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Impact of Individual Components of Emergency Department Pediatric Readiness on Pediatric Mortality in US Trauma Centers

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Dr. Remick had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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Acquisition, analysis, or interpretation of data: Newgard, Smith, Lin, Cook, Kuppermann, Ames, Malveau, Jensen, Ford, Dai, Auerbach, Glass, Jenkins, Fallat, Hewes, Mann.

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Abstract

Background: Injured children initially treated at trauma centers with high emergency department (ED) pediatric readiness have improved survival. Centers with limited resources may not be able to address all pediatric readiness deficiencies and there currently is no evidence-based guidance for prioritizing different components of readiness. The objective of this study was to identify individual components of ED pediatric readiness associated with better-than-expected survival in US trauma centers to aid in the allocation of resources targeted at improving pediatric readiness.

Methods: This cohort study of U.S. trauma centers used the National Trauma Data Bank (2012-2017) matched to the 2013 National Pediatric Readiness Project assessment. Adult and pediatric centers treating at least 50 injured children (age <18 years) and recording at least one death during the 6-year study period were included. Using a standardized risk-adjustment model for trauma, we calculated the observed-to-expected (O/E) mortality ratio for each trauma center. We used bivariate analyses and multivariable linear regression to assess for associations between individual components of ED pediatric readiness and better-than-expected survival.

Results: Among 555 trauma centers, the O/E mortality ratios ranged from 0.07 to 4.17 (IQR 0.93, 1.14). Unadjusted analyses of 23 components of ED pediatric readiness showed that trauma centers with better-than-expected survival were more likely to have a validated pediatric triage tool, comprehensive quality improvement processes, a pediatric-specific disaster plan, and critical airway and resuscitation equipment (all $p < 0.03$). The multivariable analysis demonstrated that trauma centers with both a physician and a nurse pediatric emergency care coordinator had better-than-expected survival, but this association weakened after accounting for trauma center level. Child maltreatment policies were associated with lower-than-expected survival, particularly in Level III-V trauma centers.

Conclusion: Specific components of ED pediatric readiness were associated with pediatric survival among US trauma centers.

Level of Evidence: Care management, level III.

Social Media Summary:

A recent study of 555 US trauma centers demonstrated lower mortality risk among injured children is associated with presence of a validated pediatric triage tool, a comprehensive quality improvement process, and presence of nurse and physician pediatric emergency care coordinators.

Keywords

Pediatric readiness; mortality; pediatric injury; trauma centers

BACKGROUND

Injury remains the leading cause of death in children older than one year in the United States.[1] The development of trauma centers and trauma systems has led to improved survival in adults and children.[2–6] Despite the resources required of trauma centers, considerable variation persists across trauma center emergency departments (EDs) in the resources

needed to effectively treat injured children.[7] While children have improved survival when treated at pediatric trauma centers compared to adult or mixed trauma centers,[2] 43% of children in the US live greater than 30 miles from a level 1 or level 2 pediatric trauma center.[8] In the absence of proximate pediatric trauma centers, injured children rely on adult trauma centers with variable pediatric capabilities for initial resuscitation and stabilization.

To address large variability in the emergency and trauma care of children, the Emergency Medical Services for Children (EMSC) program created the National Pediatric Readiness Project (NPRP), a national quality improvement initiative. Emergency department pediatric readiness represents the preparedness of EDs to care for acutely ill and injured children, as measured through 6 domains (administrative oversight and coordination, provider training, quality improvement, safety, policies and procedures, and equipment and supplies).[9] The components of pediatric readiness were developed for all EDs, regardless of access to tertiary care resources or inpatient capabilities. A composite score, termed the weighted Pediatric Readiness Score (wPRS), was developed using the components of ED readiness.[10] The wPRS has been used to quantify large variability in ED readiness across US hospitals and trauma centers.[7,9] Using the same measure, recent studies have shown that high ED pediatric readiness in US trauma centers is associated with improved short- and long-term survival among injured children.[11,12] However, the individual components of ED readiness that drive the improvement in survival are unknown. Because ED pediatric readiness is being integrated to the new verification criteria for trauma centers, determining the most important aspects of readiness could help guide implementation and improvement processes.[13]

In this study, we postulated that the survival benefit derived from higher wPRS at US trauma centers is attributable to specific components of ED pediatric readiness. To test this hypothesis and provide guidance to EDs lacking in pediatric readiness, we examined the association between individual components of ED pediatric readiness and the mortality risk of injured children.

METHODS

Study design:

We performed a secondary analysis of a cohort study approved by institutional review boards at participating universities, which waived the requirement for informed consent. We used the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline for cohort studies.[14]

Study Setting and Participants:

The parent cohort included injured children 0-17 years cared for in 832 trauma centers (Level I – V, adult, pediatric, and mixed) matched to the 2013 National Pediatric Readiness Project (NPRP) assessment in 50 states and the District of Columbia submitting data to the National Trauma Data Bank (NTDB) from 1/1/2012 through 12/31/2017.[11] For the current study, we limited the sample to trauma centers that cared for at least 50 children during the 6-year study period, had at least one death, and matched to the American Hospital

Association Annual Survey[15] to provide additional hospital-level characteristics (Figure 1). This resulted in inclusion of 555 unique trauma centers.

