Trauma Surgery & Acute Care Open

Which curve is better? A comparative analysis of trauma scoring systems in a South Asian country

Asma Altaf Hussain Merchant ,[1] Natasha Shaukat,[2] Naela Ashraf,[2] Sheza Hassan,[2] Zeerak Jarrar,[3] Ayesha Abbasi,[2] Tanveer Ahmed,[4] Huba Atiq,[2,5] Uzma Rahim Khan,[5] Nadeem Ullah Khan,[5] Saima Mushtaq,[6] Shahid Rasul,[7] Adnan A Hyder ,[8] Junaid Razzak,[2,9] Adil H. Haider[1,10]

For numbered affiliations see end of article.

Correspondence to
Dr Asma Altaf Hussain Merchant; asma.altafmerchant@gmail.com

The results of this article have previously been presented at the 18th Annual Academic Surgical Congress in Houston, Texas, USA.

Received 11 May 2023
Accepted 13 October 2023

ABSTRACT

Objectives A diverse set of trauma scoring systems are used globally to predict outcomes and benchmark trauma systems. There is a significant potential benefit of using these scores in low and middle-income countries (LMICs); however, its standardized use based on type of injury is still limited. Our objective is to compare trauma scoring systems between neurotrauma and polytrauma patients to identify the better predictor of mortality in low-resource settings.

Methods Data were extracted from a digital, multicenter trauma registry implemented in South Asia for a secondary analysis. Adult patients (≥18 years) presenting with a traumatic injury from December 2021 to December 2022 were included in this study. Injury Severity Score (ISS), Trauma and Injury Severity Score (TRISS), Revised Trauma Score (RTS), Mechanism/GCS/Age/Pressure score and GCS/Age/Pressure score were calculated for each patient to predict in-hospital mortality. We used receiver operating characteristic curves to derive sensitivity, specificity and area under the curve (AUC) for each score, including Glasgow Coma Scale (GCS).

Results The mean age of 2007 patients included in this study was 41.2±17.8 years, with 49.1% patients presenting with neurotrauma. The overall in-hospital mortality rate was 17.2%. GCS and RTS proved to be the best predictors of in-hospital mortality for neurotrauma (AUC: 0.885 and 0.874, respectively), while TRISS and ISS were better predictors for polytrauma patients (AUC: 0.729 and 0.722, respectively).

Conclusion Trauma scoring systems show differing predictability for in-hospital mortality depending on the type of trauma. Therefore, it is vital to take into account the region of body injury for provision of quality trauma care. Furthermore, context-specific and injury-specific use of these scores in LMICs can enable strengthening of their trauma systems.

Level of evidence Level III.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ While trauma scoring systems have shown potential in identifying in-hospital outcomes of trauma patients, context-specific use of such scores has been limited, especially in low-resource settings. Furthermore, its use has majorly been described in polytrauma patients but a comparison has not been done yet to identify specific trauma scoring systems for various types and body regions of injury. Identifying this in a resource-limited setting has the potential to greatly influence triage and treatment, especially for patients with predominant neurotrauma who can develop major disabilities if management is delayed.

WHAT THIS STUDY ADDS

⇒ Since injuries pertaining to neurotrauma and polytrauma can have significantly different impact on quality of life, it is vital to use injury-specific trauma scoring systems. This study took into account multiple scoring systems and revealed Glasgow Coma Scale to be the better predictor of in-hospital mortality for neurotrauma patients but Trauma and Injury Severity Score to be better for polytrauma patients. Therefore, while these scoring systems prove to be a good prognostic tool for in-hospital mortality, it is vital to take injury specifications into account when using them.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Several studies have been published relating to the use of trauma scoring systems, but our results open up an avenue to use these scores depending on the type of injury. Furthermore, the majority of these scores have been validated in high-income countries but need validation in other regions of the world, owing to differing characteristics that might impact post-trauma outcomes. Validation and context-specific use of such scores can ultimately strengthen and benchmark trauma systems in resource-limited settings.

INTRODUCTION

Injuries contribute to 8% of all global deaths,[1] making it a worldwide concern today. While healthcare systems have developed globally, injuries continue to have disastrous effects on the life of trauma patients. Since injuries have been predicted to become the third leading cause of death by 2030,[2] it is imperative to identify the gaps in the current trauma system to reduce its mortality. This is specifically significant in low and middle-income countries (LMICs), where injuries continue to be a major burden of both mortality and disability.[3 4]

© Author(s) (or their employer(s)) 2023. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Merchant AAH, Shaukat N, Ashraf N, *et al*. *Trauma Surg Acute Care Open* 2023;**8**:e001171.

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

As a means to understanding trauma care and improving its quality, trauma registries have been developed at regional, national and international levels.[5] One vital component of these registries is the trauma scoring systems, which is used to quantify the degree and severity of injury, predict outcomes and act as a parameter for quality improvement.[6] The integration of such scores is important in LMICs, where major challenges to trauma care include rudimentary emergency medical systems, inadequate human resources, financial limitations, and uncoordinated healthcare systems.[7 8]

Multiple scoring systems are used in LMICs to triage patients who undergo trauma, with Injury Severity Score (ISS) being the most common one.[9] This anatomic score incorporates Abbreviated Injury Scale (AIS) and reflects the severity of injuries within different body regions.[9] Another score that factors anatomic injuries within its calculation is the Trauma and Injury Severity Score (TRISS), introduced in 1981.[10] While ISS and TRISS have been extensively used in high-income countries (HICs), their validity and feasibility have been limited in LMICs.[11] This limitation can be attributed to the lack of extensive medical records, radiographic images, and autopsy results in low-resource settings.

