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The value of the Injury Severity Score in pediatric trauma: Time for a new definition of severe injury?

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Abstract

Background—The Injury Severity Score (ISS) is the most commonly used injury scoring system in trauma research and benchmarking. An ISS>15 conventionally defines severe injury; however, no studies evaluate whether ISS performs similarly between adults and children. Our objective was to evaluate ISS and AIS to predict mortality and define optimal thresholds of severe injury in pediatric trauma.

Methods—Patients from the Pennsylvania trauma registry 2000–2013 were included. Children were defined as age<16years. Logistic regression predicted mortality from ISS for children and adults. The optimal ISS cut-off for mortality that maximized diagnostic characteristics was determined in children. Regression also evaluated association between mortality and maximum AIS in each body-region, controlling for age, mechanism, and non-accidental trauma. Analysis was performed in single and multisystem injuries. Sensitivity analyses with alternative outcomes were performed.

Results—There were 352,127 adults and 50,579 children included. Children had similar predicted mortality at ISS of 25 as adults at ISS of 15 (5%). The optimal ISS cut-off in children was ISS>25 and had a positive predictive value (PPV) of 19% and negative predictive value (NPV)

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AUTHOR CONTRIBUTIONS: J.B.B. and B.A.G designed the study and performed the literature search. J.B.B. and M.L.G. performed the data collection. J.B.B performed the data analysis. J.B.B., M.L.G., C.M.L. and B.A.G. participated in initial manuscript preparation. All authors contributed to data interpretation and critical revision of the manuscript.

of 99% compared to PPV of 7% and NPV of 99% for ISS>15 to predict mortality. In single-system injured children, mortality was associated with head (OR 4.80; 95%CI 2.61–8.84, p<0.01) and chest AIS (OR 3.55; 95%CI 1.81–6.97, p<0.01), but not abdomen, face, neck, spine, or extremity AIS (p>0.05). For multisystem injury, all body region AIS were associated with mortality except extremities. Sensitivity analysis demonstrated ISS>23 to predict need for full trauma activation, and ISS>26 to predict impaired functional independence were optimal.

Conclusions—ISS>25 may be a more appropriate definition of severe injury in children. Pattern of injury is important, as only head and chest injury drive mortality in single-system injured children. These findings should be considered in benchmarking and performance improvement efforts.

Level of Evidence—III, epidemiologic

Keywords

pediatric; ISS; mortality; abbreviated injury scale; AIS

BACKGROUND

Injury scoring systems have long been used for research, quality improvement, and trauma center benchmarking. Performance of injury scoring systems has significant impact across these domains, and it is necessary to assess the scoring systems across diverse populations. The most well-known scoring system is the Injury Severity Score (ISS), based on the Abbreviated Injury Scale (AIS). The ISS, first published in 1974, is calculated as the squared value of the three highest AIS scores across different body regions.[1] Despite a number of proposed modifications and alternate scoring systems,[2–6] ISS remains the most widely used to define severely injured patients.[7] An ISS>15 has traditionally been used to define severe injury.[2, 7, 8] This threshold has also been used to classify patients requiring trauma center care or full trauma team activation.[8, 9]

The ISS remains the standard for pediatric trauma patients, despite the availability of several pediatric specific trauma scoring systems.[10, 11] While several studies have evaluated the performance of ISS in adults,[12] there is no evidence to suggest ISS performs similarly in pediatric patients. Given the difference in physiologic response to injury between adults and children, the anatomically based ISS may over-estimate mortality when applied in pediatric patients. Some have compared ISS to other scoring systems in pediatric patients,[11, 13] but no study has evaluated whether currently accepted ISS thresholds in adults have similar predictive performance for mortality in children. This is critical to ensure benchmarking and quality assurance efforts based on ISS definitions of severe injury in pediatric patients are using appropriate evidence-based ISS thresholds. Use of an inaccurate ISS threshold to define severe injury in pediatric patients can result in imprecise benchmarking, poor quality improvement targets, and waste resources with unnecessary performance review of low risk cases.

Therefore, our objective was to evaluate ISS and AIS for the ability to predict mortality and define the optimal ISS threshold to define severe injury in pediatric trauma patients. We hypothesized that the conventional threshold for severe injury of ISS>15 would be low for identifying severely injured pediatric patients based on mortality. We also hypothesized individual body region AIS score would correlate poorly with mortality, particularly in patients with injuries isolated to a single body system.

