Emergency Department Pediatric Readiness and Mortality in Critically Ill Children

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abstract

BACKGROUND: Emergency departments (EDs) vary in their level of readiness to care for pediatric emergencies. We evaluated the effect of ED pediatric readiness on the mortality of critically ill children.

METHODS: We conducted a retrospective cohort study in Florida, Iowa, Massachusetts, Nebraska, and New York, focusing on patients aged 0 to 18 years with critical illness, defined as requiring intensive care admission or experiencing death during the encounter. We used ED and inpatient administrative data from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project linked to hospital-specific data from the 2013 National Pediatric Readiness Project. The relationship between hospital-specific pediatric readiness and encounter mortality in the entire cohort and in condition-specific subgroups was evaluated by using multivariable logistic regression and fractional polynomials.

RESULTS: We studied 20 483 critically ill children presenting to 426 hospitals. The median weighted pediatric readiness score was 74.8 (interquartile range: 59.3–88.0; range: 29.6–100). Unadjusted in-hospital mortality decreased with increasing readiness score (mortality by lowest to highest readiness quartile: 11.1%, 5.4%, 4.9%, and 3.4%; $P < .001$ for trend). Adjusting for age, chronic complex conditions, and severity of illness, presentation to a hospital in the highest readiness quartile was associated with decreased odds of in-hospital mortality (adjusted odds ratio compared with the lowest quartile: 0.25; 95% confidence interval: 0.18–0.37; $P < .001$). Similar results were seen in specific subgroups.

CONCLUSIONS: Presentation to hospitals with a high pediatric readiness score is associated with decreased mortality. Efforts to increase ED readiness for pediatric emergencies may improve patient outcomes.

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Drs Ames, Davis, and Kahn conceptualized and designed the study, conducted the data analysis, drafted the initial manuscript, and reviewed and revised the manuscript; Drs Marin, Fink, Olson, and Gausche-Hill participated in the study design and revised and critically reviewed the manuscript for important intellectual content; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

WHAT'S KNOWN ON THIS SUBJECT: The majority of children present to general emergency departments (EDs) that may be underprepared to care for them. Previous work has evaluated the pediatric readiness of EDs, but it is unknown whether pediatric readiness is associated with improved patient outcomes.

WHAT THIS STUDY ADDS: Presentation to an ED with lower pediatric readiness was associated with increased risk-adjusted mortality for children with critical illness. Efforts to improve ED pediatric readiness may reduce mortality for these children.

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Children account for >30 million emergency department (ED) visits annually, constituting 20% of all ED visits in the United States.[1,2] Although some visits occur in specialized pediatric EDs, most occur in general EDs, which may face challenges in caring for pediatric emergencies.[3–7] The 2013 National Pediatric Readiness Project (NPRP) assessment found the median score on a standardized measure of readiness was 69 on a scale ranging from 22 to 100, demonstrating that many US hospitals lacked core elements of pediatric readiness recommended by national guidelines.[8,9] A subsequent study indicated most US children live >30 miles from a facility with a high pediatric readiness score, suggesting geographic disparities in access to high-quality emergency care.[10]

Although these studies demonstrate variability in pediatric readiness among some US hospitals, it remains unclear how often critically ill children present to hospitals with a low pediatric readiness score and whether presentation to these hospitals is associated with increased mortality. We sought to address this knowledge gap by linking hospital-level pediatric readiness scores from the NPRP to nationally representative encounter-level data on ED visits and hospitalizations. Focusing on children with critical illness, our objectives were to determine the proportion of patients presenting to EDs with various levels of pediatric readiness and to evaluate if ED pediatric readiness is associated with mortality.

METHODS

Data Sources

We performed a retrospective cohort study using 2013 data from the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project (HCUP). We used 2 HCUP databases: the State Emergency Department Databases (SEDD) and the State Inpatient Databases (SID). The SEDD contains administrative records from ED encounters that do not result in a hospitalization at the associated hospital, whereas the SID contains administrative records from all hospitalizations, including those originating in the ED of the associated hospital. For this study, we used HCUP data from Florida, Iowa, Massachusetts, Nebraska, and New York. These states represent a geographically diverse population, provide both SEDD and SID data, and contain unique patient and hospital identifiers, allowing patients to be tracked across hospitals over time and enabling a complete picture of episodes of emergency care, including patients transferred between hospitals. These states were specifically chosen for our analysis because the unique patient identifier is not available in all states that provide data to the HCUP.

We augmented HCUP data with data from 3 ancillary hospital-level sources: the 2013 Centers for Medicare and Medicaid Services Healthcare Cost Report Information System, which contains data on hospital size, teaching status, and location; the 2011 American Hospital Association Annual Survey, which contains data on the presence of a pediatric ED, pediatric inpatient unit, and PICU; and the 2013 NPRP assessment, which contains data on ED pediatric readiness.[9] The NPRP assessment data were collected between January 1, 2013, and August 31, 2013, and reflect hospital pediatric readiness and capabilities experienced by patients in the 2013 HCUP databases.

