Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Impact of the AIS 2015 Revision on Injury Severity and Mortality Prediction: A Single-Center Study

Byung Hee Kang
Ajou University
Cheawon Min
Ajou University Hospital
Jina Jung
Ajou University Hospital
Yo Huh
ermdhuhyo@gmail.com

Ajou University

Research Article

Keywords: Abbreviated Injury Scale, Injury Severity Score, trauma registries, prognosis, quality improvement

Posted Date: November 12th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11168526/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Impact of the AIS 2015 Revision on Injury Severity and Mortality Prediction: A Single-Center Study

Author information

Byung Hee Kang[1,2], Cheawon Min[2], Jina Jung[2], Yo Huh[1,2,*]

[1]Department of Trauma and Acute Care, Ajou University School of Medicine, Suwon, Republic of Korea

[2]Regional Trauma Center, Ajou University Hospital, Suwon, Republic of Korea

***Corresponding author**

Yo Huh

Department of Trauma and Acute Care, Ajou University School of Medicine,

164 Worldcup-ro, Yeongtong-gu, Suwon 16499, Republic of Korea

Tel: +82-31-219-7492

Fax: +82-31-219-7781

ermdhuhyo@gmail.com

Abstract

Background: The Abbreviated Injury Scale (AIS) is fundamental for anatomical assessment of injury severity. The AIS 2015 revision introduced significant changes; however, its impact on existing trauma registries relative to the AIS 2005 version remains insufficiently explored. We aimed to evaluate the effect of differences between the AIS 2005 and 2015 revisions on mortality prediction.

Methods: We conducted a dual-coding study of 3,578 trauma patients at a Level I trauma center in 2025. All injuries were concurrently coded using both AIS 2005 and AIS 2015 by Certified Abbreviated Injury Scale Specialists. Changes in Injury Severity Score (ISS) and Trauma and Injury Severity Score (TRISS) were compared.

Results: The 2015 revision altered the AIS codes in 545 patients (15.2%), which subsequently resulted in changes to the ISS in 417 patients (11.7%). The ISS differed significantly between AIS 2005 and AIS 2015 (10 [5–19] vs. 10 [5–18], $p < 0.001$). The head/neck region showed the most frequent upgrades, while the abdominal region showed the most frequent downgrades. The proportion of patients with ISS ≥15 was slightly lower with the AIS 2005 version than with the AIS 2015 version (36.2% vs. 36.4%, $p < 0.001$). Mortality prediction performance was similar, with an area under the receiver operating characteristic curve of 0.922 for both TRISS models.

Conclusion: Although the AIS revision resulted in statistically significant changes in the ISS, these differences did not translate into clinically meaningful changes in mortality prediction.

Keywords: Abbreviated Injury Scale, Injury Severity Score, trauma registries, prognosis, quality improvement

Background

Trauma is a clinical entity, but is also characterized by diverse physiological responses, multi-organ involvement, and the need for multidisciplinary management. Accordingly, trauma scoring systems are essential for stratifying injured patients and predicting clinical outcomes [1]. Among available approaches, anatomical scoring systems remain the primary tools for objective injury severity assessment [2].

The Abbreviated Injury Scale (AIS), developed by the Association for the Advancement of Automotive Medicine, is the most widely used anatomically based injury coding system worldwide for classifying injury severity [3,4]. The Injury Severity Score (ISS), derived from the AIS, has become the standard measure of overall injury severity. To reflect changes in injury patterns and advancements in trauma care, the AIS has undergone several revisions. The longitudinal integration of these different coding eras has historically required rigorous data-mapping methodologies, such as translating older AIS 1990 codes to the AIS 1998 revision, which served as a stepping-stone for subsequent trauma registry evaluations [5]. Following the AIS 2005 revision (updated in 2008; AIS05), the latest revision, AIS 2015 (AIS15), was released in 2018 [6].

Despite its potential advantages, AIS15 has not yet been universally adopted across trauma registries, which often creates logistical challenges in longitudinal data tracking. In this context, previous literature has demonstrated that the use of different revisions of the AIS can systematically alter the operational definition of major trauma and affect patient classification within registries [7]. AIS15 has not been widely adopted across many trauma registries, and comparative studies comparing AIS15 with AIS05 remain limited [8,9].

To improve trauma care systems, many countries have established national trauma databases. Our institution participates in both the Korean Trauma Data Bank (KTDB) and the U.S. National Trauma Data Bank (NTDB). Because these registries require different AIS revisions, injuries at our center have been coded concurrently according to both AIS05 and AIS15. This dual-coding practice provides a unique opportunity to directly compare these two revisions within the same patient cohort.

Therefore, this study evaluated differences in injury coding between AIS05 and AIS15 and investigated their impact on injury severity assessment and mortality prediction.

Methods

Ethical Statements

This study was approved by the Institutional Review Board of our hospital (AJOUIRB-DB-2026-123). Given its retrospective design, the requirement for informed consent was waived.

