moderate

several studies.[59,60] There were mixed results in the few studies that examined ED LOS, suggesting both within- and between-hospital differences, but few large studies exist.[55,58] Key research questions related to ED operations are noted in Table 5, along with consensus determinations for their priority and feasibility.

Analgesia

Racial inequities in pain management have been well documented for decades in EM. An expanding body of evidence reveals that these inequities persist for historically minoritized groups in multiple health care settings, including the prehospital environment[61] and in the ED[62–65] as well as in simulated clinical encounters.[66] Multiple studies analyzed administration of pain medication by chief complaint, thus mitigating the potential confounding variable of ED utilization; racial and ethnic inequities in pain management persist.[67–74] Two priority research questions related to analgesia in EM emerged from these findings and are listed in Table 6.

Respiratory conditions

The majority of studies examining racial disparities related to respiratory complaints assess the differences in prevalence, severity, and treatment of asthma. Black[75–77] and Latinx individuals[38] have a higher prevalence of asthma, are more likely to have severe symptoms,[78–80] are less likely to see an outpatient physician for asthma[74,77] or use controller medications,[77] and have higher rates of ED visits, especially in low-income areas.[37,38,76,78,81–85] Black women have the highest mortality rate from asthma compared to all other ethnic groups.[86] Black and Latinx pediatric patients are more likely to be admitted for pneumonia[87]; Black adults with pneumonia are less likely to receive timely antibiotics in the ED and are less likely to receive antibiotics that adhere to current guidelines.[88] Geographic areas with greater racial segregation have higher rates of ED visits for acute chronic obstructive pulmonary disease (COPD) exacerbations.[89] Recommended areas for further research related to racial inequities in EM management of respiratory complaints are outlined in Table 7, along with consensus determinations of priority and feasibility.

Neurologic conditions

Most studies evaluating racial inequities in neurologic care focus on the treatment of stroke.[54,90–96] These studies identified racial inequities in receipt of tissue plasminogen activator (tPA), door-to-needle time, and wait times[54,90] but no difference in the occurrence of thrombectomy.[90] Higher levels of implicit racial bias decreased a physician's likelihood of providing thrombolytics in simulated encounters,[92] and differences in declination of tPA were seen.[94] Arrival by emergency medical systems (EMS) influenced the likelihood of receiving tPA[91] but racial differences in arrival by EMS were mixed.[91,96,97] Notably, between-hospital differences may also contribute to racial inequities in stroke care.[91] Two studies explored other aspects of neurologic care, finding mixed racial inequities in admission for neurologic conditions and less frequent outpatient

TABLE 5 Key questions and recommendations for EM research related to ED operations, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
18	How can EDs track and address racial inequities in ED operations, both in real time and through incentivized review processes? What can we learn from other specialties and organizations?	Highest	Moderate
19	Priority should be given to the creation and testing of interventions that mitigate inequities in LOS/wait time, not just for time-sensitive conditions but for all chief complaints given the downstream effects of such inequities on a patient's relationship to health care.	Highest	Moderate
20	How can ED leadership engage nurses and other professionals in measuring and addressing both their own and operational inequities?	Highest/medium	Moderate

TABLE 6 Key questions and recommendations for EM research related to racial equity in analgesia, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
21	What are best practices for ensuring that all EM providers (including prehospital) recognize and address pain and discomfort equitably?	Highest	Easiest/moderate
22	What are the best ways to study and measure inequities in treatment of pain? What methods have succeeded in decreasing confounding by ED utilization and other factors?	Highest	Moderate

TABLE 7 Key questions and recommendations for EM research related to racial equity in respiratory complaints, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
23	Priority should be given to the creation and testing of ED- and hospital-level interventions to mitigate the disproportionate burden of respiratory ailments on nonwhite communities.	Medium	Moderate
24	What are best practices for understanding and mitigating racial inequities in the ED care of chronic and acute respiratory conditions?	Medium	Moderate
25	How can EDs and hospitals address the structural (e.g., environmental) factors that play a role in exacerbating these inequities?	Highest	Difficult
26	What community-, state-, and country-level policies improve the health of historically minoritized groups with chronic respiratory ailments, and how can ED providers support these interventions?	Highest	Difficult

neurologic care for nonwhite patients.[39,98] Priority questions for EM research in neurologic care are listed in Table 8.

Cardiovascular conditions

Fifteen articles related to racial and ethnic inequities in cardiology care were identified. Health care utilization, including ED visits and hospitalization, is higher for Black and American Indian/Alaskan Native individuals with hypertension and other cardiovascular risk factors than for white patients with similar conditions.[99,100] For patients with congestive heart failure (CHF), several studies documented inequities related to access to both outpatient and inpatient care.[10,42,101] Several studies explore the evaluation and management of chest pain, acute coronary syndrome (ACS) and acute myocardial infarctions (AMI) comparing Black or nonwhite patients to white individuals. Two small studies found no racial inequity in door-to-electrocardiogram (ECG) times,[102,103] while a much larger study found significant delays in door-to-ECG time for nonwhite patients presenting with chest pain.[104] Other studies demonstrate that nonwhite patients have lower awareness of heart attack symptoms,[105] lower provider-assigned pretest probability for ACS,[106] less testing