Briefly, the NPRP assessment is a 55-question online questionnaire based on the 2009 multisociety guidelines for the care of children in the ED.[8,9] The assessment evaluates hospital pediatric readiness in the following domains: administration and coordination; staffing; quality-improvement efforts; pediatric patient safety, policies, or protocols; and equipment, supplies, and medications. One-third of points are related to equipment and supplies. Full weights for each item assessed are available in Supplemental Table 4. The assessment was completed online via a hyperlink emailed to ED nurse managers at 5017 US hospitals with a 24-hours-per-day ED. The result was an overall measure of pediatric readiness known as the weighted pediatric readiness score (WPRS), a summary score derived from a modified Delphi process in which 24 of 55 questions were weighted and normalized to a 100-point scale. A WPRS of 100 indicates the ED meets all the essential elements for pediatric readiness on the basis of published guidelines.[8]

Study Population

Our primary population of interest was pediatric patients presenting to an ED with critical illness. We focused on critically ill children because they require timely treatment and specialized care, potentially making their outcomes more sensitive to ED pediatric readiness.[11,12] To identify this population, we created unique episodes of care by linking temporally adjacent records from the SEDD and SID for individual patients (ie, records in which the discharge date of the first record was equal to either the admission date or the day before the admission date of the next record). Episodes began either in the SEDD or SID and ended with hospitalization, discharge, or death.

After constructing unique episodes of care, we only included episodes involving general short-stay adult and children's hospitals. We further restricted the analysis to patients aged <18 years and those with critical illness, defined as either ICU admission or death during the episode. We included decedents in our definition of critical illness to capture patients who died in the ED before ICU admission. Finally, we excluded episodes not originating in an ED, episodes containing 3 or more administrative records because the complex trajectories of these patients may obscure the relationship between the readiness of the presenting hospital and patient outcomes, episodes originating in a hospital that did not respond to the NPRP assessment, and episodes with missing data necessary for the analysis.

Variables

The primary exposure variable was the pediatric readiness of the initial ED for each episode, defined as the hospital-specific WPRS from the 2013 NPRP assessment.[9] If patients were transferred between hospitals, only the WPRS of the initial hospital was evaluated. The primary outcome variable was mortality during the episode. Patient-level characteristics included age, race, sex, the presence of complex chronic conditions, and severity of illness. The presence of complex chronic conditions was based on *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM) diagnosis codes by using a published algorithm.[13] Severity of illness was defined by using the Pediatric Emergency Care Applied Research Network Severity Classification System, a validated score ranging from 1 (least severe) to 5 (most severe) based on the initial primary diagnosis.[14]

Hospital-level characteristics included hospital size, teaching status, geographic location, pediatric emergency volume, and the availability of a dedicated pediatric ED, pediatric inpatient unit, or PICU. We defined hospital size using total number of beds, categorized as small (<100), medium (100–250), and large (>250). We defined teaching status using the ratio of resident full-time equivalents to beds, categorized as nonteaching (no residents), small teaching (ratio <0.2), and large teaching (ratio 0.2 or higher). We defined geographic location on the basis of metropolitan statistical area population, categorized as small (<100 000), medium (100 000 to <1 million), and large (≥1 million). We defined annual pediatric emergency volume using criteria from the NPRP assessment, categorized as low volume (<1800 annual pediatric visits), medium volume (1800–4999 annual visits), medium-high volume (5000–9999 annual visits), and high volume (≥10 000 annual visits). We identified the availability of a dedicated pediatric ED, pediatric inpatient unit, or PICU directly from American Hospital Association data.

Primary Analysis

For our analysis we categorized hospitals by quartiles of pediatric readiness. We compared hospital and patient characteristics across quartiles using χ^2 tests for categorical data and Kruskal-Wallis tests for continuous data. We examined the independent relationship between pediatric readiness and episode mortality by fitting a multivariable logistic regression model in which the dependent variable was mortality and the independent variables were WPRS quartile (modeled as an indicator covariate) as well as a priori–specified patient-level confounders, including age, modeled as a continuous variable; complex chronic conditions,[13,15] modeled as individual indicator covariates; and severity of illness, modeled as an ordered categorical variable. We accounted for clustering by hospital using robust SEs. Results from this model are presented as adjusted odds ratios, with hospitals in the lowest quartile of readiness being the reference category.