Study Population

We included all patients admitted to our Level I trauma center with injury-related diagnostic codes between January 1, 2025, and December 31, 2025. To meet the requirements of the KTDB and NTDB, two trained trauma registrars coded all injuries concurrently using AIS05 and AIS15.

We excluded patients with burn injuries, as well as those who died in the emergency department, to minimize the risk of incomplete or inaccurate injury coding. Cases with an AIS code of 9 (unspecified injury) in any region of the body region were excluded to ensure accurate assessment of injury severity. Burn injuries were excluded because major burn cases are

routinely transferred to specialized burn centers after initial stabilization, and the burn coding criteria remain virtually identical between the two revisions.

AIS Coding and ISS Calculation

All injury coding was conducted by professional trauma registrars who are Certified Abbreviated Injury Scale Specialists with extensive experience in trauma data management. To ensure data integrity, a rigorous dual-coding protocol was implemented. In cases of ambiguity or disagreement during the initial independent coding phase, consensus was reached through a structured review process and formal consultation with an experienced trauma surgeon.

To calculate the ISS, injuries were categorized into six body regions: head/neck, face, chest, abdomen, extremities, and external. The Maximum AIS (MAIS) was determined for each body region, and the ISS was calculated by squaring and summing the MAIS values for the three most severely injured body regions.

Agreement between ISS values calculated using AIS05 and AIS15 was evaluated using Bland–Altman plots to assess systematic differences. The Bland–Altman method is an appropriate statistical approach for assessing agreement between two clinical coding modalities, as it quantifies the mean difference (bias) and defines the 95% limits of agreement rather than merely testing for correlation [10].

Mortality Prediction Analysis

We evaluated the predictive performance of the Trauma and Injury Severity Score (TRISS) using the Major Trauma Outcome Study coefficients for each AIS revision. TRISS probabilities of survival, calculated using either AIS05 or AIS15, were compared to assess their ability to predict

in-hospital mortality. Discriminatory performance was assessed using the area under the receiver operating characteristic curve (AUROC).

Statistical Analysis

Continuous variables are presented as medians with interquartile ranges (IQRs; 25^{th}–75^{th} percentiles), and categorical variables are presented as frequencies and percentages. The normality of continuous variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. To account for non-normal distributions, ISS and TRISS calculated from the two AIS revisions were compared using the Wilcoxon signed-rank test, whereas categorical variables were analyzed using the chi-square or Fisher's exact test, as appropriate. Agreement between ISS values calculated using AIS05 and AIS15 was assessed using Bland–Altman analysis. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 29.0 (IBM Corp., Armonk, NY, USA) or R software (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at $p < 0.05$.

Results

General Characteristics

Of the 3,708 patients, 3,578 trauma patients were included (Figure 1). The study population was a median age of 54 years (IQR, 33–69), and 2,577 patients (72.0%) were male. The most common mechanism of injury was a traffic accident, accounting for 1,771 cases (49.5%), followed by free falls (785 cases, 21.9%) and ground-level falls (466 cases, 13.0%). Penetrating injuries accounted for 5.5% of cases (196 cases) (Table 1).

Changes in Injury Severity Score According to AIS Revision

Among the 3,578 patients, the 2015 revision altered the AIS codes in 545 patients (15.2%), which subsequently resulted in changes to the ISS in 417 patients (11.7%). The ISS showed a statistically significant difference between the two AIS revisions (10 [IQR, 5–19] under AIS05 vs. 10 [IQR, 5–18] under AIS15, $p < 0.001$). This statistical significance, despite identical medians, stems from the paired Wilcoxon signed-rank test capturing individual-level directional shifts across the 417 altered cases rather than a difference in group-level medians. Similarly, the proportion of major trauma patients with ISS ≥15 demonstrated a statistically significant but small difference, representing 1,294 patients (36.2%) under AIS05 versus 1,303 patients (36.4%) under AIS15 ($p < 0.001$), yielding a net difference of only 9 patients.

When analyzed by body region, anatomical coding discrepancies were highly localized. The head and neck region showed the most frequent upgrades, affecting 296 patients (8.3% of the total cohort, compared with 68 patients with decreases), whereas the abdominal region demonstrated the most frequent downgrades, observed in 153 patients (4.3% of the total cohort, compared with 3 patients with increases) (Table 2). Detailed score changes are presented in Table 3.

Bland–Altman analysis demonstrated good agreement between ISS values calculated using AIS05 and AIS15, with a mean difference of −0.09 (95% limits of agreement, −2.27 to 2.09) (Figure 2). Although overall bias was minimal, the distribution of differences varied significantly across the severity spectrum. Notably, while ISS values in the mild-to-moderate severity range clustered tightly along the zero-difference line due to overlapping unchanged cases, a distinct vertical spread emerged in the higher-severity spectrum. This pattern suggests that the 2015

revision exerts a greater impact on the most severely injured patients, an effect that is naturally amplified by the mathematical squaring of AIS scores.