Variables:

The primary exposure variables included components of ED pediatric readiness from six domains, as measured through 55 questions included in the NPRP assessment.[9] The NPRP assessment was a national assessment of EDs providing emergency care 24 hours per day 7 days per week, based on national ED guidelines for the care of children. Nurse Managers completed the assessments in 2013, with an 83% response rate (4,149 EDs).[9] We linked the NPRP assessment data to the initial trauma center record using hospital name, address, and zip code.

We created additional ED- and hospital-level variables using data derived from the NPRP assessment, the AHA annual survey, and NTDB. These variables included trauma center level (I-V), trauma center type (adult, pediatric and mixed), annual ED pediatric volume, annual pediatric trauma volume, hospital ownership and accreditation, ED configuration, pediatric inpatient capabilities, hospital resources, staffing, and urbanicity.

Outcomes:

The primary outcome was the ratio of observed-to-expected (O/E) mortality for each trauma center. We calculated the expected mortality for each hospital using patient-level data and a standardized risk-adjustment model for trauma.[16] We modified this model for children using a hierarchical random effects multivariable logistic regression model to account for differences in ED case mix and clustering by the initial ED.[11] Patient-level covariates included: demographics, initial age-adjusted blood pressure and the Glasgow Coma Scale (GCS) score, emergent airway intervention, blood transfusion, mechanism of injury, injury severity score, transfer status, and mode of ED arrival (eTable 1).

Statistical Analysis:

We evaluated 145 potential predictors for association with O/E mortality, including non-modifiable ED- and hospital-level characteristics. The unit of analysis was the hospital and the outcome was O/E mortality. We consolidated information from the 55 ED readiness questions (representing over 80 different aspects of readiness) into 23 components from the 6 domains and used the bivariate analysis to evaluate these aspects of readiness. The 6 domains of pediatric readiness are: Administration and Coordination; Quality Improvement; Pediatric Competencies of Staff; Patient Safety; Policies, Protocols and Procedures; and Equipment, Supplies, and Medications. Because we considered the multivariable model exploratory to identifying the key aspects of ED readiness, we used several approaches. We initially used multivariable linear regression to evaluate a model with all 23 components of ED pediatric readiness. We then performed a bidirectional stepwise selection of variables, with entry criterion of $p < 0.2$ and stay criterion of $p < 0.1$. As a sensitivity analysis, we evaluated a model with the 23 components of ED readiness and trauma center level included as a fixed variable. We also evaluated models stratified by trauma center level. Significance was set at a p-value of 0.05. We conducted all statistical analyses using SAS 9.4 (SAS Institute; Cary, NC).

RESULTS

Among the 555 trauma centers included in the analysis (Figure 1), the O/E mortality ratio ranged from 0.07 to 4.17 (median 1.00; IQR 0.93, 1.14) (Figure 2). Overall unadjusted mortality in the cohort was 1.59%. Characteristics of trauma centers by O/E mortality ratio are shown in Table 1. Of the 555 centers, 288 (51.9%) had an O/E mortality ratio of less than 1 indicating lower than expected mortality (better-than-expected survival). Several non-modifiable facility characteristics were associated with lower O/E ratios, including pediatric ED configuration, presence of a pediatric intensive care unit, higher pediatric volume, trauma center level and type, and urban location (Table 1).

In Table 2, we present results from the bivariate analysis of ED pediatric readiness components by O/E mortality ratio. Readiness factors associated with better-than-expected survival included use of a validated triage tool, presence of a pediatric-specific disaster plan, more robust quality improvement (QI) processes, and stocking more pediatric-specific airway and resuscitation equipment (Table 2). Conversely, higher prevalence of a child maltreatment plan was associated with hospitals having lower-than-expected survival.

We show results from the multivariable analysis in Table 3. The presence of both a physician pediatric emergency care coordinator (PECC) and a nurse PECC was independently associated with better-than-expected survival (0.92, 95% CI 0.85-0.99), while the presence of a child maltreatment policy was associated with worse survival (1.17, 95% CI 1.06-1.30). No other variables reached the predefined level of significance in the model. In the stepwise selection model, the association of having physician and nurse PECCs (0.90, 95% CI 0.84-0.96) and presence of a child maltreatment policy (1.15, 95% CI 1.05-1.25) remained unchanged. In a sensitivity analysis that included trauma center level in the model, the association between PECCs and improved survival weakened ($p = 0.19$), while the association of a child maltreatment policy and worse survival persisted ($p = 0.04$). Trauma centers with Level 1-2 designation (pediatric or adult) had better-than-expected survival in the model (0.85, 95% CI 0.79-0.91).