METHODS

Study Population

All patients in the Pennsylvania state trauma registry between January 1st, 2000 and June 30th, 2013 were eligible for inclusion. Patients missing age data were excluded. Patients missing complete AIS score data to permit calculation of ISS were also excluded as these data were integral to the study design. Finally, patients with any AIS score of 6 that was also coded as surviving to discharge were excluded as AIS misclassification. For analysis, pediatric patients were defined as those age <16 years and adults defined as those age ≥16 years.

Demographics, injury characteristics, vital signs, *International Classification of Diseases, Ninth Revision* (ICD-9) diagnosis codes, and hospital disposition were collected for each subject. All vital signs for children were age-adjusted and binary variables created to indicate whether each vital sign was abnormal or not for the child's age.[14–16]

Missing Data

Missing data were assessed for variables to be utilized in analysis, including gender, mechanism of injury, non-accidental trauma, and admission systolic blood pressure (SBP), heart rate (HR), and respiratory rate (RR). After application of exclusion criteria, missing data were 1% or less for all analysis variables except for admission respiratory rate at 4.1%. When evaluating pediatric and adult patients separately, similar low rates of missing data were seen, except for admission SBP in pediatric patients (4.8%). Further, based on exclusion criteria, all patients had complete data for age, AIS, and ISS. Thus, given missing data <5% for all planned analysis variables and the study sample size, patients with missing data were excluded from analyses utilizing the respective missing variables.

Injury Characterization

Injuries were primarily characterized using AIS scores and body region. The Pennsylvania trauma registry allows coding of multiple AIS scores for each patient in eight body regions, including head, face, neck, chest, abdomen, spine, upper extremities, and lower extremities. The maximum AIS score for each of these body regions was identified for each patient. The number of body regions injured was calculated and patients classified as single system injury if only one AIS body region was injured, or multisystem injury if more than one AIS body region was injured. The ISS used for purposes of this study was then calculated as the sum of the squared value for the three highest AIS scores in different body regions.

Statistical Analysis

A logistic regression model was used to obtain the predicted mortality based on ISS separately for pediatric and adult patients, and predicted mortality was plotted against the

ISS for each age group. This was also performed separately for patients with single system injury and multisystem injuries.

The optimal ISS cut-off to predict mortality was determined for pediatric and adult patients by finding the cut-off that maximized the combination of sensitivity and specificity using an optimal operating slope that takes into account the prevalence of mortality and the trade-off of false negatives and false positives.[17] The diagnostic test characteristics of the optimal ISS cut-off obtained using this method for pediatric patients was then compared to the standard definition of ISS>15 to predict mortality in children.

Logistic regression was again used to evaluate the association between mortality and the maximum AIS score in each body region for pediatric patients. Models were adjusted for age, mechanism, admission vital signs, and non-accidental trauma. Robust variance estimators were used to account for clustering at the center level. These models were performed separately for single system and multisystem injuries.

Continuous data are presented as median (interquartile range [IQR]). Continuous variables were compared using Wilcoxon rank-sum tests, and categorical variables were compared using Chi-squared tests. Adjusted odds rations (AOR) with 95%CI were obtained from regression models. A two-sided p value ≤0.05 was considered significant. Data analysis was conducted using Stata v13MP (StataCorp; College Station, TX).

Sensitivity Analysis

As mortality is generally low in the pediatric trauma population, it may not serve as the best outcome for determining severely injured patients. A sensitivity analysis was performed using a consensus based definition for pediatric patients requiring the highest level of trauma activation as the outcome.[18] Pediatric patients were considered to require full trauma activation if they had any one of the following criteria: 1. Definitive airway placement prehospital or in the emergency department (ED); 2. Underwent chest tube placement in the ED; 3. Received >1 unit of blood product in the ED; 4. Underwent pericardiocentesis in the ED; 5. Underwent ED thoracotomy; 6. Underwent surgery for hemorrhage control or craniotomy within 4hours of admission; 7. Underwent interventional radiology procedure within 4hours of admission; 8. Underwent emergent cesarean delivery; 9. Received vasopressors within 4hours of admission; 10. Underwent procedure for intracranial pressure monitoring; 11. Diagnosed with spinal cord injury, 12. Died in the ED. The optimal ISS cut-off to predict need for full trauma activation was determined. The diagnostic test characteristics using this optimal ISS cut-off was again compared to an ISS>15 to predict need for full trauma activation.