TABLE 8 Key questions and recommendations for EM research related to racial equity in neurologic complaints, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
27	What structural factors affect racial inequities in stroke care and outcomes, and how can the field of EM address these factors?	Medium	Moderate
28	The identification and mitigation of racial inequities in treatment for neurologic conditions other than stroke were almost completely neglected from the literature (e.g., headache, multiple sclerosis, dementia) and should be prioritized.	Medium	Moderate

TABLE 9 Key questions for EM research related to racial equity in cardiovascular care, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
29	What interventions effectively mitigate inequities in the identification and treatment of cardiac diseases including ACS, congestive heart failure, and hypertension?	Highest	Moderate
30	As many quality markers are collected for ACS, and reimbursement is tied to quality, what are best practices for including racial inequities in a hospital's quality data and making the mitigation of these inequities a priority for a health system?	Medium	Easiest/moderate

Abbreviation: ACS, acute coronary syndrome.

and treatment including stress testing[107] and catheterization,[108] and lower rates of survival after out-of-hospital cardiac arrest.[109] One study showed increased ED crowding and worse AMI outcomes at hospitals that serve higher proportions of Black patients.[110] Priority EM research questions related to racial equity in cardiology care are included in Table 9.

Psychiatric care

Ten articles pertaining to racial and ethnic disparities in emergency psychiatric care were identified, with the majority focusing on the pediatric population. Three studies showed that historically minoritized groups, particularly Black children, were more likely than white children to use hospital-based emergency care services,[31,111,112] with these disparities increasing over time.[31] Black children are also more likely to utilize community-based crisis intervention services and make more visits to hospital-based stabilization services after initial use. These disparities widen in times of economic downturn.[111] Black and Latinx pediatric patients are also significantly more likely than white children to receive psychotic and behavioral disorder diagnoses, even after controlling for gender, age, insurance and Global Assessment of Function (a scale that rates the severity of mental illness).[113] While one study showed minimal racial inequities in ED utilization for psychiatric disorders, it showed that Black and Latinx patients' visit rates for all types of outpatient mental health services were only half of those of their white counterparts.[114] Two recent studies suggest that Black patients are more likely to be physically restrained in the ED than white patients.[115,116] Research questions related to racial equity in ED psychiatric care are included in Table 10.

Infectious diseases

Eight studies examined topics related to infectious diseases, mostly focusing on human immunodeficiency virus (HIV), other sexually transmitted infections (STIs), and metric-based infectious disease paths like sepsis and pneumonia care. Several found disparities in the areas of testing for STIs, time to antibiotics, and imaging for appendicitis.[117–119] One study found that Black patients with HIV who experienced more racial discrimination had worse health outcomes and more ED visits. One study found that Black patients had increased odds of having a health care visit (predominantly ED visits) in the period prior to contracting HIV, signaling a missed opportunity for preexposure prophylaxis prescribing.[120] Two studies showed ED providers were more likely to test female patients of color for STIs than their white counterparts, but that did not lead to increased levels of empiric treatment.[118,121] One study exploring sepsis care found hospitals that disproportionately treat Black patients may be less likely to provide timely antibiotic therapy[122] rather than this disparity reflecting within-hospital differences. The research questions that emerged from these discussions were incorporated into other sections on between- versus within-hospital inequities, addressing inequities in structural drivers of health including access to care, and understanding and mitigating provider unconscious bias.

TABLE 10 Key questions and recommendations for EM research related to racial equity in psychiatric care, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
31	What are best practices in measuring, understanding, and addressing racism in restraint use? What structural, environmental, and interdisciplinary strategies are effective for decreasing the inequitable application of restraints in the ED? Priority should be given to the creation and testing of interventions that decrease the use of restraints and mitigate inequities in the use of restraints.	Highest	Moderate
32	How are Black, Indigenous, Latinx, and patients from other historically minoritized groups—and specifically children—pathologized in the ED in ways that differ from white individuals? How does this affect the care they receive in the ED and across their subsequent encounters? What interventions (structural as well as interpersonal) are effective in creating an ED that provides equitable care for children from the most historically minoritized communities?	Highest	Moderate
33	What policies, strategies, and interventions mitigate inequity in the diagnosis and treatment of SUD within the ED? What policies, strategies, and interventions mitigate racial inequities in successful linkage to longitudinal SUD treatment programs?	Highest	Moderate

Abbreviation: SUD, substance use disorders.

Structural drivers of health

Several studies highlight population-level structural factors that contribute to racial inequities in health care access and outcomes. Adverse social determinants of health disproportionately affect Black patients, as demonstrated by a study noting higher mortality after hospital discharge among Black patients despite similar in-hospital mortality.[123] Increased racial segregation is associated with higher rates of ED visits for pulmonary complaints including asthma and COPD.[89,124,125] Black majority neighborhoods are located further from trauma centers in several major cities,[126] and a disproportionate number of pedestrian motor vehicle collisions occur in predominantly Black neighborhoods.[127] Individuals cared for at facilities that treat predominantly Black patients have higher rates of death and complications from traumatic injuries[51,52] as well as medical conditions such as AMI.[110] Higher rates of police stop-and-frisk interactions have been correlated with decreased health-seeking behaviors, including ED visits.[128] In addition, Black individuals experience significantly higher rates of injury during legal interventions compared to white people.[129] Research questions emerging from these findings are noted in Table 11.