To further evaluate these findings, we analyzed similar multivariable models of ED pediatric readiness components, stratified by trauma center (Table 4). The point estimates for having a physician and nurse PECC were similar to the overall model (for Level 1-2 centers, 0.93, 95% CI 0.86-1.00; for Level 3-5 centers, 0.93, 95% CI 0.77-1.11), but were no longer statistically significant. The association of hospital accreditation with higher O/E was limited to Level 1-2 hospitals (1.47, 95% CI 1.18-1.79), while the association of a child maltreatment policy with higher O/E was isolated to Level 3-5 hospitals (1.57, 95% CI 1.16-2.10). In eTable 2, we present a bivariate analysis of trauma center characteristics by the presence of a child maltreatment policy. These results show that hospitals with a child maltreatment policy tended to have greater inpatient pediatric resources, over-represented Level 3-5 hospitals, and had a greater proportion of hospitals serving rural and suburban regions.

DISCUSSION

In follow-up to two studies showing that high ED readiness is independently associated with short- and long-term survival among injured children treated at US trauma centers,[11,12] this study is the first to evaluate individual components of ED pediatric readiness and survival. Several ED readiness factors were associated with improved survival in unadjusted analyses, including a validated triage tool, a pediatric disaster plan, quality improvement processes, and having comprehensive airway and resuscitation supplies. While the presence of a PECC was not associated with survival in unadjusted analyses (as a 3-category variable), the combined presence of physician and nurse PECCs emerged as an important factor in the multivariable model predicting better-than-expected survival. These components of pediatric readiness may serve as targeted areas of focus for trauma centers seeking to optimize pediatric survival (Table 5).

Survival from pediatric trauma is multifactorial and includes injury characteristics, patient-level factors, fixed facility factors (e.g., trauma center level and type[2,5,6]), and modifiable factors, such as ED pediatric readiness. While injury severity and other patient-level factors likely account for much of the variance found in pediatric injury mortality, different trauma center characteristics are also associated with pediatric outcomes after injury.[2,5,6] The components of ED readiness are designed as modifiable factors that can be implemented in all EDs, regardless of inpatient resources, trauma level, or hospital type. Our results suggest that EDs lacking pediatric readiness should prioritize the implementation of certain components of readiness. The goal is to have all US trauma centers prepared to care for children through a high level of ED pediatric readiness, which has been independently associated with pediatric survival.[11,12] However, the process for reaching a high level of ED readiness will be gradual in many centers. One of the primary barriers to increasing pediatric readiness is resource availability, particularly in rural and remote settings where pediatric trauma centers are uncommon.[17,18] Prioritizing specific components of pediatric readiness may allow lower-resourced trauma centers to target the factors most likely to improve outcomes of injured children.

Previous studies have demonstrated the importance of a PECC in improving overall pediatric readiness.[2,5] To our knowledge, this is the first study to suggest that the presence of both physician and nurse PECCs at trauma centers may be associated with improved survival, although the finding was not consistent across all analyses. Adding trauma center level to the model weakened the statistical association between PECCs and survival, which may reflect other aspects of major trauma centers that incorporate the PECC role or the relatively lower influence of the PECC role compared to trauma center level. While many trauma centers have a standard model for staffing that includes a trauma program manager, oversight of ED pediatric readiness may not be incorporated into this role. Our findings also highlight the leadership role of PECCs, who are instrumental in implementing many other aspects of ED pediatric readiness to improve pediatric emergency and trauma care.

The bivariate analysis showed that a validated triage tool, pediatric disaster plan, quality improvement processes, and stocking important airway and resuscitation supplies were associated with improved survival. Previous studies have demonstrated the presence of a

quality improvement plan to be associated with the presence of a PECC and overall pediatric readiness.[9,10] However, the relationship between these factors and improved survival did not persist in multivariable analyses. It is possible that these components of readiness are closely linked to the presence of a PECC (who can be instrumental in implementing such processes and supplies), which was reflected when all components were entered into a model.

The finding that child maltreatment policies were more common in trauma centers with higher-than-expected mortality was unexpected. This finding may be related to the high overall prevalence (86%) of these policies among trauma centers, hospitals that see a disproportionate share of child maltreatment cases (with an inherently higher mortality rate), or as a marker of other less beneficial hospital- and system-level factors. Further sensitivity analysis of ED and hospital variables demonstrated that this association was most notable among Level 3-5 trauma centers. Child maltreatment policies are intended to improve pediatric care and have been integrated to the trauma center verification criteria. This association will require further research to elucidate, including whether the presence of a child maltreatment policy is a surrogate marker for other factors associated with child mortality. Trauma centers are currently required to have protocols for the evaluation of child maltreatment and multiple national trauma organizations have published guidelines and best practices for such policies.[19–21] The recent integration of ED pediatric readiness into trauma verification standards[13] should also help in this regard.