Similarly, as an alternative outcome to mortality, functional status at discharge (FSD) was evaluated. Patients in the Pennsylvania trauma registry were assessed using a modified Functional Independence Measure (FIM) score that assesses the level of independent functioning in patients 2 years and older across the five domains of feeding, locomotion, expression, transfer mobility, and social interaction. Patients can receive a score of 1 (complete dependence), 2 (modified dependence), 3 (independent with device), or 4 (completely independent) for each domain, giving a total FSD score from 5 to 20. The FSD was dichotomized at 15 to reflect patients that are at least independent with a device across all domains (FSD≥15) compared to patients with impaired functional independence in at least one domain (FSD<15). The optimal ISS cut-off to predict impaired functional independence (FSD<15) was determined. Diagnostic performance for this optimal ISS cut-off was again compared to an ISS>15 to predict impaired functional independence.

RESULTS

A total of 402,706 patients were included over the study period (Fig. 1). Pediatric patients were less likely to have penetrating injury, hypotension, abnormal heart rate, or multiple body regions injured, but more likely to have an abnormal respiratory rate than adult patients (Table 1). Unadjusted mortality was also lower in pediatric patients.

Figure 2 illustrates the predicted mortality plotted against ISS in pediatric and adult patients from logistic regression modeling. Adult patients had a predicted mortality of 5% at an ISS of 15, while pediatric patients had the same mortality rate of 5% at an ISS of 25. In patients with single system injury, predicted mortality was similar for adults with ISS of 15 and pediatric patients with ISS of 26 (eFigure 1, Supplemental Digital Content). In patients with multisystem injury, predicted mortality was similar for adults with ISS of 15 and pediatric patients with ISS of 24 (eFigure 2, Supplemental Digital Content).

Using the mortality rate of 1.7% and a trade-off cost of 10 times greater for false negative than false positive results, the optimal ISS cut-off was >25 for pediatric patients, and >15 for adult patients. Table 2 shows the diagnostic test characteristics for an ISS>25 and ISS>15 threshold in pediatric patients. An ISS>25 demonstrated higher specificity, positive predictive value (PPV), and overall accuracy compared to an ISS>15, with only a marginal decrease in negative predictive value (NPV).

Regression analysis in pediatric patients with single system injury revealed only head and chest AIS were associated with increased odds of mortality (Table 3). For pediatric patients with multisystem injury, all body region maximum AIS scores were associated with increased odds of mortality except extremity AIS (Table 3). Figure 3 demonstrates risk adjusted mortality across maximum AIS scores in the head, chest, and abdomen for single and multisystem injury in pediatric patients. Mortality for head injuries rises rapidly at an AIS of 5 in both single and multisystem injuries. Mortality for chest injuries consistently increases across AIS scores in both single and multisystem injuries. Abdominal injury mortality rises at AIS scores >3 in multisystem injury, but remains relatively low for isolated abdominal injuries, even out to an AIS of 5.

In sensitivity analysis, 17.3% of pediatric patients met the definition for requiring full trauma activation. Using a trade-off cost of 2 times greater for false negative than false positive results, the optimal ISS cut-off was >23. An ISS>23 again showed higher specificity, PPV, and accuracy compared to an ISS>15 threshold (Table 2).

Overall, 26,140 (58%) of pediatric patients had valid FSD data. Of these, 2,264 (8.7%) had impaired dependence at discharge. Using a trade-off cost of 5 times greater for false negative than false positive results, the optimal ISS cut-off was >26 for impaired functional independence. An ISS>26 again showed higher specificity, PPV, and accuracy compared to an ISS>15 threshold, with only a marginal decrease in NPV (Table 2).

