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Does a given abbreviated injury scale value in different body regions contribute to the same risks of in-hospital mortality and ICU admission in trauma patients?

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Abstract: **Objective:** We aimed to investigate the hypothesis that identical abbreviated injury scale (AIS) scores may lead to varying risks of in-hospital mortality and admission to the intensive care unit (ICU) depending on the specific body region affected.
Methods: This study focused on hospitalized trauma patients with moderate to serious injuries (AIS=2, 3). The final sample was stratified based on the injured body regions. To determine the impact of these injuries on mortality and ICU admission, we conducted binary logistic regression after adjusting for confounding factors.
Results: Overall, 16,040 trauma patients with moderate injury (AIS=2) and 1,338 trauma patients with serious injury (AIS=3) were included in this study. When comparing outcomes of trauma patients in different body regions, there was no significant difference in the odds of two main outcomes in various injury sites, except for extremities (P values>0.05). When the AIS=2 patients were controlled for confounding factors, the adjusted odds of mortality were significantly higher for head, face, and neck injuries, as well as spine/back, thoracic, and abdominal injuries, compared to extremity injuries (adjusted odds ratio (aOR)s=9.81, 8.78, 8.11, and 3.96, respectively; P-values<0.05). Among those with AIS=3, the odds of mortality were significantly greater for abdominal (aOR=7.05, P-value=0.009) and head, face, and neck injuries (aOR=2.73, P-value=0.001) than for extremity injuries.
Conclusion: Injuries with the same AIS (=2, 3) value almost indistinguishably confer the same mortality risk and ICU admission, except for extremities. The unique AIS value assigned to various body sites almost consistently indicates the same likelihood of negative outcomes.

Keywords: Abbreviated Injury Scale (AIS); Injury Severity Score (ISS); Mortality; Trauma; Wound and Injury; Scoring System

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1. Introduction

Trauma is among the first causes of mortality and morbidity worldwide (1). Various trauma scoring systems have been developed during the last 30 years to better predict patient outcomes. Each scoring system allocated numerical values to anatomical and physiological alterations following the injury. Three main types of trauma scoring systems have been developed during recent decades: anatomical systems, including the abbreviated injury scale (AIS) and the injury severity score (ISS), which are coded based on injury severity; physiological systems, including the Glasgow coma scale (GCS) and revised trauma score (RTS), which are numbered based on clinical examination; and mixed scoring systems, including the trauma and injury severity score (TRISS), which are valued based on both injury severity and physical examination (2,3).

Among these scoring systems, the AIS is an anatomical-based scale developed in 1971. It was first utilized for classifying injury severity in automobiles and aircraft; afterward, it was established as an international trauma scoring system for all types of traumas (4,5). The impact of the injury on each body region was evaluated by assigning an ordinal numerical value ranging from 1 to 6; AIS-1 represents a minor injury, AIS-2 represents moderate injury, AIS-3 represents severe injury, AIS-4 represents severe injury, AIS-5 represents critical injury, and AIS-6 represents maximal nonsurvivable injury (4). The AIS was also subsequently used for developing other trauma scoring systems, including the ISS in 1974 (6), the new injury severity score (NISS) in 1997 (7), and the exponential injury severity score (EISS) in 2014 (8).

Scoring systems, including AIS are supposed to predict poor outcomes including in-hospital mortality and ICU admission. Under desirable predictive performance of scoring systems results in either under triage or over triage. Although determining the best scoring system is crucial for health systems, validation of each assigned value in each scoring system in also necessary for policymakers (9).

It is well established that the risk of developing poorer outcomes according to one specific AIS value, including in-hospital mortality, should be identical across all body regions (10). For instance, it is postulated that the risk of hospital mortality and ICU admission for a trauma patient with an AIS=3 in the head, face, or neck should be similar and at least not significantly different from that of another trauma patient with an AIS=3 in the abdomen or thorax. The aforementioned assumption has rarely been explored in the literature (10). This study aimed to assess the odds of developing poorer outcomes, encompassing in-hospital mortality and ICU admission, for a given AIS value, either AIS=2 or 3, across various body regions. Furthermore, we investigated whether there was any significant difference in the odds of developing poor outcomes for a given AIS across various body regions.

2. Methods

2.1. Study design and participants

The patients included in this study were retrieved from the national trauma registry of Iran (NTRI), an ongoing multicenter hospital-based registry of trauma patients in Iran. As previously elaborated on the development of the NTRI and its associated questionnaire elsewhere (11,12,13,14), In 2014, the Iranian Ministry of Health and Medical Education entrusted the NTRI to the Sina Trauma and Surgery Research Center (STSRC). The primary objective of the NTRI was to conduct thorough investigations and provide high-quality care to patients who have experienced trauma. The criteria for inclusion of patients in the registry were as follows: hospitalization exceeding 24 hours, transfer from other intensive care units, or post-trauma in-shospital death within the first 24 hours. Data form all patients from 12 major trauma centers admitted between July 2016 and November 2023 were collected for this study.