Apart from these, Revised Trauma Score (RTS), Mechanism (of injury)/GCS/Age/(systolic blood) Pressure (MGAP) score and GCS/Age/(systolic blood) Pressure (GAP) score have also been introduced as validated predictors of trauma outcomes.[12] While these scores are feasible in resource-limited settings, they have yet to be widely used in LMICs. Glasgow Coma Scale (GCS) is another recognized parameter for prediction of in-hospital mortality in trauma patients globally.[13] Its use has been significant for patients with traumatic brain injury (TBI); however, it has not been extensively explored yet for polytrauma in LMICs.

Literature from HICs indicates these scoring systems to demonstrate variable predictive values for in-hospital mortality, depending on the body region of injury.[14–16] However, their impact has not yet been compared between neurotrauma and polytrauma patients in LMICs, both of which have varying injury etiology, presentation and management. Hence, this study aims to compare trauma scoring systems between neurotrauma and polytrauma patients to identify the better predictor of in-hospital mortality for these types of trauma in a low-resource setting.

METHODOLOGY

Study design and setting

A descriptive secondary analysis was conducted using data from a multicenter, prospective trauma registry in Pakistan, an LMIC in South Asia that has a population of more than 225 million people.[17] This trauma registry includes two tertiary care hospitals that deal with an extensive load of trauma patients:

1. The Aga Khan University Hospital (AKUH) is a 760-bed, private-sector hospital and is the first in the country to receive the Joint Commission International accreditation.[18] An average of 55 000 emergency patients are treated annually within the hospital.
2. Jinnah Postgraduate Medical Centre (JPMC) is a public sector hospital with a bed capacity of 2000. Like AKUH, JPMC has its own emergency facility that treats up to 100 000 emergency patients a year.

Study participants and data collection

Data were collected from the trauma registry during a period of 12 months (December 2021 to December 2022). The methodology of collecting data and enrolling patients in the registry is performed as per the Collector Trauma Registry.[19] All patients aged 18 and above who underwent trauma were included for analysis.

The variables extracted for analysis included patient demographics (age and gender), details of injury, including its mechanism and anatomic area affected, vital signs including GCS and discharge outcome. The following five trauma scoring systems were calculated to ascertain their prediction of mortality:

1. ISS: ISS is an anatomic score obtained by taking the sum of the squares of the highest three values of the AIS.[20] The AIS codes each injury based on the body region and its severity. ISS was calculated as follows:
   $ISS=(1\text{st highest AIS score})^2+(2\text{nd highest AIS score})^2+(3\text{rd highest AIS score})^2$
2. RTS: GCS, SBP and RR were coded from 0 to 4.[21] These coded values were then multiplied by pre-specified coefficients for the final RTS as shown below, where higher scores indicate increased probability of survival:
   $RTS=(0.9368\times \text{GCS Value})+(0.7326\times \text{SBP Value})+(0.2908\times \text{RR Value})$
3. TRISS: TRISS uses RTS, ISS, and age index to calculate survival. Similar to RTS, a higher TRISS score also depicts greater chances of survival.[22] For age less than 55, the age index is coded as 0, whereas for age ≥ 55, it is taken as 1. The following formula was used to calculate TRISS:
   $\text{Survival probability}=1/(1+e^{-b})$,
   Where $b=b0+b1\times RTS+b2\times ISS+b3\times \text{Age Index}$ and is calculated based on the mechanism of injury as follows:
   $b_{blunt}=-0.4499+0.8085\times RTS-0.0835\times ISS-1.7430\times \text{Age Index}$
   $b_{penetrating}=-2.5355+0.9934\times RTS-0.0651\times ISS-1.1360\times \text{Age Index}$
4. GAP: This physiologic score was calculated using the standardized scoring system,[12] as shown in table 1.
5. MGAP: Similar to GAP, this score uses the standardized scoring system shown in table 1. However, it also includes the mechanism of injury to depict its impact on survival.[12]

Since all scores were calculated during data collection, a quality assurance check was done before statistical analysis. This included accuracy checks on 10% random scores using an online calculator.[23]

Statistical analysis

Statistical analysis was performed on the Statistical Package for the Social Sciences (SPSS) V.21. For analysis, entries with

Table 1 GAP and MGAP scoring system for coding of variables

Variable	Points allotted
Mechanism of trauma	
Blunt trauma	+4
Penetrating trauma	0
GCS score	+3–15
Age (years)	
<60	+5
>60	0
Systolic blood pressure (mm Hg)	
>120	+5
60–120	+3
<60	0

GAP, GCS/Age/Pressure; GCS, Glasgow Coma Scale; MGAP, Mechanism/GCS/Age/Pressure.

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

missing values (demographic and details of injury such as mechanism, cause, etc) were excluded. Analysis was performed for all patients, as well as for patients who presented with neurotrauma and polytrauma separately. This division was done based on the anatomic region affected. Patients who presented with neurotrauma, that is, had no/minor injuries in other regions of the body and were admitted within the department of neurosurgery for treatment, were included as ‘primarily neurotrauma’. All other patients who had a major injury in another region of the body or had multiple major/minor injuries were included as ‘polytrauma’. The latter group did not receive any major neurological/neurosurgical intervention. Continuous data were reported with mean±SD, while categorical data were reported as frequencies and percentages (n/%). Receiver operating characteristic (ROC) curves were used to derive sensitivity, specificity, and area under the curve (AUC) for each scoring system.[24] This determined their effectiveness in predicting in-hospital mortality for all three groups (all patients, patients with predominantly neurotrauma, patients with polytrauma) separately.