In addition to the quartile analysis, we modeled the relationship between mortality and WPRS as a continuous variable using fractional polynomials. Fractional polynomials are a method of operationalizing continuous variables without a priori specifying their functional form, allowing the data to determine the best-fitting polynomial function and avoiding the use of arbitrary cut points.[16] Our goal with this modeling was to provide a more nuanced understanding of the relationship between the WPRS and mortality. This model was fit similarly to the regression model described above with the exception of using fractional polynomials for the WPRS. The results are shown in a figure of the relationship between the predicted mortality rate (on the y-axis) and the WPRS (on the x-axis).

Condition-Specific Analyses

We also performed analyses on 3 prespecified diagnostic conditions: cardiac arrest, sepsis, and traumatic brain injury (TBI), defined by using previously used ICD-9-CM diagnosis and procedure codes (Supplemental Table 5).[17–19] We chose these conditions because these patients are likely to benefit from timely, specialized care in the ED. We also considered examining asthma as a fourth diagnostic condition,[20] but preliminary analyses revealed patients with asthma experienced low mortality, precluding further analysis. For each diagnostic condition, we fit separate logistic regression models among patients with each condition. As in the primary analysis, we analyzed WPRS both as quartiles (using the same quartile cut points as the primary analysis) and as fractional polynomials.

Statistical analyses were performed by using Stata version 15.1 (Stata Corp, College Station, TX). All statistical tests were 2 sided, and significance was set at $P < .05$. This project was deemed to be exempt human subjects research by the University of Pittsburgh Human Research Protections Office.

RESULTS

Of 37 304 episodes of pediatric critical illness in the study sample, 20 483 episodes in 426 hospitals met all inclusion criteria (Fig 1). Most exclusions were for inpatient episodes not originating in an ED (13 775 episodes), whereas a smaller number (2698 episodes in 104 hospitals) were excluded because the hospital did not respond to the NPRP assessment. A comparison of hospital characteristics between NPRP assessment responders and nonresponders is shown in Supplemental Table 6. Compared with nonresponding hospitals, responding hospitals tended to be smaller and located in smaller communities.

Among hospitals in the final sample, the WPRS ranged from 29.6 to 100.0 with a median of 74.8 (interquartile range: 59.3–88.2). Hospital characteristics by quartile of the WPRS of the presenting hospital are shown in Table 1. Compared with hospitals with higher scores, hospitals with lower scores were more often small hospitals, nonteaching hospitals, and located in smaller communities. Hospitals with lower scores were also less likely to have a dedicated pediatric ED, pediatric inpatient unit, and/or PICU. Patient characteristics by quartile of the WPRS of the presenting hospital are shown in Table 2. Less than 5% (4.3%; n = 879) of patients presented to hospitals in the lowest quartile, whereas 68.6% (n = 14 059) presented to hospitals in the highest quartile. Compared with patients presenting to hospitals with a higher WPRS, patients presenting to hospitals with a lower WPRS were older and had fewer complex chronic conditions. Unadjusted mortality was 3.4% of those patients presenting to hospitals in the highest quartile of WPRS compared with 11.1% of those presenting to hospitals in the lowest quartile of WPRS ($P < .001$ for trend). Among decedents, most died during the initial ED encounter rather than as an inpatient or after transfer to another hospital (Supplemental Table 7).

In our regression analysis adjusting for patient characteristics, we found that presentation to a hospital in a quartile with higher readiness scores was associated with lower odds of death (Table 3). This relationship was dose dependent, with mortality decreasing as the quartile of pediatric readiness score increased.

The relationship between WPRS modeled as a continuous variable and predicted mortality rate is shown in Fig 2. As in the quartile analysis, we found that mortality generally decreased as WPRS increased. An exception was for hospitals with a WPRS <50, for which an increasing score was associated with increasing mortality. Investigating this finding further, we found that among the hospitals in our cohort, only 61 (14.4%) had scores at or below this inflection point. These hospitals had an average of 5.6 ± 7.9 episodes (range 1–49), whereas hospitals above the inflection point had an average of 51.0 ± 113.7 episodes (range 1–851).

The results of the condition-specific analyses are presented in Table 3 and Fig 3. These results are consistent with our primary analysis and show decreasing risk-adjusted mortality with an increasing readiness score, although because of small sample sizes, only the results for TBI were statistically significant.