The current study included every hospitalized trauma patient enrolled in the NTRI since its foundation until November 2023 (n=50,386). To prevent the confounding impact of trauma on other body regions, multiple trauma patients were also excluded from the present study (n=18,109). Moreover, as the number of trauma patients with AIS-4, 5, or 6 was too small to conduct statistical analysis, these patients were likewise excluded from the study (n=149, 83, and 71 patients, respectively). Finally, these patients were excluded due to the considerably negligible number of deceased and ICU-admitted patients with AIS-1 (n=8,235). The severity of injury in 1,338 patients was undetermined (AIS=7). A total of 27,985 patients were excluded. Overall, as demonstrated in figure 1, 16,040 trauma patients with moderate injury (AIS=2) and 1,338 patients with serious injury (AIS=3) were included in this study. These 22,401 patients were stratified according to the presence of head, face, or neck injuries (n=1,663); thoracic (462) or abdominal (n=571) injury; or extremity (n=18,670) or spine/back (n=880) injury. Other injuries, including genitalia, were reported in 155 patients.

2.2. Variables

Multiple traumas were defined as injuries to at least two different body regions with an AIS>2 (15,16). The mechanism of trauma was classified as road traffic crash (RTC), fall, penetrating injury due to stab and/or cut, blunt injury, or other. Other causes included drowning, animal attacks, burns, heat injuries, and unknown reasons. The GCS was classified as mild (13-15), moderate (9-12), or severe (3-8) (17). The RTS was also utilized as a physiological scoring system encompassing the respiratory rate (RR), GCS score, and systolic blood pressure (SBP). The final score ranges from 0 to 7.84 (18). ICU admission and in-hospital mortality were considered as the two main outcomes in this study. In-hospital mortality was considered the as trauma patients' death after admission at any reason. Besides, ICU admission of trauma

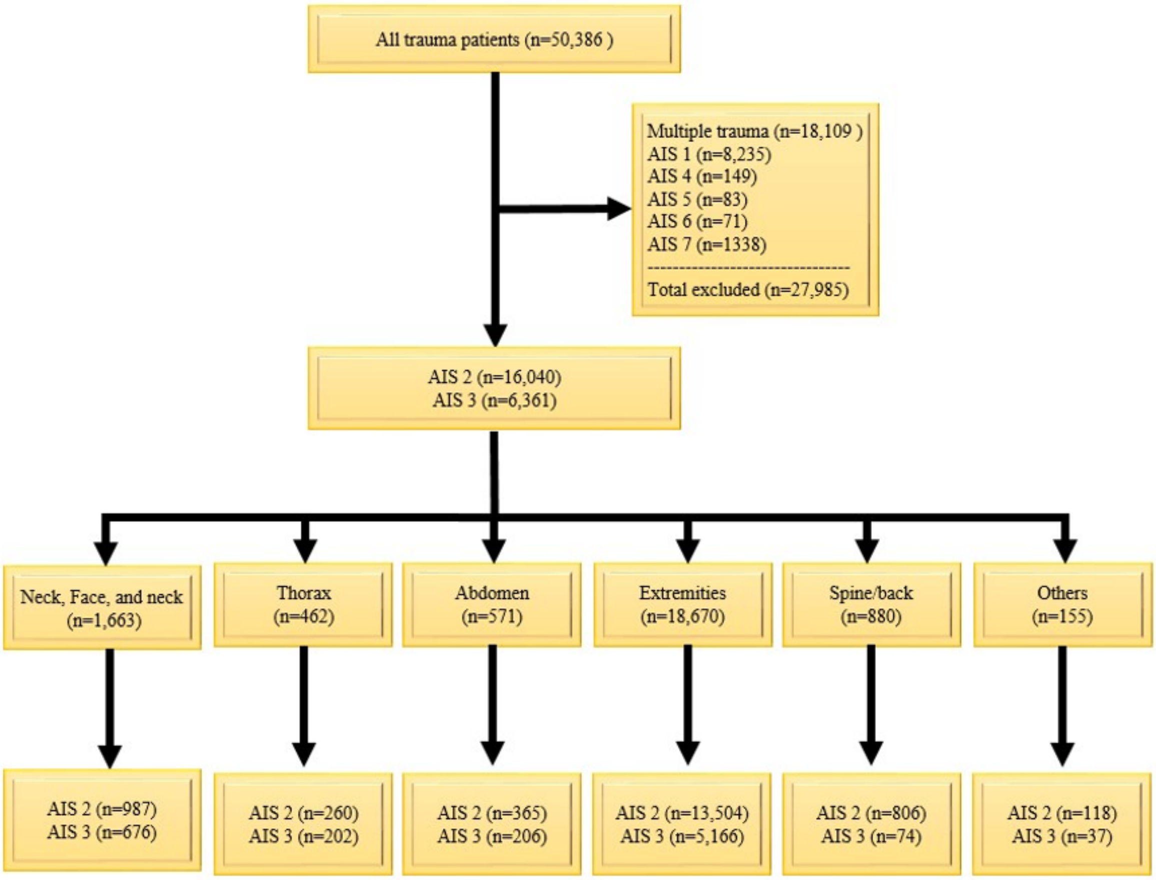

Figure 1 An overview of patients included in this study, alongside their body regions