Patient experience in the ED

Few studies attempted to evaluate the direct effects of discrimination, such as by measuring allostatic load and its relationship to health outcomes. One study found that Black patients with HIV who experienced more racial discrimination had worse health outcomes including lower CD4 counts, higher viral loads, and more ED visits.[130] Similar outcomes were found for Latinx patients; however, differences correlating with serostatus and sexual orientation were also present.[130] Almost no literature directly addressed patients' experiences of racism in the ED. One qualitative study among American Indian parents revealed frustration with lack of access and lack of child-friendly facilities as well as feeling accused and discriminated against by providers when trying to get their children care.[131] One study of patients experiencing homelessness found that 15.3% reported discrimination due to race.[132] The research questions in Table 12 reflect key areas for inquiry related to patient experience of racism and bias in the ED.

Unconscious (implicit) bias

Several studies explore the impact of unconscious (implicit) bias in EM, with mixed results. A small study on opiate administration showed resident physicians were less likely to give Black patients opioids for chronic pain versus white patients[66]; another found no racial inequities in opioid prescribing.[133] Most studies using implicit association tests demonstrate a baseline prowhite/anti-Black bias among EM physicians,[134–136] including pediatric EM providers.[137] The effects on clinical decisions are less clear: one study showed an inverse correlation between level of bias and likelihood of Black patients receiving thrombolytics,[92] while another interdisciplinary study showed no impact of bias on clinical decision making in clinical vignettes.[134] Another study demonstrated an increase in unconscious bias from pre- to postshift among providers who faced significant on-shift cognitive loads (ED overcrowding and seeing > 10 patients),[138] but did not track clinical outcomes. These findings are consistent with two other reviews concluding that although there is evidence of provider bias, its downstream clinical effects are unclear, as are mitigating strategies.[104,139] These findings led to the development of the research questions in Table 13; during consensus discussions it was also noted that resources and strategies for addressing unconscious bias may more likely be found in the nonmedical literature.

TABLE 11 Key questions for EM research related to structural drivers of health, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
34	What is the impact of police or other law enforcement presence in the ED, particularly on Black, Indigenous, and other historically minoritized communities?	Highest	Moderate
35	How do prehospital interactions (e.g., with EMS or law enforcement) influence care within the ED, including but not limited to the application of physical restraints? What strategies, policies, and collaborative interventions can mitigate racial inequities in these patient experiences and outcomes?	Highest	Moderate
36	What training do physicians need to interact with law enforcement? How should EDs be structured to protect patients both inside and outside of police custody and maintain their rights to health care and health privacy? How can EDs work with local communities to create safety in ways that eliminate the need for law enforcement in health care spaces?	Highest	Moderate
7	What are the training/education needs for EM clinicians related to caring for patients affected by incarceration (themselves or their families), including frameworks that address community advocacy for abolition?	Medium	Moderate
38	What are best practices for EDs and hospitals who want to engage with communities, local organizations. and activist groups to address structural racism and other social determinants of health in their neighborhoods?	Highest	Moderate
39	What are best practices for incorporating legal services into medical care in the ED?	Medium	Moderate

TABLE 12 Key questions for EM research related to patient experience of racism and bias, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
40	How do patients—particularly patients from historically minoritized groups—perceive race and racism affecting their lives, health and medical care, including in the prehospital and ED setting? How can negative health care experiences be addressed most effectively?	Highest	Easiest
41	How can clinicians most effectively navigate conversations exploring stressors including the experience of racism that impact patients' lives and presentations in the ED? What are the educational and training needs to enable clinicians to have these conversations?	Medium	Moderate
42	Priority should be given to the development of patient-centered outcomes related to the experience of racism and bias in medical care. These processes should center community voices from those communities affected most by the history of racism in medicine.	Highest	Moderate

EM physician perspectives and experiences

We identified 11 papers that specifically addressed provider experience with race and racism in the ED. One study demonstrated that many providers (one in three) believe patients receive better care from people of their own gender/race/religion[140]; however, in a simulation study, patient satisfaction did not appear to be related to physician race.[141] Two studies found alarmingly high levels of reported racial harassment of providers (8.9% and 26%).[142,143] Racial inequities in faculty representation and academic appointments persist in EM.[144] Multiple residencies are implementing measures to try and close this gap,[30] with important educational initiatives under way in several departments aimed to address structural competency and uplift health equity.[27,145] In considering these findings as well as the evidence previously presented, the consensus conference participants felt that establishing a research agenda focused on advancing equity for EM physicians and other health care providers was beyond the scope of our consensus process.

DISCUSSION

The scoping review and consensus-building process highlighted the need to fundamentally reevaluate the approach to research addressing racism in EM, to develop research systems and infrastructure actively antiracist in intent, methodology, and implementation. One of the largest gaps in the EM literature noted by our reviewers and consensus conference participants was that the vast majority of papers lack information about how race was defined and categorized by the research teams. Without this information, our ability to understand and apply the results is severely limited. Categorization of race can be difficult, particularly for individuals with multiple racial and ethnic heritages. In addition, self-reported race may not always serve as an accurate proxy for the experience of racism in society or medicine. However, self-reported race remains the favored methodology gathering accurate demographic data.