Our study has several limitations. We restricted the sample to trauma centers caring for at least 50 children over the 6-year period, which was necessary for the stability of estimates and calculating the O/E mortality ratio. This process excluded low volume centers, which tend to have lower pediatric readiness. Our results only apply to trauma centers meeting this volume threshold for children. Next, we used an O/E mortality ratio as the outcome. While this methodology is familiar to trauma centers, it consolidates many patient-level factors and variation into a single metric, which may not fully account for differences in case mix between hospitals. Also, many trauma centers clustered around an O/E ratio of 1, which may have prevented the ability to identify ED readiness components associated with unexpectedly high or low survival. In addition, we used hospitals as the unit of analysis, which allowed for the evaluation of ED readiness factors, but also limited our sample size and the ability to include the large number of ED- and hospital-level factors into a multivariable model. A more flexible analytic strategy that is able to accommodate a large number of predictors across multiple levels (e.g., machine learning) may produce different results. Finally, we used data from the 2013 NPRP assessment. It will be important to replicate these analyses when data from the more recent (2021) NPRP assessment and NTDB patient data become available.

In summary, among a cohort of US trauma centers, we identified specific components of ED pediatric readiness that were associated with survival. These findings may help trauma centers prioritize different aspects of ED readiness to optimize outcomes among injured children.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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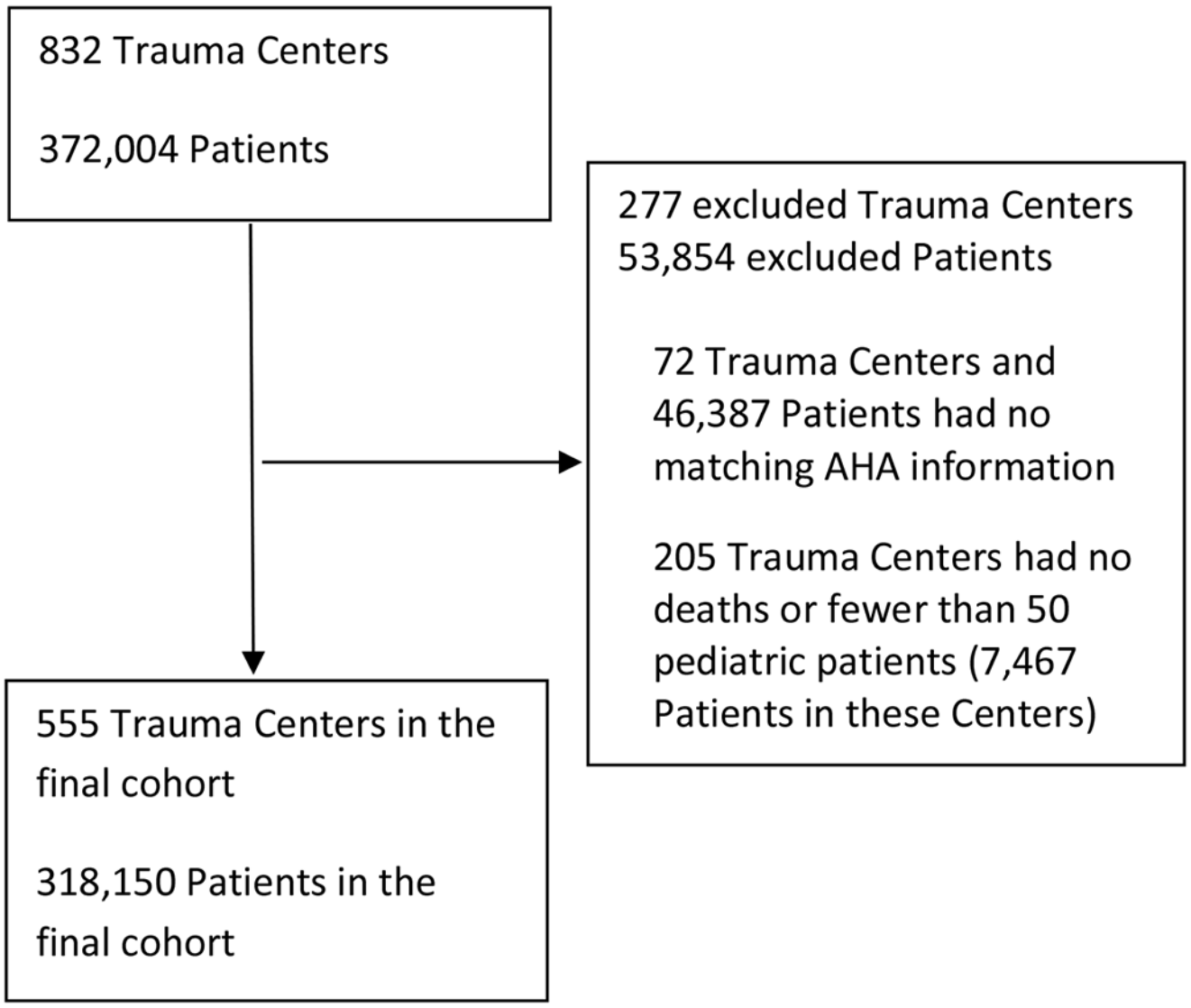

Figure 1.
Trauma centers included in the primary analytic sample.