cases due to any reasons was deemed as the second main outcome in this study.

2.3. Ethical consideration

All ethical and moral issues were considered in this study. Informed consent was obtained from the patients or their next of kin. This study was approved by the ethics committee of Sina Hospital, Tehran University of Medical Sciences (Approval ID: IR.TUMS.SINAHOSPITAL.REC.1399.090).

2.4. Statistical analysis

In this study, plots and tests were employed to evaluate the normal distribution of continuous data (age, GCS and RTS). As they did not follow a normal distribution pattern, non-parametric tests were utilized to compare means. The number and percentage were used to describe nominal and categorical variables by body region. Univariate and multiple logistic regression models were applied to assess the determinants of death and ICU admission according to the AIS strata. The multiple logistic regression models were employed to control confounders. We used the Hosmer–Lemeshow guideline for variable selection. In this approach, firstly, univariable logistic regression models for each variable were fitted separately. Then we fitted a multiple logistic regression model with variables with P<0.2 in the univariate analysis (in other words in multiple models, we entered those variables that in univariable models had a reasonably significant level, such as 0.2). In the next step one by one, we removed those variables that now appear to have lost their significance within the multiple models while checking via the likelihood ratio test that the reduced model does not fit the data significantly worse than the original multiple logistic models. Data analysis was performed using Stata software version 17.0 (Stata Corp, College Station, TX, USA).

3. Results

3.1. Injury characteristics of patients with AIS-2

Overall, 16,040 trauma patients had AIS-2 scores. Of them, extremities injuries were reported in 13,504 (84.19%), head, face, and neck in 987 (6.15%), spine/back in 806 (5.02%), abdomen in 365 (2.28%), thorax in 260 (1.62%), and others, including genitalia, in 118 (0.74%) (Figure 1). Among the aforementioned groups of trauma patients with AIS-2, patients with "other" injuries were not analyzed due to the small number of included patients (n=118). Patients with the abdominal injuries were the youngest; however, those with spine/back injuries were the oldest (32.82±16.6 vs. 43.91±18.1). RTC was the most common mechanism of trauma involving the thorax, extremities, and head, face,