The imprecision in language utilized by authors across studies was also noted to be an issue by the consensus reviewers. Many

TABLE 13 Key questions and recommendations for EM research related to unconscious bias, with consensus determination of priority and feasibility

Research question	Recommendation	Priority (lowest, medium, highest)	Feasibility (easiest, moderate, difficult)
43	What are the best and most novel techniques for creating awareness of and a collective consciousness of implicit bias and its effects on clinical decision making?	Medium	Moderate
44	Priority should be given to the creation and testing of interventions that address and decrease the impact of implicit bias among clinicians and hospital staff.	Medium	Moderate

of the articles reviewed contained inaccurate or harmful language when discussing race and racial inequities, leading to the obscuration of the fundamental structural forces at play. In particular, the use of "health disparities" to describe health *inequities* was ubiquitous. In fact, the initial literature review utilizing the word "racism," without "racial disparities," revealed few articles for review. When "racial disparities" was added, the number of articles increased 10-fold. The shifting terminology in this space reflects a crucial progression in researchers' framing of why and how differences in health care are created. *Disparity* simply indicates a difference between two groups, while the use of *inequity* explicitly characterizes these differences as unjust, avoidable, and unnecessary.[1,146] Race is a social and political invention without basis in biology or genetics; as such, health disparities between racial groups are *all* inherently unjust, avoidable, and unnecessary and can therefore be characterized as inequities.

Most prominently, this literature review and consensus process identified the stark lack of interventional studies aimed at addressing manifestations and downstream effects of racism in medicine. EM research should pivot away from seeking to re-demonstrate the well-established presence of racism in the ED setting and move toward identifying the elements that enact racism in clinical and nonclinical spaces, with an emphasis on funding interventions to actively eliminate racial inequities. Priority should be given to interventions that focus on patients and patient-centered outcomes, even if they do not conform to the standards of traditional research, which has historically privileged systems that uphold inequities instead of focusing on eliminating them. Unless funding sources and academic institutions change how they reward and incentivize these efforts, they will ultimately be replaced by less important/meaningful research that does nothing but prove the existence of inequities that are ubiquitous. Creative energy, and thus funding and protected academic time, should be directed toward reimagining the research we conduct and the care spaces in which we provide services to patients and communities. Community participation should move beyond the symbolic inclusion of one to two community members on hospital boards or projects and instead be centered alongside community members and organizations with expertise that have been centering this work. In addition, health care systems should be held accountable to the communities that they serve, including the prioritization of efforts and funding to changes and issues that are important to their constituents. When possible, these solutions should utilize structures that the community has already developed to address these issues.

LIMITATIONS

The development of this article was constrained by several limitations. First, the consensus process is limited by the system and structures in which we all work and operate, including by the implicit and explicit bias within academic medicine and large societies such as SAEM and among the consensus members themselves. While our reviewers and participants in the consensus discussions do have diverse social identities, the majority enjoy substantial social privilege based on education levels, socioeconomic status, and other factors. This necessarily influenced our discussions and the conclusions we reached. Second, we were also limited by the scale of our community engagement, both due to difficulty in securing funding to ensure that community members were compensated and because of the authors' own limited experience in community-engaged work. Third, the scoping review and our team's decisions to include or exclude articles may have failed to identify some contributions to the EM literature. Furthermore, literature that would prove valuable to setting our research agenda would not have been found if it did not directly address ED care. Lastly, there are almost certainly additional works that have been published since the time of our review, particularly given the broader societal movement toward recognizing and addressing racism and other structural drivers of inequity in medicine.

CONCLUSIONS

The harmful consequences of racism in emergency medicine have been well documented in nearly every facet of our literature. This review and consensus process identified key research priorities for the future of emergency medicine, in particular the urgent need for researchers to shift from a focus on identifying inequities to developing evidence-based interventions to address and eliminate racism and other systems of oppression in health care.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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Academic Emergency Medicine

THE BRASS TACKS: CONCISE REVIEWS OF PUBLISHED EVIDENCE

Liberal versus conservative intravenous fluid administration in pediatric diabetic ketoacidosis

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Keywords: diabetic ketoacidosis, intravenous fluids, pediatrics

NNT color recommendation	Yellow (unclear if benefits)
Summary heading	No difference in GCS reduction, cerebral edema, or hospital length of stay
Benefits in NNT	None were helped
Benefits in percentages (absolute risk reduction)	N/A
Harms in NNT (NNH)	None were harmed
Harms in percentages	None were harmed
Efficacy endpoints	Reduction in GSC (primary), cerebral edema, hospital length of stay
Harm endpoints	Adverse events such as pulmonary edema, thrombosis, alteration in mental status, kidney injury, electrolyte imbalances
Who was in the studies	Three trials of 1323 children aged 0–18 years presenting to emergency departments with diabetic ketoacidosis

NARRATIVE

Diabetic ketoacidosis (DKA), a dangerous condition of elevated blood glucose, dehydration, and acidosis, is associated with morbidity and mortality in children.[1] Much of this is due to neurologic damage and deaths from DKA-related brain injury, a condition occurring in 0.3%–0.9% of children with DKA.[2–4] Unfortunately, the cause of cerebral edema in DKA is unknown, and there is controversy about whether rate, volume, or type of intravenous (IV) fluid therapy plays a role.[5–7]

The systematic review summarized here included randomized controlled trials (RCTs) comparing liberal (fast) versus conservative (slow) IV fluid infusion during management of children with DKA.[8] Participants were under 18 years of age and required IV fluid and insulin infusion. The primary outcome in the systematic review was reduction in Glasgow Coma Scale (GCS). Secondary outcomes included development of cerebral edema and hospital length of stay (LOS). Adverse events included pulmonary edema, development of kidney injury, and electrolyte imbalances.