DISCUSSION

The current study demonstrates differences in performance for ISS to predict mortality between adult and pediatric patients. Mortality in adult patients at the conventional threshold for severe injury of ISS>15 corresponds to a similar mortality at an ISS of 25 for pediatric patients. An ISS threshold of 25 was also identified as the optimal cut-off for mortality in pediatric patients, and had better diagnostic test characteristics when compared to the conventional ISS cut-off of 15. A similar threshold was seen in children with either single system or multisystem injury. Further, when examining the need for full trauma activation an ISS>23 was identified as the optimal cut-off in pediatric patients. The optimal cut-off to predict impaired functional independence at discharge was an ISS>26. These findings suggest using an ISS>15 to define severe injury in pediatric patients is low and over-estimates the likelihood of death, need for full trauma activation, and impaired functional outcome.

When controlling for confounders among pediatric patients with single system injury, only the severity of head and chest injury was associated with mortality. However, in pediatric patients with multisystem injury, head, face, neck, and torso injuries were associated with mortality. This suggests the pattern of anatomic injury and number of body systems injured play significant roles in mortality for pediatric injuries. While one might conclude that the findings demonstrating differences between adults and children is not surprising or novel, adult metrics continue to be applied in the pediatric population and the assumptions these will perform equally well needs to be challenged as we have done in the current study.

Several other authors have demonstrated that the ISS threshold associated with increased mortality is higher than the conventional cut-off of 15 in pediatric patients. Orliaguet and colleagues examined 507 pediatric trauma patients and also determined the ISS threshold that maximized sensitivity and specificity for predicting mortality was an ISS≥25.[19] Another study of pediatric patients with traumatic brain injury identified an ISS≥28 as the threshold that maximized sensitivity and specificity.[20] Palmer demonstrated an ISS>20 threshold resulted in maximized sensitivity and specificity, while an ISS>25 threshold maximized correct classification of over 8,000 injured children.[7]

Thus, our findings are similar to prior studies that indicate an ISS threshold of 15 is low and over-estimates the risk of death. The current study has several advantages over prior work. First, our method of finding the optimal ISS cut-off takes into account the prevalence of the outcome in the study population, as well as different costs for false negatives and positives. We used a high cost for false negatives (not identifying a child as severely injured who dies) to false positives (identifying a child as severely injured who does not die). Simply finding the threshold that maximizes the sum of sensitivity and specificity as prior work has done assumes the same cost of each type of misclassification. Further, this is the first study to compare mortality rates between adult and pediatric patients from a similar population, while prior studies focus on only adults or children to evaluate ISS.

There may be several potential explanations for our findings. First, children are more resilient with more physiologic reserve in their response to injury.[21] Since ISS is an anatomic based score, pediatric patients are able to compensate for the same level of anatomic injury better than adults. The ISS is also based on AIS. As shown here, the specific body systems injured and the number of body systems injured has a significant effect on risk of mortality.

Further, AIS is not weighted, with each body system given the same significance; however, this may not be accurate. Maximum head AIS was the strongest predictor of mortality among both single system and multisystem injury. This is not surprising, as traumatic brain injury remains the primary cause of death among pediatric trauma patients.[22] Further, traumatic brain injury also is a source of ongoing disability among pediatric trauma survivors.[23] Chest injuries were the next most deadly injuries, particularly among children with single system isolated thoracic injury. Chest injury, whether single or multisystem, demonstrated the most consistent increase in risk-adjusted mortality across maximum AIS scores. Others have similarly reported high mortality in pediatric thoracic trauma, noting it ranks second only to head injury in this population.[24] The high mortality rate in isolated chest trauma among children has been associated with penetrating injuries.[25] Interestingly, abdominal maximum AIS was associated with a relatively low increase in mortality compared to other body systems for multisystem injury, and was not associated with mortality in isolated abdominal injury. Cooper et al also noted that while abdominal injuries were 30% more common than thoracic injury in pediatric patients, they were associated with a 20% lower risk of death.[24] Thus, giving the same weight to head and chest AIS as extremity AIS likely does not reflect the underlying risk of death.

Thus, the specific pattern of injury may affect mortality more than the global ISS. For example, a patient recently seen in our pediatric trauma center presented with an isolated grade 4 splenic laceration, giving an abdominal AIS of 4 which translates to an ISS of 16, and is considered to have severe injury under current conventions. However, this patient was discharged the day following admission and has done well at follow up. Our data suggest this abdominal injury does not place this child at an increased risk of death and should not be considered to have severe injury. However, given current accreditation and benchmarking standards using an ISS>15 to define severe injury in children, this patient was required to undergo full performance review and was considered under-triaged as the patient did not undergo the highest level of trauma activation.