Table 1 Injury characteristics of trauma cases with AIS 2

AIS2	Head, neck, and face	Thorax	Abdomen	Extremities	Spine/back	Others	Total	P-value
N (%)	987 (6.2)	260 (1.6)	365 (2.3)	13,504 (84.2)	806 (5.0)	118 (0.7)	16,040 (100)	—
Age†								
Mean (SD)	34.17 (20.9)	37.71 (18.1)	32.82 (16.6)	35.29 (20.8)	43.91 (18.1)	33.32 (20.3)	35.6 (20.7)	<0.001
Median (IQR)	30.0 (29)^{a}	35.0 (28)^{b}	30.0 (22)^{a}	34.0 (31)^{a}	41.0 (26)^{c}	31.0 (26)^{a}	34 (31)	
Sex (male); n (%)	728 (74)^{a,b}	215 (83)^{c}	254 (69.6)^{a,b}	10199 (75.6)^{a,c}	556 (69)^{b}	79 (67.5)^{a,b}	12068 (75.1)	<0.001
Mechanism of trauma; n (%)								
RTC	419 (42.5)^{a}	81 (31.2)^{b}	78 (21.4)^{b}	6188 (45.8)^{a}	365 (45.3)^{a}	1 (0.8)^{c}	7151 (44.5)	
Fall	194 (19.7)^{a}	51 (19.6)^{a}	32 (8.8)^{b}	5650 (41.8)^{d}	403 (50)^{c}	0^{e}	6335 (39.4)	
Stab/cut	37 (3.7)^{a}	73 (28.1)^{b}	49 (13.4)^{c}	446 (3.3)^{a}	5 (0.6)^{d}	0^{a},^{d}	610 (3.8)	<0.001
Blunt	78 (7.9)^{a}	17 (6.5)^{a},^{b,c}	17 (4.7)^{a,b,c}	960 (7.1)^{d}	28 (3.5)^{c}	0^{e}	1106 (6.9)	
Others	259 (26.2)^{a}	38 (14.6)^{b}	189 (51.8)^{c}	260 (1.9)^{d}	5 (0.6)^{d}	117 (99.2)^{e}	878 (5.5)	
GCS†								
Mean (SD)	13.93 (2.12)	14.68 (1.29)	13.81 (2.31)	14.97 (0.33)	14.85 (0.74)	15 (0)	14.87 (0.79)	<0.001
Median (IQR)	15 (2)^{a}	15 (0)^{b}	15 (2)^{a}	15 (0)^{c}	15 (0)^{b}	15 (0)^{c}	15 (0)	
GCS; n (%)								
3 to 8	36 (3.7)^{a}	3 (1.2)^{a,b}	16 (4.4)^{a}	5 (0.0)^{c}	2 (0.3)^{b,c}	0^{a,b,c}	62 (0.4)	
9 to 12	108 (11.2)^{a}	10 (3.9)^{b}	53 (14.6)^{a}	42 (0.3)^{c}	13 (1.6)^{b}	0^{a,b,c}	228 (1.4)	<0.001
13 to 15	824 (85.1)^{a}	244 (94.9)^{b}	295 (81)^{a}	13383 (99.7)^{c}	784 (98.1)^{b}	117 (100)^{b,c}	15685 (97.5)	
ISS; n (%)								
1 to 8	985 (99.8)	260 (100)	365 (100)	13491 (99.9)	806 (100)	118 (100)	16,065 (99.9)	
9 to 15	2 (0.2)	0	0	13 (0.1)	0	0	15 (0.1)	0.743
>=16	0	0	0	0	0	0	0	
RTS†								
Mean (SD)	7.59 (0.64)	7.75 (0.37)	7.55 (0.72)	7.77 (0.42)	7.81 (0.20)	7.78 (0.32)	7.76 (0.4)	<0.001
Median (IQR)	7.84 (0)^{a}	7.84 (0)^{b}	7.84 (0)^{a}	7.84 (0)^{c,b}	7.84 (0)^{c}	7.84 (0)^{b}	7.84 (0)	
In-hospital mortality; n (%)	30 (3)^{a}	5 (1.9)^{a}	9 (2.5)^{a}	12 (0.1)^{b}	10 (1.2)^{a}	1 (0.8)^{a},^{b}	67 (0.4)	<0.001
ICU admission; n (%)	179 (18.1)^{a}	29 (11.2)^{a}	97 (26.6)^{b}	346 (2.6)^{c}	117 (14.5)^{a}	1 (0.8)^{c}	771 (4.8)	<0.001

N: Number; SD: Standard Deviation; RTS: Revised Trauma Score; ISS: Injury Severity Score; GCS: Glasgow Coma Scale; AIS: Abbreviated Injury Scale; ICU: Intensive Care Unit; RTC: Road Traffic Crash; IQR: Interquartile Range
Each subscript letter denotes a subset of body zone categories whose column proportions do not differ significantly from each other at the 0.05 level
†These three did not follow a normal distribution pattern. Nonparametric tests were utilized for comparison

and neck (31.2%, 45.8%, and 42.5%, respectively). The most frequent cause of trauma in spine/back injuries was falls (50%). In summary, RTC was the most common mechanism of trauma (44.5%), followed by falls (39.4%), blunt trauma (6.9%), and stabbing/cutting (3.8%).

Mild trauma based on the GCS (GCS: 13 to 15) was documented in the extremities (99.7%), spine/back (98.1%), thorax (94.9%), head, face, and neck (85.1%), and abdomen (81%). Moderate trauma based on the GCS (GCS: 9 to 12) was reported in abdominal (14.6%), head, face, and neck (11.2%), thorax (3.9%), spine/back (1.6%), and extremity (0.3%) injuries. Severe trauma, according to the GCS (3 to 8), was outlined in the abdomen (4.4%), head, face, and neck (3.7%), thorax (1.2%), spine/back (0.3%), and extremities (0%). In total, 15,685 (97.5%) patients had a GCS ranging from 13 to 15, 228 (1.4%) had a GCS ranging from 9 to 12, and 62 (0.4%) had a GCS ranging from 3 to 8. All patients with thorax, abdominal, or spine/back injuries had mild injuries (i.e., ISS: 1 to 8). Only 13 (0.1%) patients with extremity injuries and 2 (0.2%) patients with head, face, or neck injuries had moderate ISSs, i.e., 9 to 15. Altogether, 15 (0.1%) patients had ISSs ranging from 9 to 15. The mean±standard deviation (SD) RTS was the highest at 7.81 (0.20) for spine/back injuries, followed by 7.77 (0.42) for extremities; 7.59 (0.64) for the head, face and neck; 7.75 (0.37) for the thorax; and 7.55 for abdominal injuries (Table 1).