The meta-analysis identified three RCTs conducted in the emergency department, one of which contributed 1389 out of 1457 (95%) of the total DKA episodes analyzed.[9] Concentrations of saline infusion were mostly either 0.45% or 0.9%. All three trials compared 20 mL/kg (liberal) with 10 mL/kg administered as IV bolus or over 1 h; however, the definition of "liberal" and "conservative" differed among the three trials. The largest trial used a two-by-two factorial design also comparing 0.45% to 0.9% saline solution.[9] No study reported DKA severity, mortality, PICU admission, or development of kidney injury.

There was no difference in reduction in GCS ($n = 1361$), development of cerebral edema ($n = 1439$), or hospital LOS ($n = 1439$). There were no cases of pulmonary edema or thrombosis reported. Three percent of the total study population experienced a serious adverse event, most commonly an alteration in mental status. Hyperchloremic metabolic acidosis and hypocalcemia were more common in the liberal infusion group, but rates of hypoglycemia and hypokalemia were similar.[9] Subgroup analysis evaluating <0.9% saline compared with 0.9% saline found no difference in outcomes.

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CAVEATS

No significant differences in outcomes between fluid rate or fluid choice were identified in this meta-analysis. However, the presented data have several limitations. The most significant limitation is that one trial accounts for 95% of patients and episodes in the analysis, and this trial's results have not been reproduced or externally validated.[9] This trial incorporated a two-by-two factorial design based on fluid infusion amount and saline concentration.[9] There was also important heterogeneity in study designs and primary outcomes among the included trials. While all studies used saline, they differed in maintenance infusions and concentrations. Moreover, "evidence certainty" was rated as low to very low because all trials were at high risk of bias due to a lack of blinding of participants, providers, or outcome assessors. The wide confidence intervals for the effect sizes are likely due to small sample sizes and heterogeneity, suggesting the need for trials with larger sample sizes with more homogenous populations. Finally, no trial used "balanced" electrolyte solutions (e.g., Ringer's lactate).

Based on the available evidence, we have assigned a color recommendation of yellow (unclear if benefit) for liberal versus conservative IV fluid regimens. The high risk of bias and lack of any trials reproducing the findings of the lone large study suggest larger, more rigorous trials will be critical. Future studies evaluating IV fluid administration and IV fluid type with clear, patient-centered outcomes are necessary. It is reassuring that the overall conclusion of the systematic review is in line with the rigorous randomized trial published in 2018, which was included in the systematic review and demonstrates no evidence that fluid rate or fluid choice has an important impact on cerebral edema or adverse outcomes in children with DKA.[9]

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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COMMENTARY - UNSOLICITED

Toward development of the standardized dispatcher algorithm for telephone assistance in choking

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Foreign body airway obstruction (FBAO) is a common prehospital emergency and one of the leading causes of accidental death. Mortality rate among persons with life-threatening FBAO who present to emergency department exceeds 51%, whereas only 29% of the victims have favorable neurological outcome.[1]

The majority of fatal choking incidents is witnessed by other people,[2] and the FBAO can be successfully resolved with immediate bystander intervention.[3] Nevertheless, bystanders frequently do not provide necessary help.[4] This could be due to the witnesses' inability to recognize choking as a cause of the emergency and/or lack of basic understanding of how to deal with a choking victim.

Similar to dispatcher-assisted cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest, provision of instructions on first aid in choking by emergency medical services (EMS) dispatchers over the telephone may improve laypeople's willingness to help and, consequently, enhance rates and effectiveness of the bystander response.[5] Dispatcher assistance in suspected FBAO is reported to be a standard practice of EMS in the United States[6] and Japan.[1,7] So far, however, there has been little scientific discussion about how the telephone support should best be provided. Absence of a standardized evidence-based approach for dispatcher-assisted first aid in choking may limit its implementation on a large scale.

In June 2022, English-language EMS dispatch guidelines/protocols containing prearrival instructions (PAI) for bystanders as well as national and international guidelines on first aid were searched online. Instructions and recommendations on first aid in choking were collected using a predesigned checklist and analyzed comparatively (see Birkun dataset[8]).