To ascertain the sensitivity of the original results, multiple imputations (MI) were first performed on the original dataset with all patients for missing values. Five imputation models were developed, each with different imputed values based on the original dataset. Final imputed values were derived after analyzing the imputed datasets separately. Sensitivity analysis was then conducted to compare the OR of non-imputed variables with imputed values,[25] specifically age, mechanism and cause of injury, surgical intervention, and trauma scoring systems (TRISS, RTS, GAP, MGAP, and GCS).

RESULTS

Data were extracted for a total of 2817 patients. Patients not meeting inclusion criteria (n=412) and those with missing data (n=398), that is, GCS, SBP, RR, etc, were excluded from the analysis (figure 1). The remaining 2007 patients were included for final analysis to identify trauma scoring systems that are better predictors of in-hospital mortality within our cohort. This cohort of 2007 patients was further analyzed after division into patients with predominantly neurotrauma (n=986) and polytrauma (n=1021) separately.

The mean age of total patients was 41.2±17.8 years, with the majority of participants being males (80.6%) and residents of the same city as the included hospitals (81.6%). The most common mechanism of injury was blunt trauma (85.2%), while road traffic crash was the most frequent cause of trauma (59.2%). About half of the patients (49.1%) presented predominantly with neurotrauma, while 50.9% were admitted as polytrauma patients. A total of 52.9% patients underwent surgical intervention. This included procedures from various specialties for polytrauma patients, such as open reduction internal fixation, exploratory laparotomy, wound debridement, etc, while for neurotrauma patients, surgical interventions mainly comprised craniotomies. In-hospital mortality rate for the total cohort was 17.2%, while for neurotrauma and polytrauma patients, it was 31.4% and 3.5%, respectively. Further demographic details for all trauma patients, along with specifications for neurotrauma and polytrauma patients, are shown in table 2.

Among the vital signs used for the calculation of trauma scoring systems for total sample, average SBP was 124.4±22.3 mm Hg while the mean RR was 20.3±4.9 breaths per minute. Table 3 shows mean trauma scoring systems for all patients (A), patients with neurotrauma (B) and patients with polytrauma (C), stratified by their outcome.

While the mean ISS for all patients was 12.2±7.3, it was relatively higher for patients with neurotrauma (15.7±7.1) and lower for polytrauma patients (8.8±5.8). This indicated increased severity of injury in patients with neurotrauma. Similar results

Table 2 Demographics, injury details and outcomes of post-traumatic patients

Variable	All trauma patients n=2007 n (%)	Polytrauma patients n=1021 n (%)	Neurotrauma patients n=986 n (%)
Age			
18–35	957 (47.7)	480 (47.0)	477 (48.4)
36–55	613 (30.5)	310 (30.4)	303 (30.7)
55–75	357 (17.8)	174 (17.0)	183 (18.6)
>75	80 (4.0)	57 (5.6)	23 (2.3)
Gender			
Male	1618 (80.6)	789 (77.3)	829 (84.1)
Female	389 (19.4)	232 (22.7)	157 (15.9)
City			
Karachi	1637 (81.6)	841 (82.4)	796 (80.7)
Outside Karachi	370 (18.4)	180 (17.6)	190 (19.3)
Ethnicity			
Sindhi	431 (21.5)	213 (20.9)	219 (22.2)
Balochi	140 (7.0)	65 (6.4)	75 (7.6)
Punjabi	170 (8.5)	85 (8.3)	85 (8.6)
Urdu speaking	867 (f.2)	434 (42.5)	442 (44.8)
Pathan	168 (8.4)	94 (9.2)	74 (7.5)
Others	231 (11.5)	130 (12.7)	91 (9.2)
Mechanism of injury			
Blunt trauma	1709 (85.2)	770 (75.4)	939 (95.2)
Penetrative trauma	298 (14.8)	251 (24.6)	47 (4.8)
Cause of trauma			
Road traffic crash (RTC)	1189 (59.2)	481 (47.1)	708 (71.8)
Assault	252 (12.6)	203 (19.9)	49 (5.0)
Fall	492 (24.5)	280 (27.4)	212 (21.5)
Others	74 (3.7)	57 (5.6)	17 (1.7)
Surgical intervention			
Yes	1061 (52.9)	770 (75.4)	291 (29.5)
No	946 (47.1)	251 (24.6)	695 (70.5)
Discharge outcome			
Alive	1661 (82.8)	985 (96.5)	676 (68.6)
Died	346 (17.2)	36 (3.5)	310 (31.4)

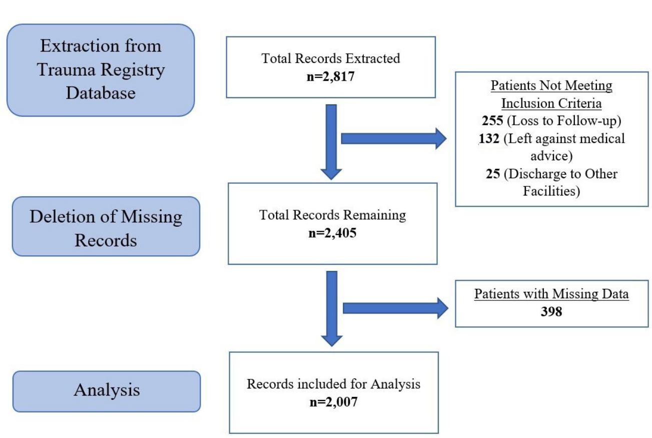

Figure 1 Inclusion and exclusion criteria for analysis.