3.2. Injury characteristics of patients with AIS-3

In summary, 6,361 trauma patients had AIS-3. Of them, extremities injuries were documented in 5,166 (81.21%), head, face, and neck in 676 (10.63%), abdomen in 206 (3.24%), thorax in 202 (3.18%), spine/back in 74 (1.16%), and other, including genitalia in 37 (0.58%) (Figure 1). Among the aforementioned groups of trauma patients with AIS-3, patients with "other" injuries were not analyzed due to the small number of included patients (n=37). Patients with abdominal injuries were the youngest; however, those with extremity injuries were the oldest (33.75±15.90 vs. 55.10±27.64). The most common mechanism of trauma involving the thorax and head, face, or neck was road traffic crashes (RTCs) (41.6% and 59.9%, respectively). The most common mechanism of trauma in the extremities and spine/back injuries was falls

Table 2 Injury characteristics of trauma cases with AIS 3

AIS3	Head, neck, and face	Thorax	Abdomen	Extremities	Spine/back	Others	Total	P-value
N (%)	676 (10.6)	202 (3.2)	206 (3.2)	5166 (81.2)	74 (1.2)	37 (0.6)	6361 (100)	—
Age†								
Mean (SD)	36.88 (23.6)	38.99 (19.2)	33.75 (15.9)	55.10 (27.6)	43.08 (18.5)	23.97 (24.1)	51.6 (27.6)	
Median (IQR)	33.5 (37)^{a,b}	35 (29)^{a,b}	31.5 (24)^{a,b}	62 (48)^{c}	40 (29)^{b}	21 (35)^{a}	55 (50)	<0.001
Sex (male); n (%)	560 (82.8)^{a}	173 (86.1)^{a}	113 (55.1)^{b}	3178 (61.6)^{b}	54 (73)^{a,b}	23 (62.2)^{b}	4110 (64.5)	
Mechanism of trauma; n (%)								
RTC	405 (59.9)^{a}	84 (41.6)^{b}	12 (5.8)^{b}	1631 (31.6)^{a}	32 (43.2)^{a}	1 (2.7)^{c}	2166 (34)	
Fall	177 (26.2)^{a}	40 (19.8)^{a}	2 (1)^{b}	3232 (62.6)^{d}	34 (45.9)^{c}	0^{e}	3485 (54.7)	
Stab/cut	19 (2.8)^{a}	60 (29.7)^{b}	7 (3.4)^{c}	67 (1.3)^{a}	2 (2.7)^{d}	0^{a,d}	155 (2.4)	<0.001
Blunt	36 (5.3)^{a}	10 (5.0)^{a,b,c}	4 (1.9)^{a,b,c}	151 (2.9)^{c}	5 (6.8)^{a}	0^{b},^{c}	206 (3.2)	
Others	39 (5.8)^{a}	8 (4)^{b}	181 (87.9)^{c}	85 (1.6)^{d}	1 (1.4)^{d}	36 (97.3)^{e}	359 (5.6)	
GCS†								
Mean (SD)	13.01 (3.4)	14.55 (1.7)	13.63 (2.5)	14.93 (0.5)	14.74 (1.0)	14.97 (0.2)	14.66 (1.5)	<0.001
Median (IQR)	15 (3)^{a}	15 (0)^{b}	15 (2)^{a}	15 (0)^{c}	15 (0)^{b,c}	15 (0)^{c,b}	15 (0)	
GCS categorical; n (%)								
3 to 8	89 (13.4)^{a}	5 (2.5)b	11 (5.4)^{b}	6 (0.1)^{c}	1 (1.4)^{b,c}	0^{a,b,c}	115 (1.8)	
9 to 12	87 (13.1)^{a}	4 (2)^{b}	32 (15.5)^{a}	41 (0.8)^{b}	2 (2.7)^{a,b}	0^{a,b}	168 (2.6)	<0.001
13 to 15	489 (73.5)^{a}	190 (94.1)^{b}	161 (78.2)^{a}	5087 (98.5)^{c}	69 (95.8)^{b,c}	37 (100)^{b,c}	6038 (94.8)	
ISS categorical; n (%)								
1 to 8	10 (1.5)^{a}	2 (1)^{a}	1 (0.5)^{a}	29 (0.6)^{a}	10 (13.5)^{b}	37 (100)^{a,b}	52 (0.8)	<0.001
9 to 15	666 (98.5)^{a}	200 (99)^{a}	205 (99.5)^{a}	5137 (99.4)^{a}	64 (86.5)^{b}	0a,b	6319 (99.2)	
>=16	0	0	0	0	0	0	0	
RTS†								
Mean (SD)	7.29 (1.0)	7.73 (0.6)	7.56 (0.6)	7.78 (0.4)	7.67 (0.7)	7.80 (0.2)	7.73 (0.5)	<0.001
Median (IQR)	7.84 (0.94)^{a}	7.84 (0)^{c}	7.84 (0)^{b}	7.84 (0)^{c}	7.84 (0)^{c}	7.84 (0)^{c}	7.84 (0)	
In-hospital mortality; n (%)	72 (10.7)^{a}	9 (4.5)^{a,b}	7 (3.4)^{b}	88 (1.7)^{b}	1 (1.4)^{a,b}	0^{a,b}	179 (2.8)	<0.001
ICU admission; n (%)	309 (45.7)^{a}	37 (18.3)^{b,c}	37 (18)^{b,c}	899 (17.4)^{b,c}	19 (25.7)^{c}	0^{b}	1305 (20.5)	<0.001