The search revealed a total of five sets of dispatch PAI, all originating from the United States, dated 2008 ($n = 2$), 2010 ($n = 1$), 2020 ($n = 1$), and 2022 ($n = 1$). Being generally similar in content, all sets of PAI include sequential abdominal thrusts as the only maneuver aimed at relieving choking in responsive adults and children beyond infancy with severe FBAO. This is in line with 2010 American Heart Association Guidelines for CPR (the last revision where the topic of choking was reviewed)[9] but contradicts to the 2020 scientific consensus of the International Liaison Committee on Resuscitation that recommends to use back slaps as initial measure to relieve severe FBAO and move to abdominal thrusts when back slaps are ineffective.[10] Further, three out of five sets of PAI do not contain an instruction to encourage the victim to cough in nonsevere airway obstruction. It is also noteworthy that both the dispatch PAI and the first aid guidelines lack recommendation to perform manual extraction of visible foreign body from the mouth in responsive victim with severe FBAO (currently recommended for nonresponsive persons only). Supposedly, performance of these swift and simple actions by a bystander following dispatcher instructions could improve chances for successful resolution of choking. Considering results of the analysis, a basic algorithm of telephone dispatcher assistance in choking was synthesized (Figure 1) and is now suggested for discussion and evaluation as an evidence-based tool that may contribute to increasing rates of provision of appropriate lifesaving bystander help through the EMS dispatcher advice.

CONFLICT OF INTEREST

The author declares no potential conflict of interest.

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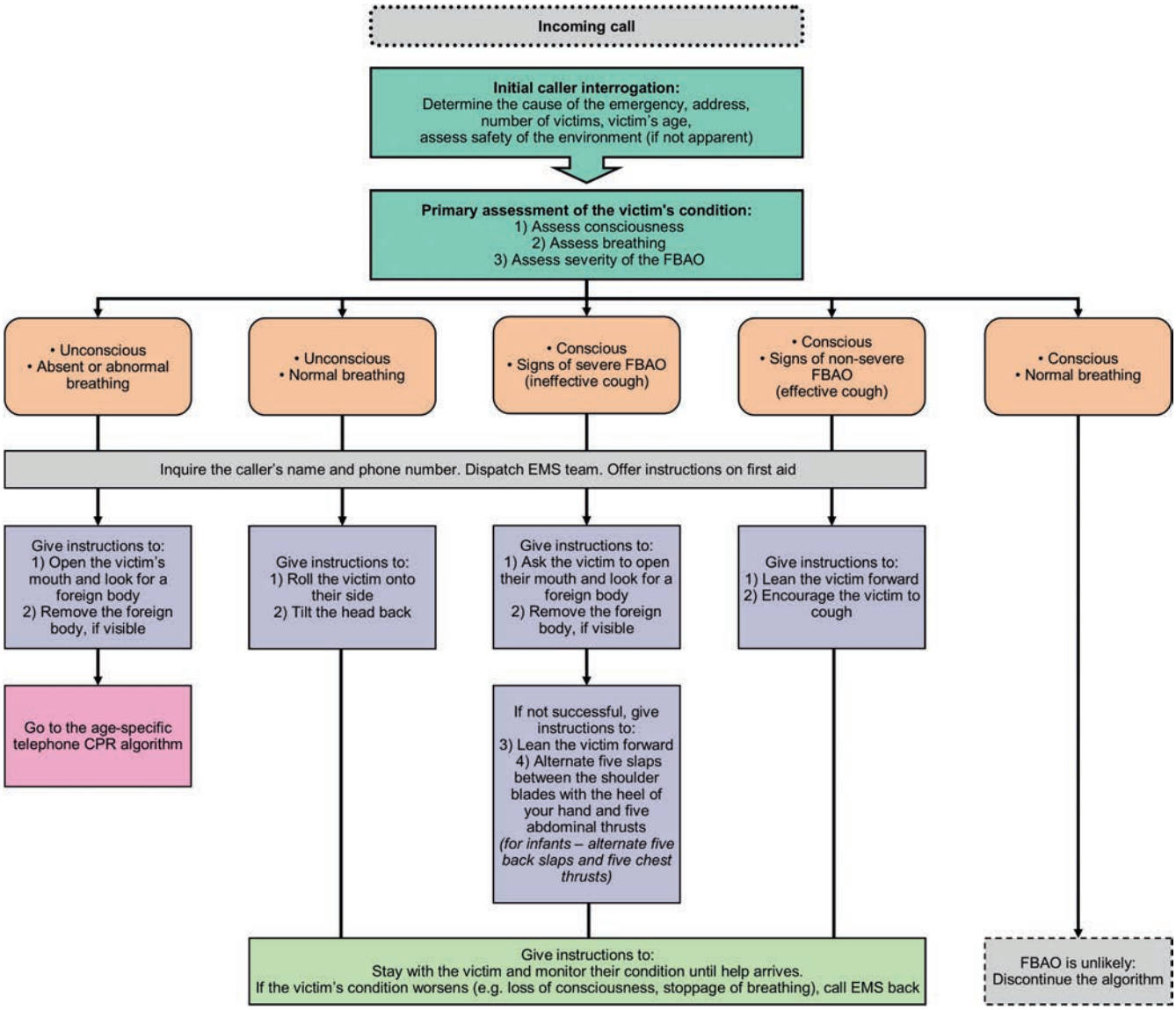


FIGURE 1 Basic algorithm for dispatcher telephone assistance in choking. CPR, cardiopulmonary resuscitation; EMS, emergency medical services; FBAO, foreign body airway obstruction.