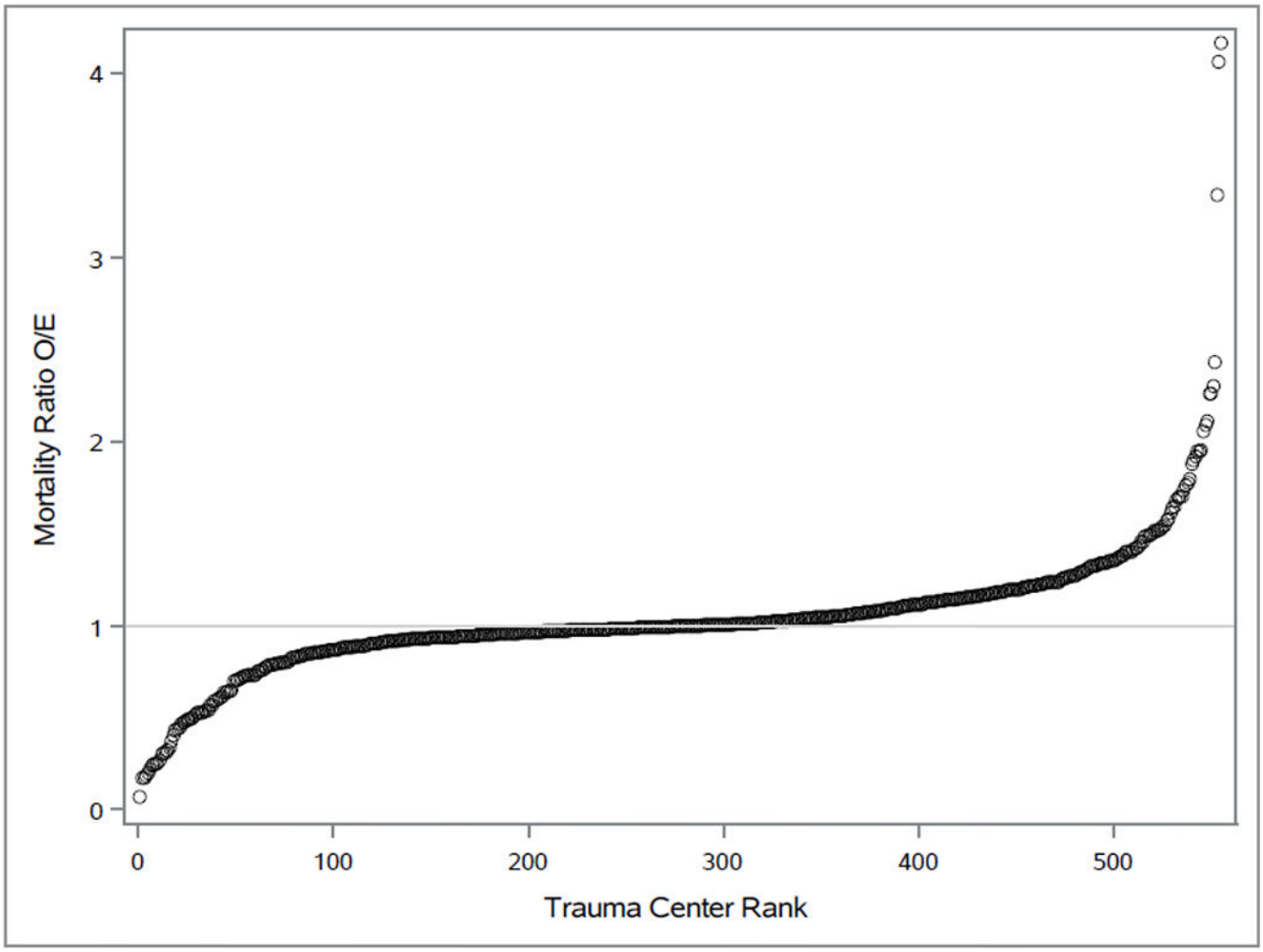

Figure 2.
Distribution of observed-to-expected (O/E) mortality ratios across 555 trauma centers.

Table 1.

Facility characteristics of trauma center cohort by observed/expected mortality ratio (n = 555 trauma centers).