N: Number; SD: Standard Deviation; RTS: Revised Trauma Score; ISS: Injury Severity Score; GCS: Glasgow Coma Scale; AIS: Abbreviated Injury Scale; ICU: Intensive Care Unit; RTC: Road Traffic Crash; IQR: Interquartile

Each subscript letter denotes a subset of body zone categories whose column proportions do not differ significantly from each other at the 0.05 level other at the 0.05 level

†These three did not follow a normal distribution pattern. Nonparametric tests were utilized for comparison

Table 3 Comparison of death and ICU admission as two main outcomes in different body zone injuries in AIS 2 after adjustment for age, gender, GCS, RTS, mechanical ventilation, and trauma mechanism

Variables	Death		ICU admission	
	Adjusted OR (95% CI)	**P value**	**Adjusted OR (95% CI)**	**P value**
Extremities	1	—	1	—
Spine/back	8.78 (3.50,22.03)	**<0.001**	8.63 (3.42,21.77)	**<0.001**
Thorax	8.11 (2.23,29.39)	**0.001**	7.94 (2.18,28.84)	**0.002**
Abdomen	3.96 (1.08,14.47)	**0.037**	3.92 (1.07,14.27)	**0.038**
Head, face, and neck	9.81 (4.03,23.84)	**<0.001**	9.64 (3.96,23.44)	**<0.001**

OR: Odds Ratio; CI: Confidence Interval; AIS: Abbreviated Injury Scale; GCS: Glagow Coma Scale; RTS: Revised Trauma Score; ICU: Intensive Care Unit

Table 4 Comparison of death and ICU admission as two main outcomes in different body zones injuries in AIS 3 after adjustment for age, gender, GCS, RTS, mechanical ventilation, and mechanism of trauma

Variables	Death		ICU admission	
	Adjusted OR (95% CI)	**P value**	**Adjusted OR (95% CI)**	**P value**
Extremities	1	—	1	—
Spine/back	NA	NA	NA	NA
Thorax	2.07 (0.63,6.87)	0.230	2.07 (0.63,6.87)	0.230
Abdomen	7.05 (1.62,30.62)	**0.009**	7.05 (1.62,30.62)	**0.009**
Head, face, and neck	2.73 (1.52, 4.90)	**0.001**	2.74 (1.52,4.90)	**0.001**

OR: Odds Ratio; CI: Confidence Interval; NA: Not Applicable; AIS: Abbreviated Injury Scale; ICU: Intensive Care Unit; GCS: Glasgow Coma Scale; RTS: Revised Trauma Score

(62.6% and 45.9%, respectively). The most prevalent mechanism of trauma in the AIS-3 group was falls (54.7%), followed by RTC (34%), blunt trauma (3.2%), and stabbing/cutting (2.4%). Patients with a GCS score ranging 13 to 15 years were reported to have extremity injuries (98.5%), followed by spine/back (95.8%), thorax (94.1%), abdominal (78.2%), head, face, and neck injuries (73.5%). Patients with a GCS score ranging from 9 to 12 were documented most frequently in the abdomen (15.5%), head, face, and neck (13.1%), followed by the spine/back (2.7%), thorax (2%), and extremities (0.8%). Eventually, a GCS score ranging from 3 to 8 was recorded most for the head, face, and neck (13.4%), followed by the abdomen (5.4%), thorax (2.5%), spine/back (1.4%), and extremities (0.1%). In total, mild trauma, based on the GCS scoring system, was reported in 6,038 (94.8%) patients, moderate trauma in 168 (2.6%) patients, and severe trauma in 115 (1.8%) patients. Moderate injuries (i.e., ISS: 9 to 15) were documented for 205 (99.5%) abdominal, 5,137 (99.4%) extremities, 200 (9%) thorax, 666 (98.5%) head, face, and neck, and 64 (86.5%) spine/back injuries. In total, 6,319 (99.2%) trauma patients had ISSs ranging from 9 to 15. The highest RTS was reported at 7.78 (0.36) in the extremities, followed by 7.73 (0.57) in the thorax, 7.67 (0.71) in the spine/back, 7.56 (0.65) in the abdomen, and 7.29 (1.03) in the head, face, and neck (Table 2).