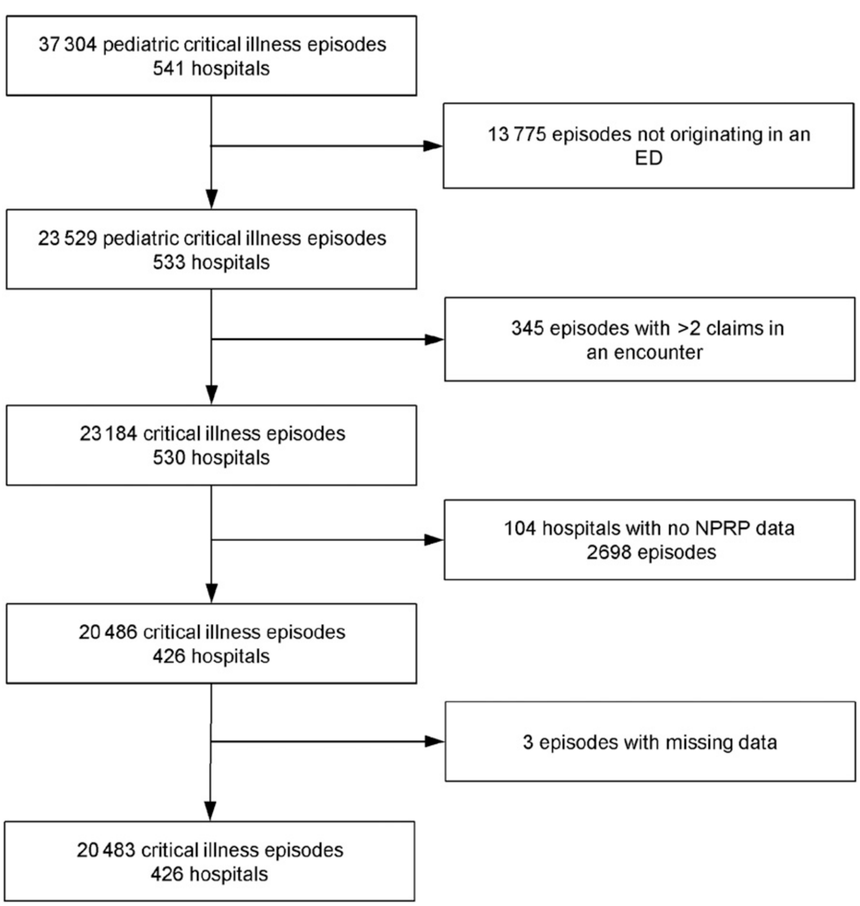

FIGURE 1
Flowchart of emergency care episodes in the study.

TABLE 1 Hospital Characteristics by Quartile of Pediatric Readiness as Measured by the WPRS

Characteristic	Quartile 1, *N* = 107	Quartile 2, *N* = 106	Quartile 3, *N* = 107	Quartile 4, *N* = 106	*P*
WPRS					
Range	29.6–59.3	59.4–74.8	74.9–88.0	88.2–99.9	—
Mean ± SD	48.2 ± 6.4	66.9 ± 4.4	81.5 ± 3.7	95.0 ± 3.6	—
Median (IQR)	49.3 (43.0–53.2)	67.0 (62.8–70.5)	81.4 (78.2–84.6)	95.0 (92.5–98.3)	—
Size, hospital beds, frequency (%)					<.001
>250	11 (10.3)	15 (14.2)	30 (28.0)	71 (67.0)	
100–250	19 (17.8)	35 (33.0)	49 (45.8)	28 (26.4)	
<100	77 (72.0)	56 (52.8)	28 (26.2)	7 (6.6)	
Teaching status, frequency (%)					<.001
Large teaching	4 (3.7)	3 (2.8)	19 (17.8)	43 (40.6)	
Small teaching	9 (8.4)	22 (20.8)	18 (16.8)	33 (31.1)	
Nonteaching	94 (87.9)	81 (76.4)	70 (65.4)	30 (28.3)	
Community size, frequency (%)					<.001
Large	16 (15.0)	29 (27.4)	44 (41.1)	72 (67.9)	
Medium	31 (29.0)	29 (27.4)	33 (30.8)	28 (26.4)	
Small	60 (56.1)	48 (45.3)	30 (28.0)	6 (5.7)	
Pediatric capabilities, frequency (%)					
Pediatric ED	11 (10.3)	14 (13.2)	22 (20.6)	60 (56.6)	<.001
Pediatric inpatient unit	26 (24.3)	32 (30.2)	44 (41.1)	71 (67.0)	<.001
PICU	2 (1.9)	2 (1.9)	11 (10.3)	43 (40.6)	<.001
Annual pediatric ED volume, frequency (%)					<.001
High	3 (2.8)	7 (6.6)	19 (17.8)	62 (58.5)	
Medium-high	14 (13.1)	13 (12.3)	22 (20.6)	20 (18.9)	
Medium	26 (24.3)	34 (32.1)	37 (34.6)	16 (15.1)	
Low	64 (59.8)	52 (49.1)	29 (27.1)	8 (7.5)	

IQR, interquartile range; —, not applicable.