	Hospital-level Observed/Expected Mortality Ratio		
	< 1 (N = 288)	**>= 1 (N = 267)**	**P-value**
ED configuration			<.001[1]
General ED[2]	183 (63.5%)	235 (88.0%)	
Separate pediatric area ED	66 (22.9%)	27 (10.1%)	
Pediatric-specific ED	39 (13.5%)	5 (1.9%)	
Pediatric Inpatient capabilities			<.001[1]
None	25 (8.7%)	23 (8.6%)	
Other (nursery, NICU, adult ward, adult ICU)	44 (15.3%)	41 (15.4%)	
Pediatric inpatient ward	71 (24.7%)	155 (58.1%)	
Pediatric intensive care unit	147 (51.0%)	47 (17.6%)	
Missing	1 (0.3%)	1 (0.4%)	
Average annual total pediatric volume in the ED			0.002[1]
Less than 1,800	33 (11.5%)	31 (11.6%)	
1,800-5,000	60 (20.8%)	66 (24.7%)	
5,000-10,000	54 (18.8%)	79 (29.6%)	
Greater than 10,000	141 (49.0%)	91 (34.1%)	
Trauma center level			<.001[1]
Level 3/4/5	44 (15.3%)	118 (44.2%)	
Level 2	111 (38.5%)	114 (42.7%)	
Level 1	133 (46.2%)	35 (13.1%)	
Pediatric trauma center level			<.001[1]
None	179 (62.2%)	235 (88.0%)	
Level 3/4	6 (2.1%)	11 (4.1%)	
Level 2	42 (14.6%)	12 (4.5%)	
Level 1	61 (21.2%)	9 (3.4%)	
Geographic category			0.011[1]
Wilderness	1 (0.3%)	0 (0.0%)	
Rural	12 (4.2%)	25 (9.4%)	
Suburban	6 (2.1%)	15 (5.6%)	
Urban	268 (93.1%)	227 (85.0%)	
Missing	1 (0.3%)	0 (0.0%)	

[1] Chi-squared test

[2] Adult and pediatric patients cared for in shared area

Table 2.

Bivariate analysis of ED pediatric readiness elements by observed/expected mortality ratio (n = 555 trauma centers)

		Hospital-level Observed/Expected Mortality Ratio		
Pediatric Readiness Domain		**< 1 (N = 288)**	**>= 1 (N = 267)**	**P-value**
Administration and Coordination	Accreditation[1]: Yes	276 (95.8%)	253 (94.8%)	0.549
	Administration/coordination			0.087
	None	118 (41.0%)	123 (46.1%)	
	Physician or nurse PECC[2]	46 (16.0%)	53 (19.9%)	
	Both physician and nurse PECC[2]	124 (43.1%)	91 (34.1%)	
Pediatric Competencies	Presence of staff physicians trained in emergency medicine or pediatric emergency medicine: Yes	279 (96.9%)	262 (98.1%)	0.347
	All staff physicians Board certified in pediatric emergency medicine or emergency medicine: Yes	101 (35.1%)	98 (36.7%)	0.688
	Physician courses			0.544
	None	132 (45.8%)	132 (49.4%)	
	Pediatrics[3] or trauma[4] training	57 (19.8%)	44 (16.5%)	
	Both trainings	99 (34.4%)	91 (34.1%)	
	Nurse certification[5]: Yes	80 (27.8%)	70 (26.2%)	0.679
	Nurse courses			0.289
	None	12 (4.2%)	7 (2.6%)	
	Pediatrics[6] or trauma[7] training	65 (22.6%)	50 (18.7%)	
	Both trainings	211 (73.3%)	210 (78.7%)	
	Nurse competencies: Yes	233 (80.9%)	220 (82.4%)	0.650
Policies, Procedures, and Protocols	Use of a validated pediatric triage tool: Yes	163 (56.6%)	113 (42.3%)	<.001
	Policies: Pediatric patient assessment reassessment: Yes	247 (85.8%)	216 (80.9%)	0.124
	Policies: Child maltreatment: Yes	239 (83.0%)	240 (89.9%)	0.018
	Hospitals disaster plan addresses issues specific to the care of children: Yes	193 (67.0%)	154 (57.7%)	0.023
	Interfacility transfer agreements: Yes	207 (71.9%)	192 (71.9%)	0.993
Patient Safety	Policies: Reduced-dose radiation for CT and x-ray based on pediatric age or weight: Yes	195 (67.7%)	168 (62.9%)	0.236
Equipment, Supplies and Medications	ED staff is trained on the location of pediatric equipment and medication: Yes	287 (99.7%)	266 (99.6%)	0.957
	Daily method to verify the proper location and function of pediatric equipment and supplies: Yes	278 (96.5%)	251 (94.0%)	0.160
	System to ensure proper sizing of resuscitation equipment and dosing of medications: Yes	288 (100.0%)	266 (99.6%)	0.299
Quality Improvement	Quality improvement (4 pts possible): Mean (SD)	2.5 (1.81)	1.9 (1.84)	<.001
	Patient safety (8 pts possible): Mean (SD)	7.2 (1.01)	7.0 (1.06)	0.135
	Interfacility guidelines (8 pts possible): Mean (SD)	5.6 (3.43)	5.6 (3.35)	0.764