3.3. Outcomes of patients with AIS-2

The highest rate of death was reported for head, face, and neck injuries, with 30 (3%) deceased patients, followed by 9 (2.5%) with abdominal injuries, 2 (1.9%) with thorax injuries, 10 (1.2%) with spine/back injuries, and 12 (0.1%) with extremity injuries. In total, 67 (0.4%) patients in the AIS-2 group died (Table 1). after adjustment for age, sex, GCS score, RTS score, mechanical ventilation status, mechanism of trauma, the adjusted odds of mortality were significantly greater for head, face, and neck injuries, as well as spine/back, thoracic, and abdominal injuries, than for extremity injuries (adjusted odds ratio (aOR)s: 9.81, 8.78, 8.11, and 3.96, respectively; P values<0.05). However, there was no statistically significant difference in the adjusted odds of mortality between any two other body regions (P values>0.05). The aOR of ICU admission were significantly greater for head, face, and neck injuries, as well as spine/back, thoracic, and abdominal injuries, than for extremity injuries (aORs: 9.64, 8.63, 7.94,3.92; P values<0.05). There was no statistically significant difference in ICU admission between any of the other two body regions (P values>0.05).

3.4. Outcomes of patients with AIS-3

The highest rate of death was documented for head, face, and neck injuries, with 72 (10.7%) deceased patients, followed by 9 (4.5%) deaths in the thorax, 7 (3.4%) deaths in the abdomen, 88 (1.7%) deaths in the extremities, and 1 (1.4%) death in the spine/back (Table 2).

Due to the small number of AIS-3 patients with spine/back injuries, they were not included in the final regression model. After adjusting for confounding factors, consisting of age, sex, GCS score, RTS score, mechanical ventilation, and mechanism of trauma, the odds of mortality were significantly greater for abdominal (aOR: 7.05, P value=0.009) and head, face, and neck (aOR: 2.73, P value=0.001) injuries than for extremity injuries; however, there was no significant difference in the odds of mortality between thoracic and extremity injuries (P value=0.230). No significant differences in the odds of mortality were found between any of the other two regions. In addition, the odds of ICU admission were markedly greater for abdominal (aOR: 7.05, P value: 0.009) and head, face, and neck (aOR: 2.74, P value: 0.001) injuries than for extremity injuries, even though there was no significant difference in the odds of ICU admission between thoracic and extremity injuries (P value>0.05). No significant difference was revealed in the odds of ICU admission between any of the other two body regions (P values>0.05).

4. Discussion

It is now almost known that the mechanism of injury (penetrating vs blunt), mechanism of trauma (road traffic accident, fall, and gunshot among the others), and age of patients can affect the mortality in a given AIS for different body regions (19). In the recent years, it has been raised that even the body region could impact the outcome of trauma patient in a same AIS value (10,20). Here, we investigated this hypothesis based on available data from the NTRI.

In the current study, we compared the adjusted odds of mortality and ICU admission in patients with AIS-2 and AIS-3 across different body regions. We found that in patients with AIS-2, the odds of poor outcomes were considerably greater in all body regions according to the AIS lexicon than in those with extremity injuries, for which the data were inadequate. Despite finding out that there was a significant difference in the odds of both mortality and ICU admission for abdominal and extremity injuries, as well as head, face, and neck, when compared to extremity injuries, there was no significant different in odds of developing poorer outcomes, when compared to one another. The results of the present study contradict those of previous studies, suggesting that the same AIS value may almost indistinguishably contribute to the same outcome across different body regions, except for extremities (10).

Many research databases, including the national trauma data bank (NTDB), the national automotive sampling system-crashworthiness data system (NASS-CDS), and the trauma audit and research network (TARN), apply AIS scores for stratifying injury severity (5). AIS 1990 was the first version of a six-digit number and changed the brain and pediatric AIS scoring system. Furthermore, in 1998, some coding rules were also added. Substantial changes were made at AIS 2005, and more than 400 codes were added. Fewer changes were made further at AIS 2008 and 2015 (5).

Given that there are only six values for the severity of the injury, ranging from 1: mild to 6: maximal injury, according to the AIS scoring system, allocating the same value to dissimilar body regions may result in uneven patient outcomes (21,22). Overall, 1,322 injuries were listed in the AIS lexicon. As assigning injury severity values to each of these 1,322 injuries is a subjective task performed by clinical experts, it might result in some degree of heterogeneity (21,22). In addition to being an expert-dependent score, the mechanism of injury might result in some degree of clinical difference between different body regions. In a study conducted by Rowell et al., it was concluded that trauma patients with an AIS=4 in the head, an AIS=3 in the abdomen, and an AIS=3 in the extremities with penetrating injuries had a significantly greater rate of mortality than patients with blunt trauma in these regions, even after adjustment for confounding factors. The greatest difference between penetrating and blunt trauma mortality was reported for head injuries (19). Hence, the mechanism of trauma is an inseparable part of outcome prediction in trauma cases that has been neglected in AIS value assignments.