DISCUSSION

In a multistate cohort study of pediatric ED encounters, we found that critically ill children presenting to hospitals with a higher WPRS had lower odds of death compared with those presenting to hospitals with a lower WPRS. Similar findingswere also observed when we examined condition-specific groups of critically ill children. The results of our analysis using fractional polynomials suggested that mortality also decreased in hospitals with low readiness scores. However, the

TABLE 2 Patient Characteristics by Quartile of the WPRS of the Presenting Hospital

Characteristic	Quartile 1, *N* = 879	Quartile 2, *N* = 1903	Quartile 3, *N* = 3642	Quartile 4, *N* = 14c059	*P*
Age, y, mean ± SD	8.5 ± 6.6	9.6 ± 6.0	6.9 ± 6.2	7.0 ± 5.9	<.001
Female sex, frequency (%)	355 (40.4)	848 (44.6)	1562 (42.9)	6262 (44.5)	.04
Race, frequency (%)					<.001
White	514 (58.5)	674 (35.4)	1433 (39.3)	4904 (34.9)	
African American	90 (10.2)	366 (19.2)	804 (22.1)	4053 (28.8)	
Hispanic	64 (7.3)	160 (8.4)	671 (18.4)	2918 (20.8)	
Other	79 (9.0)	102 (5.4)	540 (14.8)	1798 (12.8)	
Missing	132 (15.0)	601 (31.6)	194 (5.3)	386 (2.7)	
Chronic conditions, frequency (%)					<.001
0	608 (69.2)	1364 (71.7)	2341 (64.3)	7701 (54.8)	
1	148 (16.8)	319 (16.8)	649 (17.8)	2645 (18.8)	
2 or more	123 (14.0)	220 (11.6)	652 (17.9)	3713 (26.4)	
ED severity score,[a] frequency (%)					<.001
1 (least severe)	6 (0.7)	(0.0)	3 (0.1)	18 (0.1)	
2	33 (3.8)	55 (2.9)	186 (5.1)	751 (5.3)	
3	355 (40.4)	674 (35.4)	1375 (37.8)	4900 (34.9)	
4	298 (33.9)	905 (47.6)	1407 (38.6)	5723 (40.7)	
5 (most severe)	107 (12.2)	160 (8.4)	416 (11.4)	1473 (10.5)	
Missing	80 (9.1)	109 (5.7)	255 (7.0)	1194 (8.5)	
Subgroups, frequency (%)					
Cardiac arrest	48 (5.5)	58 (3.0)	85 (2.3)	193 (1.4)	<.001
Sepsis	7 (0.8)	24 (1.3)	58 (1.6)	368 (2.6)	<.001
TBI	76 (8.6)	86 (4.5)	184 (5.1)	677 (4.8)	<.001
In-episode mortality, frequency (%)	98 (11.1)	103 (5.4)	178 (4.9)	483 (3.4)	<.001

[a] See Table 1.

TABLE 3 Adjusted Relationship Between the WPRS of the Presenting Hospital and In-Hospital Mortality

Cohort	Quartile 1	Quartile 2, Odds Ratio (95% Confidence Interval)	Quartile 3, Odds Ratio (95% Confidence Interval)	Quartile 4, Odds Ratio (95% Confidence Interval)
All patients, n = 18 818	Referent	0.52 (0.30–0.90); P = .018	0.36 (0.22–0.58); $P <$ .001	0.25 (0.18–0.37); $P <$ .001
Patients by subgroup				
Cardiac arrest, n = 377	Referent	0.70 (0.05–10.78); P = .802	0.22 (0.02–2.57); P = .229	0.23 (0.02–2.16); P = .198
Sepsis, n = 419	Referent	1.84 (0.12–29.21); P = .666	0.57 (0.05–7.11); P = .662	0.59 (0.05–7.31); P = .680
TBI, n = 729	Referent	0.62 (0.12–3.12); P = .560	0.72 (0.19–2.73); P = .629	0.21 (0.06–0.78); P = .020

smaller numbers of hospitals and episodes below the inflection point and the associated wide confidence intervals indicate that this finding should be interpreted with caution.

Although several previous studies demonstrate that hospitals vary widely in their ability to care for pediatric emergencies,[6,21,22] to date, few studies have evaluated the effect of pediatric readiness on patient outcomes. Previous data suggest that care at specialized pediatric trauma centers is associated with lower mortality after severe traumatic injury,[4,23] and management in high-volume PICUs is associated with lower mortality in pediatric critical illness.[24,25] Our study expands on this literature by demonstrating an association between hospital-level capabilities for pediatric emergencies and mortality for critically ill children.