These findings have several implications. The ISS is widely used in research to stratify and risk-adjust patients for injury severity. Studies evaluating pediatric trauma patients should consider using an ISS>25 to define severe injury based on these and others' findings. This may be particularly salient when ISS is used as inclusion or subgroup criteria to identify severely injured children for study.

Quality and performance improvement programs also use ISS to classify patients as severely injured. Monitoring of primary and secondary under- and over-triage is often based on stratifying patients using an ISS>15 to denote severely injured patients. Further, assessment of appropriate trauma team activation, such as the Cribari grid method, uses an ISS>15 to identify patients that should undergo full trauma activation.[26] Thus, using an ISS>15 for performance improvement activities results in inappropriate classifications of under-triage and devotes significant man-hours and resources to monitoring and review of low-risk patients. Consideration should be given to trialing an ISS>25 to define severely injured pediatric patients for these activities. These results may also have implications for risk-adjustment methods used in trauma center benchmarking efforts, such as the recently launched Pediatric Trauma Quality Improvement Program.[27] Inappropriately including low-risk patients can skew benchmarking results, and make it difficult to identify useful performance improvement targets and best practices that can potentially improve outcomes. Further study is necessary to evaluate the potential effect of increasing the ISS threshold for defining severe injury in pediatric patients to ensure an appropriate balance of under- and over-triage is maintained. As would be expected, increasing the ISS threshold decreases sensitivity of picking up patients; however, the decrease in NPV is much lower because it depends on the prevalence of the outcome. Given the lower prevalence of outcomes studied here, the NPV is more relevant than sensitivity, but requires careful monitoring.

Additionally, we found that only maximal head and chest AIS drove outcome in severe injury. Thus, consideration should be given to distinguishing single and multi-system in the performance improvement and benchmarking of pediatric patients. In these cases, ISS appears to be of little value and attention should be shifted to using the individual AIS scores and the particular system injured for children with isolated injury.

Finally, it is important to consider the most appropriate outcome in pediatric trauma patients. Use of a resource-based definition of severe injury such as need for full trauma activation as well as impaired functional status at discharge demonstrated higher prevalence in the study population, are clinically relevant endpoints, and may serve as better outcome targets in the injured pediatric population. While the ISS is intended for prediction of mortality, this outcome may be less useful in pediatric patients given the low prevalence. This further argues for consideration of individual injury patterns and perhaps abandoning the use of global ISS to define severe injury in pediatric patients.

This study has several limitations. First are those of a retrospective design. Second are those of a registry study. The data available were not collected specifically for this study, which limits outcomes and covariates for risk-adjustment. Missing data were minimal with all analysis variables missing <5%, and unlikely to affect our results given the sample size. Our largest exclusion was for patients missing AIS data; however, this only represented 5.7% of the eligible study population. As this represented a small proportion of overall patients available, and AIS data were integral to the study, we elected not to employ missing data methods such as multiple imputation for AIS scores. The ISS is complex mathematically and only certain values are possible based on the squared AIS values.

The Pennsylvania trauma registry collects data from only trauma centers, and we could not evaluate injured patients not transported to a trauma center in Pennsylvania. Other important outcomes such as long-term health related quality of life were not available; but important to evaluate in pediatric trauma, especially given the possibility of productivity loss over a lifetime. Mortality is low overall and may not be the best outcome to evaluate in the pediatric trauma population. We did evaluate both the need for full trauma activation based on resource utilization criteria and functional status at discharge as alternate outcomes, and found a similar ISS threshold that indicates an increased risk of needing full trauma activation. A significant proportion of patients did not have FIM data documented, but is comparable with other trauma registries such as the National Trauma Databank.[28]