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

Table 3 Mean trauma scoring systems for enrolled patients with specification for survivors and non-survivors

Trauma scoring system	Mean±SD Overall patients	Discharge outcome: alive	Discharge outcome: died
A. All patients with trauma			
ISS	12.2±7.3	10.9±6.7	18.6±7.0
TRISS	93.8±12.8	96.9±6.4	78.6±21.8
RTS	7.2±1.1	7.5±0.7	5.6±1.4
GCS	12.4±3.9	13.6±2.6	6.8±4.0
MGAP	24.1±4.2	25.2±3.3	18.8±4.2
GAP	20.6±4.2	21.8±3.2	15.1±4.2
B. Patients with neurotrauma			
ISS	15.7±7.1	14.2±6.8	19.1±6.5
TRISS	89.4±16.5	95.1±8.8	77.1±21.8
RTS	6.7±1.3	7.3±0.9	5.4±1.3
GCS	10.2±4.2	12.0±3.2	6.1±3.3
MGAP	22.3±4.7	24.2±3.8	18.3±3.9
GAP	18.5±4.6	20.3±3.7	14.5±3.7
C. Patients with polytrauma			
ISS	8.8±5.8	8.6±5.5	14.5±9.7
TRISS	97.9±5.0	98.2±3.6	91.3±18.1
RTS	7.7±0.5	7.7±0.4	7.2±1.2
GCS	14.6±1.6	14.7±1.4	12.9±4.0
MGAP	25.7±2.8	25.8±2.7	23.2±4.1
GAP	22.7±2.5	22.8±2.3	20.6±4.0

GAP, GCS/Age/Pressure; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; MGAP, Mechanism/GCS/Age/Pressure; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

were seen with other scores, where lower scores imply increased injury severity. For patients with neurotrauma, all these scores were relatively lower than the mean of total cohort, highlighting poor anatomic and physiologic parameters at presentation.

ROC curves were used to predict in-hospital mortality for all neurotrauma and polytrauma patients separately (figure 2). The area under the ROC (AUROC) for each trauma scoring system was calculated, along with its sensitivity and specificity as shown in table 4.

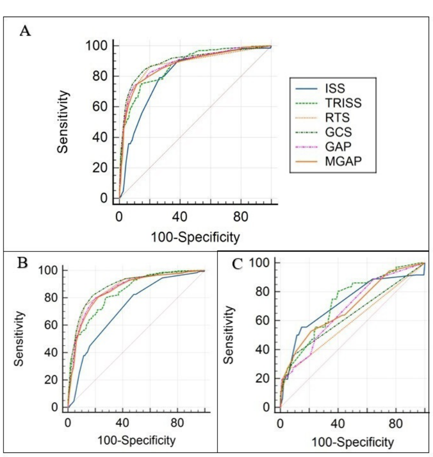

Figure 2 Receiver operating characteristic (ROC) curves for six trauma scoring systems (Injury Severity Score (ISS); Trauma and Injury Severity Score (TRISS); Revised Trauma Score (RTS); Glasgow Coma Scale (GCS); GCS/Age/Pressure (GAP); Mechanism/GCS/Age/Pressure (MGAP)). (A) All trauma patients. (B) Neurotrauma patients. (C) Polytrauma patients.

While all scores were significant in predicting in-hospital mortality for all patients ($p<0.05$), physiologic trauma scoring systems (ie, GCS, RTS, GAP and MGAP) proved to be better predictors than ISS and TRISS (table 4A). Among the physiologic scores, GCS proved to be the best predictor of in-hospital mortality with an AUROC of 0.897, followed by GAP (AUC: 0.883), RTS (AUC: 0.882), and MGAP (AUC: 0.874). While TRISS and ISS were significant predictors of mortality, the AUROC for these scores was less than other scores, depicting their lower efficacy in predicting in-hospital mortality for post-traumatic patients. Similar results were seen for patients with neurotrauma, where GCS had the highest AUC (0.885), while ISS had the least (0.724). However, for polytrauma patients, TRISS and ISS showed better prediction of in-hospital mortality as compared with other trauma scoring systems, with an AUC of 0.729 and 0.722, respectively. For patients with polytrauma, GCS had an AUC of less than 0.800 contrary to its value in other groups (AUC: 0.638). While RTS still showed lesser predictability than other scores for in-hospital mortality in patients with polytrauma (AUC: 0.595), it was not significant ($p=0.052$).

To conduct a sensitivity analysis, MIs were performed for missing data, resulting in 2405 complete entries. Using in-hospital mortality as the outcome, multivariable regression was conducted for both imputed ($n=2405$) and non-imputed ($n=2007$) datasets. Sensitivity analysis concluded no statistical difference between the results of regression from the two datasets, indicating reliable results of mortality prediction from the original, non-imputed data.