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COMMENTARY - UNSOLICITED

Detecting corneal injury with a selfie

Eye trauma makes up approximately 3% of all emergency department visits, the majority of which involve corneal injury.[1] Early diagnosis and management of corneal injuries is critical to prevent sight- and eye-threatening infections (e.g., corneal ulcer, endophthalmitis), corneal scarring, corneal perforation, and/or permanent vision loss.[2] Although the slit-lamp examination of the ocular anterior segment with fluorescein staining of the damaged cornea epithelium is the criterion standard for diagnosis, slit-lamp microscopes may not be readily available in acute or resource-limited settings.

Custom smartphone-based adjuncts have been produced to improve portability and accessibility of the cobalt blue light, allowing for fluorescein-based ocular examinations in the clinic and community.[3–5] However, these devices are generally not commercially available, require time-consuming assembly, and require specific smartphone models. Our team has developed an attachment-free application for use on iOS-based devices (e.g., iPhone or iPad) to serve as a low-cost ($0.99 USD) and convenient tool for corneal injury detection.

Institutional review board approval was obtained from the University of California, Irvine (IRB#HS-2019-5612). The smartphone application All In One Ophthalmology uses a specific RGB color model to display a blue hue on the smartphone's liquid crystal display (LCD) screen.[6] In the "Cobalt Blue Selfie" mode, the front camera preview screen is presented in the center of the cobalt blue screen for user visualization. After fluorescein is instilled into the user's affected eye, the smartphone is held approximately 7 to 10 cm away and a photograph is taken in a dimly lit room with the user looking directly into the front camera (Figure 1A,C). Subsequent editing of photographs with a grayscale filter may help further delineate fluorescein-stained cornea epithelium by enhancing lightness and darkness of the image (Figure 1B,D). This technique has been previously demonstrated to better delineate borders of vitiligo under a Wood's lamp examination.[7]

Our group has previously demonstrated the fluorescein-illuminating capabilities of a cobalt blue smartphone LCD screen.[6,8,9] However, its use was previously limited by the need for two smartphones: one presenting the cobalt blue screen to the patient's affected eye and a second to capture a photograph. The new "Cobalt Blue Selfie" mode obviates the need for a second smartphone, allowing providers and patients to capture fluorescein-illuminated photographs much like they would obtain a selfie.

The utility of this smartphone application stems from the ubiquity of smartphones and the ease by which photographs can be taken. Nonophthalmology providers can more readily perform fluorescein-based ocular testing and send photographs to specialists for teleconsultation purposes. Photographs of various ocular pathology may be obtained for recordkeeping. Future studies are currently under way to assess how well patients can perform and photograph their own fluorescein-based ocular examination using the smartphone application. As the acceptance and adoption of virtual office visits becomes more widespread, it would be reasonable for this smartphone application to facilitate remote examinations and home monitoring of certain ocular pathology.

It is important to note that this application does not replace the criterion standard slit-lamp microscopy. The front camera of most smartphones lacks magnification capabilities and sufficient resolution to perform a comprehensive examination of the ocular anterior segment. More thorough testing is required to better understand the limitations in its diagnostic capabilities. Nevertheless, it is our hope that the demonstrated efficacy of this application will promote future works to enhance the technology and perhaps improve prompt diagnosis and treatment of superficial corneal injuries.

CONFLICT OF INTEREST

Amir Hakimi performed the programming and development of the All In One Ophthalmology application. In addition, he receives royalties from the application.

ETHICS APPROVAL

Institutional review board approval was obtained from the University of California, Irvine (IRB#HS-2019-5612). Informed consent was obtained from all patients who participated in this study.

FUNDING INFORMATION

No funding was obtained for this study, but the Gavin Herbert Eye Institute acknowledges an unrestricted departmental grant from Research to Prevent Blindness (RPB).

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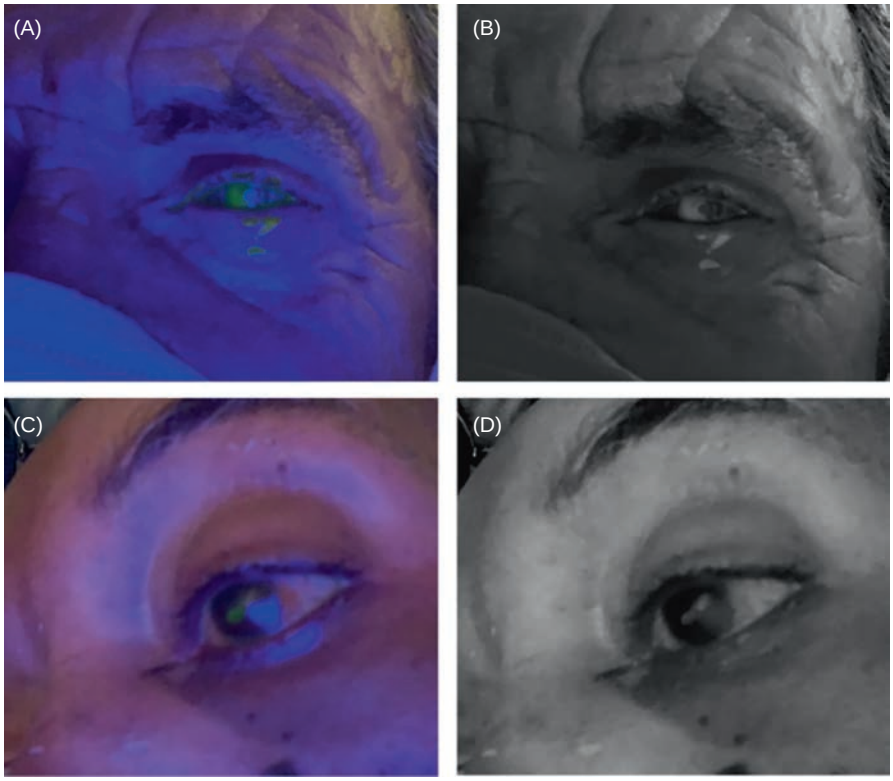