Even after adjusting for all confounding factors, including the mechanism of trauma, a significant difference in the odds of mortality was found in the literature. In an interesting study by Rau et al. in 2017, after controlling for confounding factors, including age, sex, underlying disorders, ISS, and mechanism of trauma, the adjusted odds of mortality were lower in trauma patients with AIS-3 in the extremities than in those with head/neck injuries. The results were similar for patients with AIS-5 injuries in the abdomen and for those with head/neck injuries. In contrast, in patients with AIS-4, the percentage of patients who died with extremity injuries was significantly greater than that in patients with head/neck injuries (10). These findings were consistent with our findings regarding the odds of mortality in AIS-3 patients. In this study, patients with abdominal and head, face, or neck injuries had markedly greater odds of death and ICU admission, when compared to extremities. Beyond the results of the present study, the same AIS, even within the same body region, might result in different outcomes. Aside from the individualized characteristics of patients, including age, sex, underlying disorders, and trauma itself, the main reasonable rationale for this is that multiple injuries to the same body region cannot be considered in AIS . For instance, the AIS for a trauma patient with vascular injuries is the same as that for another patient with both vascular and two other blunt abdominal trauma injuries, as AIS accounts for only the worst injury. To address this issue, the NISS was developed in 1997 to summarize the three most severely injured patients, regardless of their body regions.

In summary, as stated in the introduction section of the latest version of the AIS, i.e., the AIS of 2005, it seems impractical to compare the outcomes of each AIS severity score, as more than a thousand injuries are coded in the AIS lexicon. Despite all the well-known flaws, AIS and its derivative ISS are the best stratifying trauma scoring systems worldwide (10). Given that only a limited number of studies in the literature have evaluated the flaws in AIS scoring systems and that there are few related studies (10,19,20,23), this study helps us better understand the existing flaws in the AIS scoring system.

The findings of this study enhance our understanding of the outcomes of trauma of the same severity in different body regions. These results have direct implications for enhancing current anatomic injury severity scales. Furthermore, this research should prompt further investigation to fully elucidate this phenomenon, particularly in cases of higher AIS scores. The increased mortality rates observed among patients with injuries in body regions other than the extremities could significantly impact treatment strategies for these individuals.

5. Limitations

The current study has several limitations. First, we could not conduct a statistical analysis due to the small number of patients with higher degrees of AIS values (AIS: 4, 5, and 6); thus, these patients were excluded from the study. Second, due to the small number of patients with "other" injuries in AIS-2 and 3 patients and the limited number of patients with spine/back trauma in AIS-3 patients, we excluded them. Third, due to the historical nature of the present study, selection bias might have occurred. However, by clear inclusion and exclusion criteria defined in this study and a transparent report of our findings, we tried to address this issue. Finally, we could not access data related to prehospital deceased patients. Excluding prehospital deceased cases might impact the generalizability of our findings. Additional studies are encouraged to address the aforementioned issues and also to include deceased cases prior to hospitalization. Despite these limitations, the current study included a considerable number of trauma patients with AIS-2 and -3. In addition, to the best of our knowledge, this is the first study comparing the risk of developing poor outcomes across different body regions in patients with AIS-2 and the second study comparing this risk across patients with AIS-3. In addition, to the best of our knowledge, this is the first study comparing the risk of ICU admission within the same AIS across dissimilar body regions.

6. Conclusion

Injuries with similar AIS values of 2 and 3 nearly indistinguishably result in similar risks of mortality and ICU admission across various body regions, except for extremities. Further studies are needed to interrogate outcome differences in the same AIS in higher-degree injuries, i.e., AIS-4, -5, -6., while also including death in prehospital settings. Specialized trauma care protocols, based on injuries body regions, should be developed in trauma patients to reduce the incidence of poorer outcomes in moderate and serious injuries (AIS=2 and 3). It is highly recommended that patients receive education on how to effectively manage injuries in different regions of the body.

7. Declarations

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7.2. Authors' contribution

Contribution to the study conceptualization: SM, PS, KN, MSHZT, and MZ; Contribution to the methodology and formal analysis: VB; Contribution to writing the original draft: AK, VRM, SP, SMP, and SM; Contribution to useful resources: EF, SHSB, VH, HSB, FS, RFR, MNI, VRM, AG, RA, and MK. All authors have Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; drafting the work or reviewing it critically for important intellectual content; final approval of the version to be published; and agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

7.3. Conflict of interest

None.

7.4. Funding

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