Our findings have important implications for pediatric emergency and critical care delivery in the United States. Primarily, our findings suggest that patient outcomes may be improved by increasing the readiness of hospitals to care for pediatric emergencies. As detailed in previous work, the most common reasons for low readiness scores are lack of implementation of ED policies dedicated to children, lack of quality-improvement efforts, and absence of

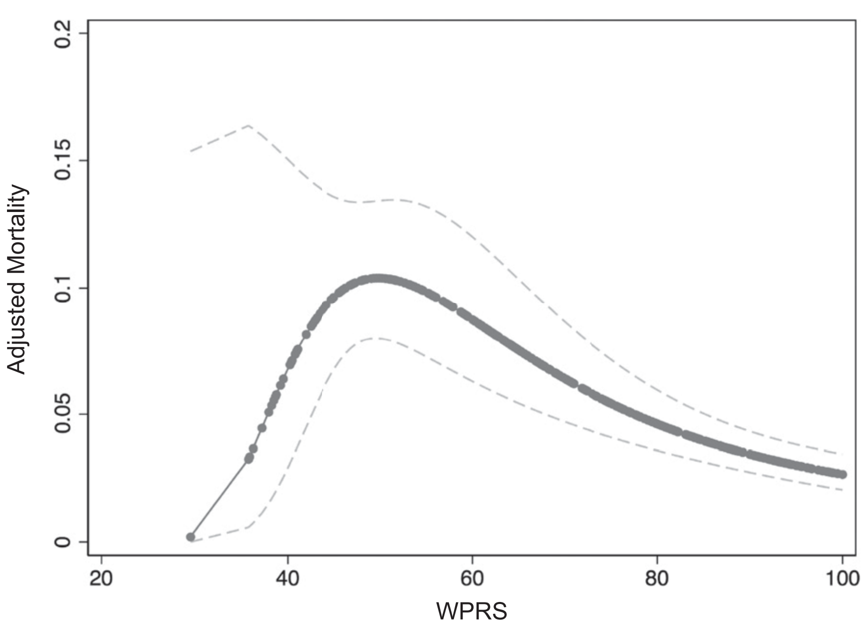

FIGURE 2
Relationship between mortality and the WPRS modeled as a continuous variable by using fractional polynomials. The solid line represents the predicted relationship, with dots indicating the predictions at observed scores. The dashed lines represent 95% confidence intervals.

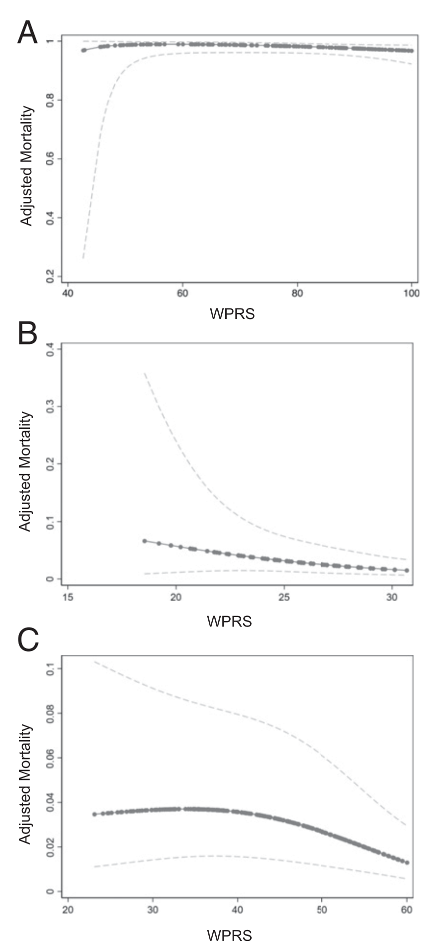

FIGURE 3
Relationship between mortality and the WPRS for specific condition subgroups modeled as continuous variables by using fractional polynomials. The solid lines represent the predicted relationships, with dots indicating the predictions at observed scores. The dashed lines represent 95% confidence intervals. A, Cardiac arrest. B, Sepsis. C, TBI.

a dedicated pediatric emergency care coordinator,[9,26] all of which are plausibly related to patient outcomes. Other factors likely to impact outcomes may include availability of pediatric resuscitation equipment, use of a medication chart or length-based tape for medication dosing, and written interfacility guidelines for transfer to a center with more pediatric capabilities.

Efforts to address these deficits might include local and state collaborations designed to provide shared resources, such as educational materials, pediatric-focused policies, collaborative quality-improvement activities, and appointment of pediatric emergency care coordinators.[27–29] Although these efforts are difficult and resource intensive, our findings suggest that they have the potential to improve clinical outcomes, particularly for children at high risk.

Our study also provides support for alternative approaches to expanding access to high-quality pediatric emergency care, such as regionalization and telemedicine. Under a system of regionalized pediatric emergency care, selected children at high risk would be systematically triaged and transferred to designated centers of pediatric readiness.[30] With pediatric emergency telemedicine, the expertise of regional referral centers is delivered to community hospitals via a real-time audiovisual link.[31] Early data suggest a potential role for both regionalization and telemedicine as strategies for improving the outcomes of severely ill children presenting to small, rural, community hospitals.[32–34] More work is needed to identify the barriers to adopting these approaches and to develop strategies to effectively incorporate them into the pediatric emergency care landscape.[35–37]