DISCUSSION

The results from this study indicate the significance of using injury-specific trauma scoring systems in predicting in-hospital

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

Table 4 Sensitivity, specificity, area under the curve with 95% CI, cut-off value and p value for each trauma scoring system (ordered as per AUC)

Trauma scoring system	Sensitivity (%)	Specificity (%)	Area under the curve	95% CI	Cut-off value	P value
A. All patients with trauma						
GCS	86.4	80.1	0.897	0.876 to 0.918	≤12	**<0.001**
GAP	82.4	80.1	0.883	0.862 to 0.904	≤19	**<0.001**
RTS	86.7	79.7	0.882	0.858 to 0.905	≤7.01	**<0.001**
MGAP	74.9	88.5	0.874	0.852 to 0.896	≤21	**<0.001**
TRISS	75.1	85.4	0.871	0.851 to 0.891	≤96.02	**<0.001**
ISS	79.2	73.6	0.814	0.791 to 0.838	>15	**<0.001**
B. Patients with neurotrauma						
GCS	81.9	81.8	0.885	0.863 to 0.908	≤9.5	**<0.001**
RTS	74.5	87.4	0.874	0.850 to 0.898	≤6.29	**<0.001**
GAP	80.0	79.7	0.861	0.836 to 0.886	≤17.5	**<0.001**
MGAP	80.6	77.8	0.855	0.830 to 0.880	≤21.5	**<0.001**
TRISS	80.0	72.5	0.839	0.814 to 0.865	≤95.4	**<0.001**
ISS	82.6	51.9	0.724	0.691 to 0.757	>15	**<0.001**
C. Patients with polytrauma						
TRISS	80.6	60.0	0.729	0.648 to 0.810	≤98.97	**<0.001**
ISS	55.6	84.9	0.722	0.623 to 0.820	>11.5	**<0.001**
MGAP	52.8	78.6	0.696	0.602 to 0.789	≤23.5	**<0.001**
GAP	47.2	75.9	0.679	0.590 to 0.767	≤22.50	**<0.001**
GCS	36.1	90.7	0.638	0.531 to 0.744	≤14.50	**0.005**
RTS	27.8	89.7	0.595	0.489 to 0.702	≤7.70	0.052

A p-value of <0.05 is considered statistically significant.
AUC, area under the curve; GAP, GCS/Age/Pressure; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; MGAP, Mechanism/GCS/Age/Pressure; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score.

mortality within a resource-limited setting. In our study, physiologic trauma scores such as GCS, GAP, RTS and MGAP predicted in-hospital mortality better than ISS and TRISS for the overall cohort as well as for patients with predominant neurotrauma. While GCS and RTS proved to be the best predictor for these groups, TRISS and ISS proved better predictability for in-hospital mortality among patients with polytrauma, indicating the significance of incorporating anatomic parameters for the latter group.

Baker *et al* initially used ISS in an HIC as a prediction tool of survival in victims of motor vehicle crashes.[20] The study concluded ISS to be a good predictor of mortality, determining a higher risk of death with each increasing unit of ISS. Since then, it has been a standard severity score in HICs for the triage of post-traumatic patients to predict their probability of survival using a cut-off value of ≥15 for poor outcomes.[26] Furthermore, it has also shown to have a greater association with in-hospital mortality after TBI as compared with GCS.[27] In contrast, our study showed ISS to have lesser predictability for in-hospital mortality within the whole cohort and patients with neurotrauma, but better predictive value for patients with polytrauma. This was also seen in literature from other LMICs comparing ISS with other trauma scoring systems (without distinction between neurotrauma and polytrauma), where ISS was the least predictive of in-hospital mortality.[28 29] Since the score only caters to the three most affected body regions, the prediction value of ISS might be better demonstrated in patients undergoing blunt trauma of specific body regions,[30 31] or in those with isolated abdominal gunshot wounds.[32] Hence, scores that also use physiologic parameters, such as TRISS, are considered more accurate.

TRISS has shown variable results in predicting in-hospital mortality for neurotrauma patients, where a Korean study suggests this score to be efficient in predicting survival after TBI,[33] while a Thailand study indicates it to be poor in predicting postneurotrauma survival.[34] Our study concluded TRISS to have a lower AUC for neurotrauma patients but the greatest AUC for polytrauma patients. Similar to our results, TRISS has shown a higher efficacy in predicting in-hospital mortality for polytrauma patients in HICs. A study from Malaysia indicated TRISS to have a higher AUC of 0.812 than RTS (AUC: 0.802).[35] Similarly, another study comparing trauma scoring systems for a trauma registry cohort in the USA highlighted TRISS to have an AUC of 0.938, making it the best predictor of in-hospital mortality in postsurgical trauma patients.[36]

One of the major reasons for this difference between neurotrauma and polytrauma patients can be attributed to the coefficients used to calculate TRISS. Since these coefficients have been derived from Major Trauma Outcome Study making use of patients from an HIC population,[37] it can have limited applicability for neurotrauma patients owing to the lack of stratification within original data. Hence, coefficients for TRISS should be validated for specific populations, rather than the ones developed in HICs, to allow for a more sensitive and specific result. Furthermore, RTS was among the highest physiologic predictors of in-hospital mortality for neurotrauma patients and lowest for polytrauma patients. However, it has shown to underestimate injury severity in LMIC populations.[13] The mean RTS of 7.2 in our study for all patients was also comparable with the literature from South Africa, indicating a possibility of prehospital mortality among severely injured patients with a low RTS.[38]