We used methods to identify the optimal ISS cut-off that takes into account the trade-off of false negatives and false positives. We used a high cost of false negatives for mortality as it is much preferable to over-triage a child than miss a child at high risk for death, while the cost is likely much lower for a limited versus full trauma activation and functional independence somewhere between these two. However, the exact trade-offs used here are arbitrary as no literature exists to guide the specific values for these trade-offs. We started with a 10-fold trade-off for mortality based on the ratio of the commonly used acceptable over-triage rate of 50% and under-triage rate of 5%, and scaled the other trade-offs to the secondary outcomes relative to the importance of mortality. Analysis using different trade-off ratios for mortality, functional independence, and full trauma activation show fairly similar ISS cut-offs as the values used in the primary analysis for trade-off values that preserve high specificity (eTable 1, Supplemental Digital Content). While these specific values may be debated, we believe using this method that allows for differential costs of false negatives and false positives is more accurate in reflecting the philosophy of trauma triage than assuming equal weight between these types of misclassification. Finally, we focus on ISS and AIS in this study given its wide adoption in trauma research and benchmarking, but other scoring systems may ultimately yield better prediction of poor outcome in pediatric patients and warrant further consideration and acceptance.

CONCLUSION

An ISS>25 may be a more appropriate definition of severe injury in pediatric trauma patients, as it is a better predictor of mortality than the conventional definition of ISS>15. Only head and chest injury drive mortality in pediatric patients with single system injury, and the specific pattern of injury may be more important than the global ISS. Mortality may not universally be the optimal endpoint in children, and consideration should be given to resource based or functional outcomes. These findings should be considered in research, benchmarking, and performance improvement efforts that rely on ISS to identify severely injured children. The assumption that adult injury metrics can be applied to pediatric patients with adequate performance needs to be robustly evaluated to ensure the best care for the injured child.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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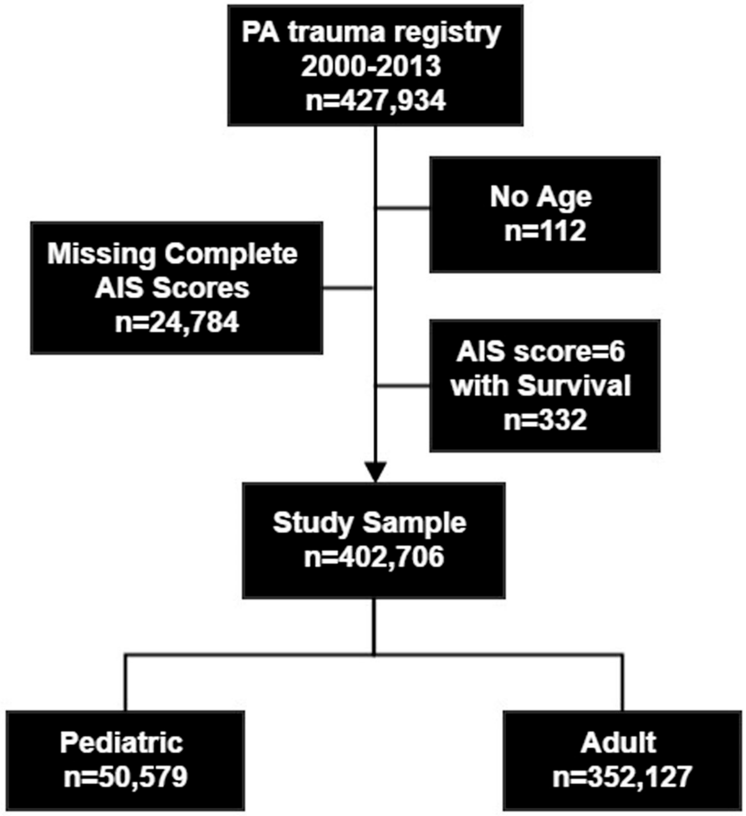

Figure 1.
Study participant selection of pediatric and adult trauma patients from the Pennsylvania trauma registry 2000—2013.