There are limitations to our study. First, we used administrative data, which lack granular clinical risk-adjustment variables, such as vital signs and laboratory results, which could result in unmeasured confounding. However, high-readiness hospitals would be expected to see patients with greater complexity and severity of illness than other hospitals,[22] meaning our results are a conservative estimate of the benefit of presentation to a high-readiness hospital. In addition, there were baseline imbalances in ethnicity and severity of illness across quartiles of readiness scores, although not to such a degree that the multivariable models could not address confounding by these variables. Also, the use of mortality as an outcome measure may not be a sensitive marker of quality care in many pediatric conditions for which mortality rates are low. Future condition-specific analyses for conditions with low mortality rates should focus on other outcomes, such as length of stay or development of new morbidities. In addition, our definition of critical illness may have missed patients who were dead on arrival to the ED or critically ill patients admitted to hospitals without an ICU. Our study was further limited by the availability and quality of NPRP assessment data, which are available for 82.7% of hospitals in the United States and 80.8% of hospitals in our study. It is possible NPRP responders differed from nonresponders in ways that could bias our results, making it difficult to draw conclusions about hospitals that did not participate. In addition, the assessment is a self-reported reflection of hospital pediatric capabilities, and no validation was performed to confirm the accuracy of responses.

CONCLUSIONS

Presentation to a hospital with lower pediatric readiness is associated with increased risk of death for children with critical illness. Efforts are needed to improve the pediatric readiness of EDs that care for children, ensuring critically ill children have access to timely, well-resourced, and effective emergency care.

ABBREVIATIONS

ED: emergency department
HCUP: Healthcare Cost and Utilization Project
ICD-9-CM: *International Classification of Diseases 9th Revision*: *Clinical Modification*
NPRP: National Pediatric Readiness Project
SEDD: State Emergency Department Databases
SID: State Inpatient Databases
TBI: traumatic brain injury
WPRS: weighted pediatric readiness score

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REFERENCES

1. Sun R, Karaca Z, Wong HS. Trends in Hospital Emergency Department Visits by Age and Payer, 2006-2015: Statistical Brief #238. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville, MD: Agency for Healthcare Research and Quality; 2018
2. McDermott KW, Stocks C, Freeman WJ. Overview of Pediatric Emergency Department Visits, 2015: Statistical Brief #242. In: *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. Rockville, MD: Agency for Healthcare Research and Quality; 2015
3. Hansen M, Fleischman R, Meckler G, Newgard CD. The association between hospital type and mortality among critically ill children in US EDs. *Resuscitation*. 2013;84(4):488–491
4. Potoka DA, Schall LC, Gardner MJ, et al. Impact of pediatric trauma centers on mortality in a statewide system. *J Trauma*. 2000;49(2):237–245
5. Hampers LC, Trainor JL, Listernick R, et al. Setting-based practice variation in the management of simple febrile seizure. *Acad Emerg Med*. 2000;7(1):21–27
6. Athey J, Dean JM, Ball J, Wiebe R, Melese-d'Hospital I. Ability of hospitals to care for pediatric emergency patients. *Pediatr Emerg Care*. 2001;17(3):170–174
7. Sullivan AF, Rudders SA, Gonsalves AL, et al. National survey of pediatric services available in US emergency departments. *Int J Emerg Med*. 2013;6(1):13
8. American Academy of Pediatrics; Committee on Pediatric Emergency Medicine; American College of Emergency Physicians; Pediatric Committee; Emergency Nurses Association Pediatric Committee. Joint policy statement–guidelines for care of children in the emergency department. *Pediatrics*. 2009;124(4):1233–1243
9. Gausche-Hill M, Ely M, Schmuhl P, et al. A national assessment of pediatric readiness of emergency departments. *JAMA Pediatr*. 2015;169(6):527–534
10. Ray KN, Olson LM, Edgerton EA, et al. Access to high pediatric-readiness emergency care in the United States. *J Pediatr*. 2018;194:225–232.e1
11. Potoka DA, Schall LC, Ford HR. Improved functional outcome for severely injured children treated at pediatric trauma centers. *J Trauma*. 2001;51(5):824–832–834
12. Carcillo JA, Kuch BA, Han YY, et al. Mortality and functional morbidity after use of PALS/APLS by community physicians. *Pediatrics*. 2009;124(2):500–508
13. Feudtner C, Christakis DA, Connell FA. Pediatric deaths attributable to complex chronic conditions: a population-based study of Washington State, 1980-1997. *Pediatrics*. 2000;106(1, pt 2):205–209
14. Alessandrini EA, Alpern ER, Chamberlain JM, et al; Pediatric Emergency Care Applied Research Network. Developing a diagnosis-based severity classification system for use in emergency medical services for children. *Acad Emerg Med*. 2012;19(1):70–78
15. Edwards JD, Houtrow AJ, Vasilevskis EE, et al. Chronic conditions among children admitted to U.S. pediatric intensive care units: their prevalence and impact on risk for mortality and prolonged length of stay*. *Crit Care Med*. 2012;40(7):2196–2203
16. Royston P, Altman DG. Regression using fractional polynomials of continuous covariates: parsimonious parametric modeling. *Appl Stat*. 1994;43:429–467
17. Balamuth F, Weiss SL, Neuman MI, et al. Pediatric severe sepsis in U.S. children's hospitals. *Pediatr Crit Care Med*. 2014;15(9):798–805
18. Bennett TD, Riva-Cambrin J, Keenan HT, Korgenski EK, Bratton SL. Variation in intracranial pressure monitoring and outcomes in pediatric traumatic brain injury. *Arch Pediatr Adolesc Med*. 2012;166(7):641–647
19. Dombrovskiy VY, Martin AA, Sunderram J, Paz HL. Rapid increase in hospitalization and mortality rates for severe sepsis in the United States: a trend analysis from 1993 to 2003. *Crit Care Med*. 2007;35(5):1244–1250
20. Grana J, Preston S, McDermott PD, Hanchak NA. The use of administrative data to risk-stratify asthmatic patients. *Am J Med Qual*. 1997;12(2):113–119
21. Kessler DO, Walsh B, Whitfill T, et al. Disparities in adherence to pediatric sepsis guidelines across a spectrum of emergency departments: a multicenter, cross-sectional observational in situ simulation study. *J Emerg Med*. 2016;50(3):403–415–3
22. Bourgeois FT, Shannon MW. Emergency care for children in pediatric and general emergency departments. *Pediatr Emerg Care*. 2007;23(2):94–102
23. Sathya C, Alali AS, Wales PW, et al. Mortality among injured children treated at different trauma center types. *JAMA Surg*. 2015;150(9):874–881
24. Markovitz BP, Kukuyeva I, Soto-Campos G, Khemani RG. PICU volume and outcome: a severity-adjusted analysis. *Pediatr Crit Care Med*. 2016;17(6):483–489
25. Marcin JP, Song J, Leigh JP. The impact of pediatric intensive care unit volume on mortality: a hierarchical instrumental variable analysis. *Pediatr Crit Care Med*. 2005;6(2):136–141
26. Pilkey D, Edwards C, Richards R, Olson LM, Ely M, Edgerton EA. Pediatric readiness in critical access hospital emergency departments [published online ahead of print July 30, 2018]. *J Rural Health*. doi:10.1111/jrh.12317