Pediatric Readiness Domain		Hospital-level Observed/Expected Mortality Ratio		
		< 1 (N = 288)	>= 1 (N = 267)	P-value
	Monitoring equipment[8] (6 pts possible): Mean (SD)	5.9 (0.32)	5.9 (0.50)	0.190
	Airway equipment[8] (42 pts possible): Mean (SD)	39.6 (4.34)	39.0 (3.89)	0.007
	Resuscitation equipment[8] (6 pts possible): Mean (SD)	5.7 (0.66)	5.5 (0.78)	0.006

[1] Accreditation by the Joint Commission or Det Norske Veritas (DNV)

[2] Pediatric Emergency Care Coordinator

[3] Pediatric Advanced life support (PALS), Advanced Pediatric Life Support (APLS), or Neonatal Resuscitation Program (NRP)

[4] Advanced Trauma Life Support (ATLS) or Intermediate Trauma Life Support (ITLS)

[5] Certified Emergency Nurse (CEN) or Certified Pediatric Emergency Nurse (CPEN)

[6] Pediatric Advanced life support (PALS), Advanced Pediatric Life Support (APLS), Neonatal Resuscitation Program (NRP), or Emergency Nurse Pediatric Care (ENPC)

[7] Intermediate Trauma Life Support (ITLS) or Trauma Nurse Core Course (TNCC)

[8] As per the 2009 Guidelines for Pediatric Readiness in the Emergency Department. We conducted the bivariate analysis using the Chi-squared test and Wilcoxon rank-sum test.

Table 3.

Multivariable analysis of emergency department pediatric readiness components and observed-to-expected mortality (n = 555 trauma centers).

	Mortality Ratio O/E Effect (95% CI)
Accreditation [1]	
No	Reference
Yes	1.11 (0.96, 1.28)
Administration/coordination	
None	Reference
Physician or nurse PECC[2]	0.95 (0.87, 1.04)
Both physician and nurse PECC[2]	0.92 (0.85, 0.99)
Presence of staff physicians trained in emergency medicine or pediatric emergency medicine	
No	Reference
Yes	1.01 (0.84, 1.22)
All staff physicians Board certified in pediatric emergency medicine or emergency medicine	
No	Reference
Yes	0.95 (0.86, 1.04)
Physician courses required	
None	Reference
Pediatrics[3] or trauma[4] training	0.93 (0.83, 1.04)
Both pediatric and trauma training	0.98 (0.89, 1.09)
Nurse specialty certification required [5]	
No	Reference
Yes	0.98 (0.92, 1.05)
Nurse courses required	
None	Reference
Pediatrics[6] or trauma[7] training	1.04 (0.88, 1.23)
Both pediatric and trauma training	1.05 (0.89, 1.23)
Nurse pediatric competency requirement	
No	Reference
Yes	1.04 (0.96, 1.13)
Use of a validated pediatric triage tool	
No	Reference
Yes	0.96 (0.90, 1.03)
Policies: Pediatric patient assessment reassessment	
No	Reference
Yes	0.95 (0.87, 1.04)
Policies: Child maltreatment	
No	Reference

	Mortality Ratio O/E Effect (95% CI)
Yes	1.17 (1.06, 1.30)
Policies: Reduced-dose radiation for CT and x-ray based on pediatric age or weight	
No	Reference
Yes	1.00 (0.94, 1.07)
Hospital's disaster plan addresses issues specific to the care of children	
No	Reference
Yes	1.02 (0.95, 1.09)
Interfacility transfer agreements	
No	Reference
Yes	0.96 (0.90, 1.03)
ED staff trained on the location of pediatric equipment and medication	
No	Reference
Yes	0.95 (0.55, 1.55)
Daily method to verify the proper location and function of pediatric equipment and supplies	
No	Reference
Yes	0.92 (0.79, 1.05)
System to ensure proper sizing of resuscitation equipment and dosing of medications	
No	Reference
Yes	0.63 (0.30, 1.14)
Quality improvement process that includes children	1.00 (0.98, 1.02)
Pediatric patient safety	0.99 (0.96, 1.02)
Interfacility transfer guidelines	1.00 (0.99, 1.01)
Monitoring equipment [8]	1.01 (0.93, 1.08)
Airway equipment [8]	1.00 (0.99, 1.01)
Resuscitation equipment [8]	0.97 (0.92, 1.02)

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[7] Intermediate Trauma Life Support (ITLS) or Trauma Nurse Core Course (TNCC)

[8] As per the 2009 Guidelines for Pediatric Readiness in the Emergency Department.

Table 4.

Multivariable analysis of emergency department pediatric readiness components and observed-to-expected mortality, stratified by trauma center level.