FIGURE 1 Photographs of (A) corneal ulcer and (C) corneal abrasion taken using the "Cobalt Blue Selfie" feature of the All In One Ophthalmology application. A grayscale filter was applied to both photographs (B, D) to better delineate the borders of fluorescein illumination.

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REFLECTION

ER seasons

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Early Bluebells are lavender
black-eyed Susans are gold
fluorescent light is sliced by curtains
and spills under doors.
The blood is so red
it names itself Red,
pools at the feet of bystanders
while a woman waits
in the breath of summer
unmoved by whirring fans.
Summer's body spackled by fireflies,
mouth full of cicadas,
their dirge-like drone
stopping and starting as a twisted tongue.
The guttural cry when
her anger breaks
and shatters on the floor.
***
Listen for the susurrations of trees
until they bare their empty hands,
hold something to remember
you will not last forever,
hold something when cold and bundled bodies
fill the beds which fill the hallways.
Walk fast, especially when
you have nowhere to go.
Become another body eating breakfast,
become another body that does not want so much:
a figure wading
through late afternoons smeared dark.
Build a home
in this snow
so when it is spring
the flowers can be color,
a fresh collar for the season
to pick for no one.
***
And if a motorcycle slides from the highway,
and a wife waits,
worrying ring against knuckle,
look for the chaplain.
Find him on a bench
eating a sandwich
each bite wistful as a prayer.

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REFLECTION

Behind the mask

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It enwraps the mouth, impinges on the bridge of the nose, and loops around the ears. Underneath this uninvited yet necessary accessory have dwelt emotions of fear, anger, pride, sadness, trust, and hope.

Fear that a virus that knows no boundaries, age, or race, will continue to kill into the future. Fear that the long-term damage may never be appreciated by the unaffected.

Anger that the coronavirus disease-2019 (COVID-19) pandemic has uncovered the inability of many to differentiate between an infectious disease pandemic and a natural disaster—catastrophes with different characteristics and timelines. A pandemic is mitigated through public health measures; a natural disaster demands immediate containment to prevent ongoing damage and preserve life. The pandemic needs human spread to propagate; if uncontained, the epicenter will continue to migrate. Natural disasters often occur as a single event with a static epicenter. It is appalling that in some world communities, health care workers are vilified for taking care of patients with COVID-19.

Why would the ongoing pandemic engender *pride*? So many stepped up to ensure the survival of our collective humanity. I take pride in health care workers, in individuals who donated personal protective equipment to health care establishments, in the scientists who created vaccines[1,2] and researchers who investigated therapies,[3] and in patients who participated in research trials and vaccine studies.

I was *saddened* by the rip-roaring effects of the virus as it initially ran rampant through the age-appointed homes of our elderly in nursing homes, sweeping them away in a flood of epic proportions. With our storytellers gone, how will the stories of lives past be told to the generations yet to come? It is tragic that over 6 million fellow human beings have succumbed to this disease in the past 2 years.[4] As a critical care pediatrician who redeployed to take care of adults with COVID-19 during the horrific first wave, sadness gripped me when on the telephone with their loved ones. The wife of a middle-aged man informed me he had two daughters who doted on him and could not afford to lose him. I prayerfully cried behind the mask that he would defy the odds and survive.

It is heartwarming that science is leading humanity beyond the pandemic. My *trust* in the communication of information has, however, been shaken often during this pandemic: by the initial mixed messages from scientists regarding masks and the route of transmission of the virus and by the politicization of the use of mitigation strategies. I often cringed behind the mask and likened the average citizen to the pedestrian trying to run across a multiple-lane freeway because a pedestrian crossing was never constructed: "put masks on," "maybe not," "now you need to," all in rapid succession. It is important that there be unison in the packaging and dissemination of information. Only then does society trust scientists and the science. I hope the world now knows to build a public health infrastructure to withstand the infectious disease scourges of the future; hospitals are not ideal weapons to combat an infectious disease pandemic.

The man survived! His recovery gave me *hope*; the world community needs hope. The road is winding and the finish line is but a blur on the horizon, yet the future is bright. The vaccines have buoyed our spirits, yet the waters are likely to remain tempestuous as vaccination will not lead to immediate cessation of all viral activity. In the hospital, we have learnt a lot about this unwanted intruder despite untold hardship, and we soldier on. The human spirit is indeed strong and vibrant; we will beat this scourge.

CONFLICT OF INTEREST

The author declares no potential conflict of interest.

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