27. Whitfill T, Gawel M, Auerbach M. A simulation-based quality improvement initiative improves pediatric readiness in community hospitals. *Pediatr Emerg Care*. 2018;34(6):431–435

28. Barata IA, Stadnyck JM, Akerman M, et al. Novel approach to emergency departments' pediatric readiness across a health system [published online ahead of print February 5, 2018]. *Pediatr Emerg Care*. doi:10.1097/PEC.0000000000001385

29. Rice A, Dudek J, Gross T, St Mars T, Woolridge D. The impact of a pediatric emergency department facility verification system on pediatric mortality rates in Arizona. *J Emerg Med*. 2017;52(6):894–901

30. Lorch SA, Myers S, Carr B. The regionalization of pediatric health care. *Pediatrics*. 2010;126(6):1182–1190

31. Heath B, Salerno R, Hopkins A, Hertzig J, Caputo M. Pediatric critical care telemedicine in rural underserved emergency departments. *Pediatr Crit Care Med*. 2009;10(5):588–591

32. Ramnarayan P, Thiru K, Parslow RC, et al. Effect of specialist retrieval teams on outcomes in children admitted to paediatric intensive care units in England and Wales: a retrospective cohort study. *Lancet*. 2010;376(9742):698–704

33. Dharmar M, Romano PS, Kuppermann N, et al. Impact of critical care telemedicine consultations on children in rural emergency departments. *Crit Care Med*. 2013;41(10):2388–2395

34. Dharmar M, Marcin JP, Romano PS, et al. Quality of care of children in the emergency department: association with hospital setting and physician training. *J Pediatr*. 2008;153(6):783–789

35. Horeczko T, Marcin JP, Kahn JM, Sapien RE; Consortium Of Regionalization Efforts in Emergency Medical Services for Children (CORE-EMSC). Urban and rural patterns in emergent pediatric transfer: a call for regionalization. *J Rural Health*. 2014;30(3):252–258

36. Ray KN, Felmet KA, Hamilton MF, et al. Clinician attitudes toward adoption of pediatric emergency telemedicine in rural hospitals. *Pediatr Emerg Care*. 2017;33(4):250–257

37. Uscher-Pines L, Kahn JM. Barriers and facilitators to pediatric emergency telemedicine in the United States. *Telemed J E Health*. 2014;20(11):990–996

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