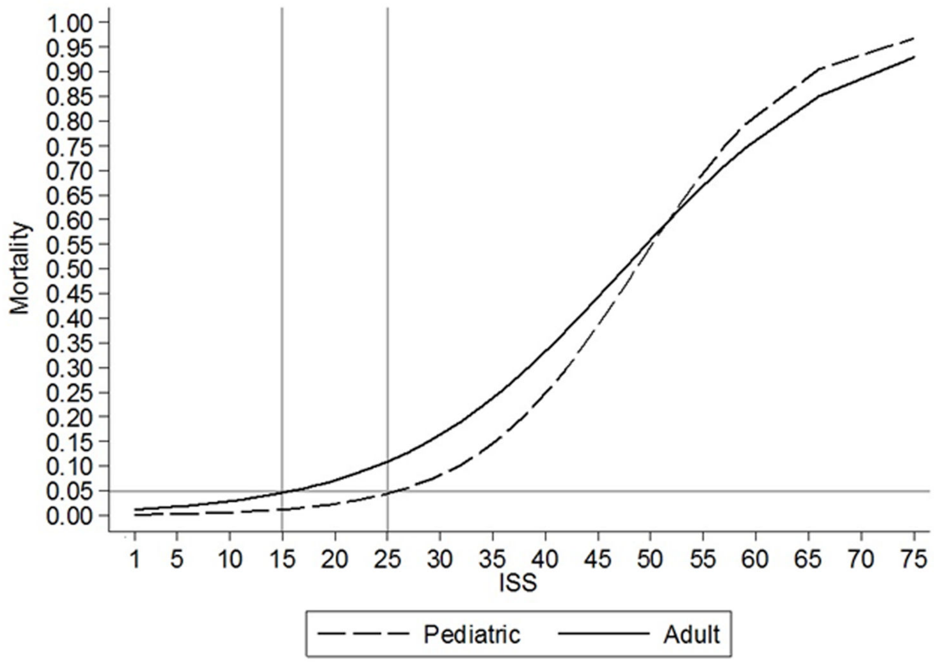

Figure 2.

Predicted mortality across ISS in pediatric and adult trauma patients. Pediatric patients have a similar predicted mortality rate at ISS of 25 as adults at ISS of 15.

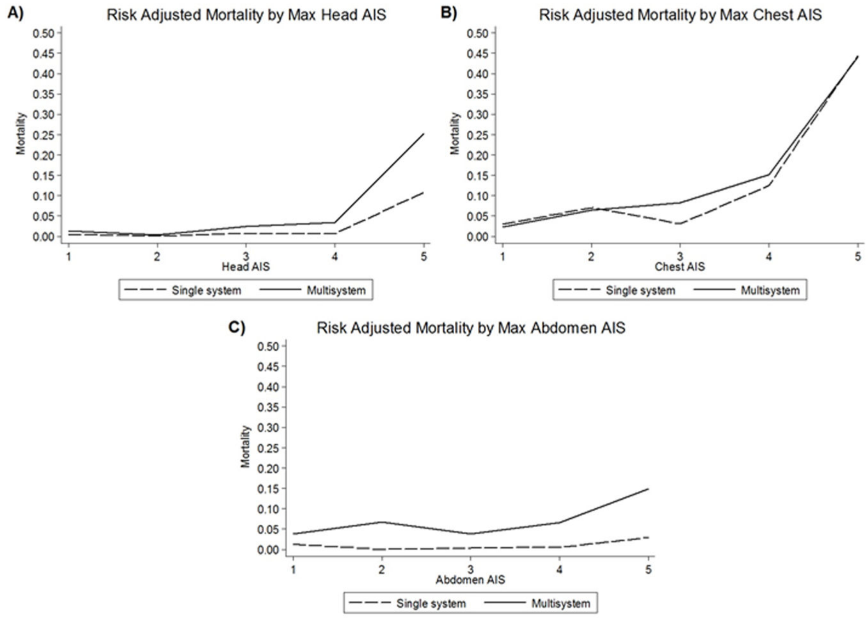

Figure 3.
Risk-adjusted mortality in pediatric trauma patients across head (A), chest (B), and abdominal (C) maximum AIS score for single and multisystem injuries.