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

Our study identified GAP and MGAP as better predictors of in-hospital mortality than ISS for neurotrauma patients. Both GAP and MGAP are validated physiologic scores developed to cater to the gaps brought about by RTS. One of the key factors not taken into account in RTS is the patient's age, which has been shown to impact their outcome independently.[39] Apart from incorporating age, MGAP also includes the mechanism of injury within its score that changes management and outcome assessment methodologies.[40] Limited literature using these scoring systems highlights GAP and MGAP as better predictors of in-hospital mortality than anatomic scores for all trauma patients.[29 41] Likewise, the AUROC for both GAP and MGAP also corresponds to that specified before from South Asian LMICs, that is, 0.85–0.99 and 0.84–0.99, respectively.[29 41 42] Our results for neurotrauma patients are also consistent with the literature, where MGAP had no significant difference in predicting in-hospital mortality for patients with post-TBI when compared with GCS.[14] It is interesting to note that while GAP was higher than MGAP for neurotrauma patients, MGAP had a higher AUC than GAP for polytrauma patients. This indicates the significance of including mechanism of injury for management of patients presenting with polytrauma. Since these scores have only been validated in HICs yet, there is a need to further explore them in other settings by comparing with anatomic scores.

The use of GCS as a trauma scoring system is widely implemented in LMICs, owing to its easier calculation without any imaging and its proven significance as a strong predictor of in-hospital mortality.[13] Congruent to our results, GCS has shown to be a vital predictive factor of mortality in patients with TBI in both HICs and LMICs.[14 43] A retrospective analysis from Egypt showed a mean GCS of 14.06 ± 1.77 for survivors of post-trauma, while for those who died during their hospital stay, it was 8.85 ± 3.84.[12] This correlates with our finding for the total sample, where ≤12 was identified as the cut-off between survivors and non-survivors, regardless of the body region of injury. However, for neurotrauma separately, the cut-off was calculated to be 9.5. Similar to this, Watanitanon *et al* also highlighted the greatest proportion of in-hospital mortality among isolated patients with TBI with a GCS score of 9 as compared with those having a GCS score of greater than 9.[44]

This study is among the first of its kind from an LMIC to compare trauma scoring scores between neurotrauma and polytrauma patients. Additionally, comparison of GCS with all the scores used in our study has not been done previously within the same patient cohort for the two types of trauma presentation. Sensitivity analysis to negate any possible bias associated with missing data revealed no statistical difference between imputed and non-imputed datasets. This further strengthened our findings. Since the scores were calculated during the enrollment of patients in the study, a random recheck before analysis assured the quality of the data. However, there were some limitations to this study. While this was a multicenter study, both the hospitals belonged to the same province of the country. This can limit generalizability of the results to trauma patients in other regions. There were less than 10% missing data which were removed for analysis; however, any biases which could have resulted from this were reduced with sensitivity analysis, as described above. Furthermore, calculation of TRISS was done using prior validated coefficients in HICs. A validation study done in our cohort to develop TRISS equation could have further increased the strength of our findings.

CONCLUSION

This study signifies the use of context-specific and injury-specific trauma scoring systems in resource-limited settings as a guide to appropriate triage and treatment strategies. Our results concluded GCS and RTS to show a better prediction of in-hospital mortality in patients with neurotrauma, while TRISS and ISS were better predictors for patients with polytrauma. Therefore, it is vital to take into account the region of body injury for provision of quality trauma care. Furthermore, since there are variable findings in different regions of both HICs and LMICs, it is vital to use context-specific trauma scoring systems depending on differing patient populations. Validation of these scores within LMICs can further enable stakeholders to truly identify the risk of mortality and work towards strengthening and benchmarking their trauma systems.

Author affiliations
[1]Dean's Office, The Aga Khan University, Karachi, Sindh, Pakistan
[2]Centre of Excellence for Trauma and Emergencies, The Aga Khan University, Karachi, Sindh, Pakistan
[3]Department of Medicine, The Aga Khan University, Karachi, Sindh, Pakistan
[4]Department of Neurosurgery, Jinnah Postgraduate Medical Centre, Karachi, Sindh, Pakistan
[5]Department of Emergency Medicine, The Aga Khan University, Karachi, Sindh, Pakistan
[6]Department of Emergency Medicine, Jinnah Postgraduate Medical Centre, Karachi, Sindh, Pakistan
[7]Department of Surgery, Jinnah Postgraduate Medical Centre, Karachi, Sindh, Pakistan
[8]Center on Commercial Determinants of Health and Department of Global Health, George Washington University School of Public Health and Health Services, Washington, DC, USA
[9]Department of Emergency Medicine, Weill Cornell Medicine, New York, New York, USA
[10]Department of Surgery and Community Health Sciences, The Aga Khan University, Karachi, Sindh, Pakistan

Contributors The study was conceptualized and designed by AAHM, NS, JR and AHH. AAHM, NS, NA, SH, ZJ, AA and TA curated the data. AAHM and NA analyzed the dataset. The article was drafted by AAHM, NA, SH and ZJ and revised by NS, AA, TA, HA, URK, NUK, SM, SR, AAH, JR and AHH. All authors critically reviewed the final version of the article and approved its content. JR is the guarantor.

Funding Research reported in this publication was supported by the Fogarty International Center of the National Institutes of Health under award number D43TW007292—The Aga Khan University Trauma and Injury Research Training Program.