	Trauma Center Level			
	Level 1/2 Effect (95% CI)	**P-value**	**Level 3/4/5 Effect (95% CI)**	**P-value**
Accreditation		<.001		0.631
No	Reference		Reference	
Yes	1.47 (1.18, 1.79)		1.06 (0.83, 1.33)	
Administration/coordination		0.116		0.326
None	Reference		Reference	
Physician or nurse	0.98 (0.90, 1.07)		0.87 (0.72, 1.05)	
Both physician and nurse	0.93 (0.86, 1.00)		0.93 (0.77, 1.11)	
Physician training		0.632		0.525
No	Reference		Reference	
Yes	1.06 (0.84, 1.32)		1.12 (0.79, 1.55)	
Physician certification		0.963		0.138
No	Reference		Reference	
Yes	1.00 (0.90, 1.10)		0.84 (0.67, 1.06)	
Physician courses		0.621		0.271
None	Reference		Reference	
Pediatrics or trauma training	0.98 (0.88, 1.09)		0.82 (0.64, 1.05)	
Both trainings	1.02 (0.92, 1.12)		0.92 (0.72, 1.16)	
Nurse certification		0.563		0.399
No	Reference		Reference	
Yes	1.02 (0.96, 1.08)		0.93 (0.78, 1.11)	
Nurse courses		0.710		0.341
None	Reference		Reference	
Pediatrics or trauma training	1.01 (0.88, 1.17)		0.94 (0.34, 2.13)	
Both trainings	1.04 (0.90, 1.19)		0.81 (0.30, 1.83)	
Nurse competencies		0.282		0.015
No	Reference		Reference	
Yes	0.96 (0.88, 1.04)		1.25 (1.05, 1.50)	
Use of a validated pediatric triage tool		0.622		0.540
No	Reference		Reference	
Yes	0.98 (0.92, 1.05)		0.95 (0.81, 1.12)	
Policies: Pediatric patient assessment reassessment		0.392		0.471
No	Reference		Reference	
Yes	0.96 (0.88, 1.05)		0.93 (0.76, 1.13)	
Policies: Child maltreatment		0.345		0.004
No	Reference		Reference	
Yes	1.05 (0.95, 1.15)		1.57 (1.16, 2.10)	
Policies: Reduced-dose radiation for CT and x-ray based on pediatric age or weight		0.706		0.554

	Trauma Center Level			
	Level 1/2 Effect (95% CI)	**P-value**	**Level 3/4/5 Effect (95% CI)**	**P-value**
No	Reference		Reference	
Yes	0.99 (0.92, 1.06)		1.05 (0.90, 1.22)	
Hospital's disaster plan addresses issues specific to the care of children		0.427		0.878
No	Reference		Reference	
Yes	1.03 (0.96, 1.09)		0.99 (0.84, 1.16)	
Interfacility agreements		0.767		0.448
No	Reference		Reference	
Yes	0.99 (0.93, 1.05)		0.93 (0.78, 1.12)	
Daily method to verify the proper location and function of pediatric equipment and supplies		0.077		0.504
No	Reference		Reference	
Yes	0.88 (0.75, 1.01)		0.91 (0.67, 1.20)	
Quality improvement (4 pts possible)	1.00 (0.98, 1.02)	0.885	1.04 (1.00, 1.09)	0.060
Patient safety (8 pts possible)	1.00 (0.97, 1.03)	0.978	0.98 (0.91, 1.05)	0.507
Interfacility guidelines (8 pts possible)	1.00 (0.99, 1.01)	0.561	0.98 (0.96, 1.01)	0.128
Monitoring equipment (6 pts possible)	0.99 (0.91, 1.09)	0.906	1.04 (0.91, 1.18)	0.560
Airway equipment (42 pts possible)	1.00 (0.99, 1.01)	0.692	1.01 (0.99, 1.02)	0.457
Resuscitation equipment (6 pts possible)	0.98 (0.93, 1.03)	0.413	1.00 (0.90, 1.10)	0.939

Results are based on multivariable models, adjusting for each of the predictors in this table.

Table 5.

Resources for implementing components of emergency department readiness associated with improved survival.

Pediatric Readiness Component	Sample Resources
Validated pediatric triage tool	Emergency Severity Index - Pediatric Course https://www.ena.org/docs/default-source/education-document-library/triage/esi-implementation-handbook-2020.pdf?sfvrsn=fdc327df_4
Quality improvement process that includes children	Join a National EMSC Quality Improvement Collaborative or National Pediatric Readiness Quality Initiative https://emscimprovement.center/collaboratives/; www.nprqi.org
Integration of pediatric needs in hospital's disaster plan	Use the Pediatric Disaster Preparedness Toolkit and Checklist https://emscimprovement.center/education-and-resources/toolkits/pediatric-disaster-preparedness-toolbox/
Pediatric airway and resuscitation equipment	Length/Age/Weight-based resuscitation guides (e.g. Broselow, Handtevy, PediTape)
Pediatric Emergency Care Coordinator	Hire new staff (if feasible) or reduce clinical load of existing staff to assume these roles.

* Additional resources for hospitals seeking to improve emergency department pediatric readiness can be found at www.pediatricreadiness.org.