Table 1

Comparison of pediatric and adult patients

	Pediatric N=50,579	Adult N=352,127	p value
Age [years, med (IQR)]	8 (3, 12)	49 (30, 72)	<0.0001
Sex (% male)	66	62	<0.0001
Mechanism (% blunt)	94	91	<0.0001
Hypotension (%)	1	4	<0.0001
Abnormal heart rate (%)	18	29	<0.0001
Abnormal respiratory rate (%)	29	26	<0.0001
ISS [med (IQR)]	9 (4, 12)	9 (5, 17)	<0.0001
Max head AIS [med (IQR)]*	2 (2, 4)	3 (2, 4)	0.8300
Max face AIS [med (IQR)]*	1 (1, 1)	1 (1, 2)	<0.0001
Max neck AIS [med (IQR)]*	1 (1, 1)	1 (1, 2)	<0.0001
Max chest AIS [med (IQR)]*	3 (1, 3)	3 (2, 3)	<0.0001
Max abdomen AIS [med (IQR)]*	2 (1, 3)	2 (1, 3)	<0.0001
Max spine AIS [med (IQR)]*	2 (1, 2)	2 (2, 3)	<0.0001
Max UE AIS [med (IQR)]*	2 (1, 3)	2 (1, 2)	<0.0001
Max LE AIS [med (IQR)]*	2 (1, 3)	2 (1, 3)	<0.0001
Number of body regions injured [med (IQR)]	1 (1, 2)	2 (1, 3)	<0.0001
Single versus multisystem injury (%)			<0.0001
Single system	58	37	
Multisystem	42	63	
Mortality (%)	2	6	<0.0001

IQR, interquartile range; ISS, injury severity score; Max, maximum; AIS, abbreviated injury scale; UE, upper extremity; LE, lower extremity

*Among patients with at least one injury in the specified body region

Max Head AIS N: Pediatric 22,539; Adult 160,390

Max Face AIS N: Pediatric 15,502; Adult 118,286

Max Neck AIS N: Pediatric 1,263; Adult 10,022

Max Chest AIS N: Pediatric 5,542; Adult 99,727

Max Abdomen AIS N: Pediatric 8,994; Adult 63,044

Max Spine AIS N: Pediatric 2,892; Adult 72,908

Max UE AIS N: Pediatric 16,637; Adult 126,783

Max LE AIS N: Pediatric 17,130; Adult 157,190

Table 2

Comparison of diagnostic test characteristic for optimal ISS and ISS>15 thresholds in pediatric trauma patient to predict mortality, need for full trauma activation, and impaired independence

Mortality	**ISS>25**	**ISS>15**
Sensitivity (%)	65.6	84.5
Specificity (%)	95.3	80.5
PPV (%)	19.0	6.8
NPV (%)	99.4	99.7
Accuracy (%)	94.8	80.6
Need for Full Trauma Activation	ISS>23	ISS>15
Sensitivity (%)	28.0	47.8
Specificity (%)	96.7	85.1
PPV (%)	64.8	40.2
NPV (%)	86.3	88.6
Accuracy (%)	84.8	78.7
Impaired Independence	ISS>26	ISS>15
Sensitivity (%)	17.5	35.1
Specificity (%)	97.1	80.9
PPV (%)	36.4	14.8
NPV (%)	92.5	92.9
Accuracy (%)	90.2	77.0

ISS, injury severity score; PPV, positive predictive value; NPV, negative predictive value

Table 3

Association between mortality and maximum body region AIS in single and multisystem injured pediatric patients.

	AOR*	95%CI	p value
Single system injury			
Max Head AIS	4.80	2.61 – 8.84	<0.0001
Max Face AIS	NA†	-	-
Max Neck AIS	NA†	-	-
Max Chest AIS	3.55	1.81 – 6.97	0.0002
Max Abdomen AIS	1.27	0.70 – 2.31	0.4239
Max Spine AIS	1.11	0.79 – 1.57	0.5431
Max UE AIS	NA†	-	-
Max LE AIS	NA†	-	-
Multisystem injury			
Max Head AIS	3.64	2.98 – 4.45	<0.0001
Max Face AIS	1.31	1.11 – 1.55	0.0015
Max Neck AIS	1.71	1.38 – 2.11	<0.0001
Max Chest AIS	2.23	2.04 – 2.45	<0.0001
Max Abdomen AIS	1.48	1.29 – 1.70	<0.0001
Max Spine AIS	2.34	2.08 – 2.62	<0.0001
Max UE AIS	0.91	0.74 – 1.11	0.3386
Max LE AIS	1.17	0.95 – 1.44	0.1504

*Adjusted odds ratio per 1 point increase in maximum AIS score

†Too few deaths for single system injuries in this body region to execute model

AIS, abbreviated injury scale; AOR, adjusted odds ratio; 95%CI, 95% confidence interval; Max, maximum; UE, upper extremity; LE, lower extremity