Disclaimer The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by The Aga Khan University Ethics Review Committee (Reference No 2021-6251-18973). The study complies with the Declaration of Helsinki. Informed verbal consent was obtained from all the participants before starting data collection. Participation was voluntary, and the right to ask any questions and to decline participation/leave the study at any time was emphasized during the data collection. Data were anonymized during data management, analysis, and reporting. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement Data are available upon reasonable request. Deidentified participant dataset used for the analysis in this article is available from the corresponding author at reasonable request.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.

permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: http://creativecommons.org/licenses/by-nc/4.0/.

ORCID iDs

Asma Altaf Hussain Merchant http://orcid.org/0000-0002-0393-2079
Adnan A Hyder http://orcid.org/0000-0002-7292-577XreplyReply

REFERENCES

1 Haagsma JA, Charalampous P, Ariani F, Gallay A, Moesgaard Iburg K, Nena E, Ngwa CH, Rommel A, Zelviene A, Abegaz KH, *et al*. The burden of injury in central, Eastern, and Western European sub-region: a systematic analysis from the global burden of disease 2019 study. *Arch Public Health* 2022;80:142:142.:.
2 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006;3:e442.
3 WHO. Injuries and violence. 2021. Available: https://www.who.int/news-room/fact-sheets/detail/injuries-and-violence [Accessed 17 Jan 2023].
4 Chandran A, Hyder AA, Peek-Asa C. The global burden of unintentional injuries and an agenda for progress. *Epidemiol Rev* 2010;32:110–20.
5 Mobinizadeh M, Berenjian F, Mohamadi E, Habibi F, Olyaeemanesh A, Zendedel K, Sharif-Alhoseini M. Trauma Registry data as a policy-making tool: A systematic review on the research dimensions. *Bull Emerg Trauma* 2022;10:49–58.
6 Lefering R. Trauma scoring systems. *Curr Opin Crit Care* 2012;18:637–40.
7 Jat AA, Khan MR, Zafar H, Raja AJ, Hoda Q, Rehmani R, Lakdawala RH, Bashir S. Peer review audit of trauma deaths in a developing country. *Asian J Surg* 2004;27:58–64.
8 Hofman K, Primack A, Keusch G, Hrynkow S. Addressing the growing burden of trauma and injury in Low- and middle-income countries. *Am J Public Health* 2005;95:13–7.
9 Stevenson M, Segui-Gomez M, Lescohier I, Di Scala C, McDonald-Smith G. An overview of the injury severity score and the new injury severity score. *Inj Prev* 2001;7:10–3.
10 Singh J, Gupta G, Garg R, Gupta A. Evaluation of trauma and prediction of outcome using TRISS method. *J Emerg Trauma Shock* 2011;4:446–9.
11 Roy N, Gerdin M, Schneider E, Kizhakke Veetil DK, Khajanchi M, Kumar V, Saha ML, Dharap S, Gupta A, Tomson G, *et al*. Validation of international trauma scoring systems in urban trauma centres in India. *Injury* 2016;47:2459–64.
12 Mohammed Z, Saleh Y, AbdelSalam EM, Mohammed NBB, El-Bana E, Hirshon JM. Evaluation of the revised trauma score, MGAP, and GAP scoring systems in predicting mortality of adult trauma patients in a low-resource setting. *BMC Emerg Med* 2022;22:90.
13 Feldhaus I, Carvalho M, Waiz G, Igu J, Matthay Z, Dicker R, Juillard C. Thefeasibility, appropriateness, and applicability of trauma scoring systems in low and middle-income countries: a systematic review. *Trauma Surg Acute Care Open* 2020;5:e000424.
14 Basak D, Chatterjee S, Attergrim J, Sharma MR, Soni KD, Verma S, GerdinWärnberg M, Roy N. Glasgow coma scale compared to other trauma scores in discriminating in-hospital mortality of traumatic brain injury patients admitted to urban Indian hospitals: A Multicentre prospective cohort study. *Injury* 2023;54:93–9.
15 Cernea D, Novac M, Drăgoescu PO, Stănculescu A, Duca L, Al-Enezy AA, Drăgoescu NA. Polytrauma and multiple severity scores. *Curr Health Sci J* 2014;40:244–8.
16 Yadav MS, Nagar M, Joshi A, Gupta A. Performance validation of different trauma scoring systems among Polytrauma patients having predominantly blunt abdominal trauma. *J Family Med Prim Care* 2020;9:2866–70.
17 Vollset SE, Goren E, Yuan C-W, Cao J, Smith AE, Hsiao T, Bisignano C, Azhar GS, Castro E, Chalek J, *et al*. Fertility, mortality, migration, and population scenarios for 195 countries and territories from 2017 to 2100: a forecasting analysis for the global burden of disease study. *Lancet* 2020;396:1285–306.
18 AKUH receives joint Commission International Reaccreditation. 2021. Available: https://hospitals.aku.edu/pakistan/AboutUs/News/Pages/akuh-receives-joint-commission-international-accreditation-.aspx [Accessed 17 Jan 2023].
19 NSW Trauma Registry System | Institute of Trauma and Injury Management | ACI, Available: https://aci.health.nsw.gov.au/networks/itim/data/nsw_trauma_registry_system [Accessed 17 Jan 2023].
20 Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187–96.
21 Champion HR, Sacco WJ, Copes WS, Gann DS, Gennarelli TA, Flanagan ME. A revision of the trauma score. *The Journal of Trauma: Injury, Infection, and Critical Care* 1989;29:623–9.
22 Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: the TRISS method. trauma score and the injury severity score. *J Trauma* 1987;27:370–8.
23 MDApp – Your Source Of Medical Algorithms, Scores And Calculators, Available: https://www.mdapp.co/ [Accessed 17 Jan 2023].
24 Nahm FS. Receiver operating characteristic curve: overview and practical use for Clinicians. *Korean J Anesthesiol* 2022;75:25–36.
25 Carpenter JR, Kenward MG, White IR. Sensitivity analysis after multiple imputation under missing at random: A weighting approach. *Stat Methods Med Res* 2007;16:259–75.
26 Palmer C, Dip G, Epi C. Major trauma and the injury severity score - where should we set the bar? *Annu Proc Assoc Adv Automot Med* 2023;51:13.
27 Areas FZ, Schwarzbold ML, Diaz AP, Rodrigues IK, Sousa DS, Ferreira CL, Quevedo J, Lin K, Kupek E, Ritter C, *et al*. Predictors of hospital mortality and the related burden of disease in severe traumatic brain injury: A prospective Multicentric study in Brazil. *Front Neurol* 2019;10:432.
28 Hung YW, He H, Mehmood A, Botchey I, Saidi H, Hyder AA, Bachani AM. Exploring injury severity measures and in-hospital mortality: A multi-hospital study in Kenya. *Injury* 2017;48:2112–8.
29 Laytin AD, Kumar V, Juillard CJ, Sarang B, Lashoher A, Roy N, Dicker RA. Choice of injury scoring system in Low- and middle-income countries: lessons from Mumbai. *Injury* 2015;46:2491–7.
30 Restrepo-Álvarez CA, Valderrama-Molina CO, Giraldo-Ramírez N, Constain-Franco A, Puerta A, León AL, Jaimes F. Trauma severity scores. *Colombian J Anesthesiol* 2016;44:317–23.
31 Colnaric JM, El Sibai RH, Bachir RH, El Sayed MJ. Injury severity score as a Predictor of mortality in adult trauma patients by injury mechanism types in the United States: A retrospective observational study. *Medicine (Baltimore)* 2022;101:e29614.
32 Shah AA, Rehman A, Shah SJ, Haider AH, Zogg CK, Zafar SN, Hadi YB, Zafar H. Abdominal gunshot wounds-a comparative assessment of severity measures. *J Surg Res* 2015;198:334–9.
33 Moon J-H, Seo B-R, Jang J-W, Lee J-K, Moon H-S. Evaluation of probability of survival using trauma and injury severity score method in severe Neurotrauma patients. *J Korean Neurosurg Soc* 2013;54:42–6.
34 Wongsirisuwan M. Trauma and injury severity score (TRISS) in head injury patients. *Thai J Surg* 2003;24:21–8.
35 Tan JH, Tan HCL, Noh NAM, Mohamad Y, Alwi RI. Validation of the trauma mortality prediction scores from a Malaysian population. *Burns Trauma* 2017;5:37.
36 Kuza CM, Matsushima K, Mack WJ, Pham C, Hourany T, Lee J, Tran TD, Dudaryk R, Mulder MB, Escanelle MA, *et al*. The role of the American society of Anesthesiologists physical status classification in predicting trauma mortality and outcomes. *Am J Surg* 2019;218:1143–51.
37 Champion HR, Copes WS, Sacco WJ, *et al*. The major trauma outcome study: establishing national norms for trauma care. *Journal of Trauma - Injury, Infection and Critical Care* 1990;30:1356–65.
38 Gardner A, Forson PK, Oduro G, Stewart B, Dike N, Glover P, Maio RF. Diagnostic accuracy of the Kampala trauma score using estimated abbreviated injury scale scores and physician opinion. *Injury* 2017;48:177–83.
39 Kisat MT, Latif A, Zogg CK, Haut ER, Zafar SN, Hashmi ZG, Oyetunji TA, Cornwell EE, Zafar H, Haider AH. Survival outcomes after prolonged intensive care unit length of stay among trauma patients: the evidence for never giving up. *Surgery* 2016;160:771–80.
40 Haider AH, Chang DC, Haut ER, Cornwell EE 3rd, Efron DT. Mechanism of injury predicts patient mortality and impairment after blunt trauma. *J Surg Res* 2009;153:138–42.
41 Yadollahi M, Ghaedsharaf Z, Jamali K, *et al*. The accuracy of GAP and MGAP scoring systems in predicting mortality in trauma; a diagnostic accuracy study. *Front Emerg Med* 2019;4.
42 Rahmani F, Ebrahimi Bakhtavar H, Shams Vahdati S, Hosseini M, Mehdizadeh Esfanjani R. Evaluation of MGAP and GAP trauma scores to predict prognosis of multiple-trauma patients. *Trauma Mon* 2017;In press.
43 Sewalt CA, Venema E, Wiegers EJA, Lecky FE, Schuit SCE, den Hartog D, Steyerberg EW, Lingsma HF. Trauma models to identify major trauma and mortality in the Prehospital setting. *Br J Surg* 2020;107:373–80.
44 Watanitanon A, Lyons VH, Lele AV, Krishnamoorthy V, Chaikittisilpa N, Chandee T, Vavilala MS. Clinical epidemiology of adults with moderate traumatic brain injury. *Crit Care Med* 2018;46:781–7.

Trauma Surg Acute Care Open: first published as 10.1136/tsaco-2023-001171 on 22 November 2023. Downloaded from http://tsaco.bmj.com/ on May 1, 2024 by guest. Protected by copyright.