Mortality Prediction According to AIS Revision

TRISS2005 (TRISS05) and TRISS2015 (TRISS15) had identical medians and IQRs (0.987 [0.939–0.994]). Although the difference between the two TRISS measures was statistically significant ($p = 0.006$), the distributions were nearly identical. This finding may reflect the fact that the Wilcoxon signed-rank test captures individual-level directional shifts across the altered cases rather than differences in group distributions. While the overall population estimates remained similar because most cases were unchanged, the within-patient differences associated with the updated coding framework were sufficient to produce a statistically significant result.

Among the 131 deceased patients, only 6 (4.6%) showed changes in ISS between AIS revisions. Accordingly, predictive performance was the same, with an AUROC of 0.922 for both TRISS05 and TRISS15, and there was no statistically significant difference (Figure 3).

Discussion

Since its development from the AIS, the ISS has been widely used in trauma care [6]. However, AIS coding is complex and requires specialized training, which may limit its applicability, particularly in resource-limited settings [8]. As an alternative, the International Classification of Diseases-Based Injury Severity Score has been proposed and has shown comparable performance [2,9,11]. However, the ISS remains a key component of trauma systems worldwide.

To improve the assessment of injury severity, the AIS has undergone several revisions. AIS 1990 introduced a six-digit coding system, AIS 1998 incorporated organ-specific injury scales, AIS05 expanded the number of codes, and AIS15 further refined injury descriptions, including more detailed definitions of soft-tissue loss [12]. Notably, AIS15 introduced changes to the severity classification of brain and spine injuries, consistent with our findings.

Few studies have directly compared AIS05 with AIS15. While Li et al. explored the transition from AIS 1998 to AIS15 [9], our study is among the first to provide a detailed comparison between the 2005 and 2015 revisions. Using a dual-coding approach, we provide directly coded data rather than data derived from software-based conversion.

In general, AIS revisions are associated with lower ISS values [3, 13–15]. This trend may reflect how the revised coding framework adapts to contemporary trauma care, whereby injuries previously classified into higher severity tiers are reevaluated and reclassified to better reflect current clinical outcomes [15]. In this study, although ISS values differed significantly between the two AIS revisions, the median ISS remained unchanged, suggesting a limited impact on overall injury severity assessment.

Importantly, these changes varied across body regions rather than occurring uniformly. The largest differences likely reflect refinements in classifications in AIS15 [4]. For example, cerebral concussion (AIS code 161000.x), previously assigned a score of 1 (minimal) in AIS05, was reclassified as 2 (moderate) in AIS15. Conversely, most abdominal changes involved lumbar vertebral injuries; a transverse process fracture (AIS code 650620.x) was downgraded from 2 to 1.

Most changes occurred in lower-severity injuries. Among patients with AIS scores ≥3 (serious or higher) in AIS05, only 18 showed changes. These differences likely had a minimal impact on mortality prediction, which may explain similar TRISS performance. Nevertheless, some changes occurred in more severe injuries. With larger samples, these differences might become more apparent and could potentially influence prognostic performance in mortality prediction or shift the numerical outputs of the scoring models, thereby enriching the clinical utility of contemporary trauma evaluations. Although the Bland–Altman analysis (Figure 2) indicated that overall numerical differences were clustered tightly in the lower-severity spectrum due to a large number of unchanged minor injuries, the greater scatter observed at higher ISS ranges suggests that the 2015 revision possesses greater variability in severely injured cohorts. This pattern indicates that while the AIS15 revision subtly reshapes the classification of minor to moderate injuries—such as simple concussions or small vertebral fractures—it remains structurally robust for major trauma evaluation without compromising overall mortality prediction. The bidirectional distribution in Figure 2 suggests a possible offsetting effect across body regions. For example, increases in head injury scores may be offset by decreases in abdominal injury scores. This balance may contribute to stable overall injury severity distributions and explain the similar mortality prediction (AUROC 0.922) across revisions.

These findings may offer useful insights for the development of established, high-volume trauma systems. In settings with highly standardized clinical protocols, small changes in anatomical scoring may not affect clinical management or patient outcomes. This overall stability may explain why predictive performance remains consistent, even though individual ISS values showed statistically significant variation.

This study has several limitations. First, it was conducted at a single center, which may limit the generalizability of the findings. Additionally, as an observational cohort study based on a fixed 1-year registry enrollment, a formal a priori sample size calculation or non-inferiority power analysis was not performed. In this regard, European multicenter studies have consistently demonstrated that inter-center variations and inconsistencies in injury coding can significantly affect quality benchmarking in trauma registries [7]. Second, the relatively small number of patients, particularly those with penetrating injuries, may have influenced the results. Third, the involvement of multiple trauma registrars introduced interobserver variability, which may affect coding consistency despite using the same patient cohort. Finally, the limited number of severely injured patients may have reduced the statistical power to detect meaningful differences in outcome prediction. Additionally, the generalizability of our TRISS findings regarding penetrating trauma requires caution. Although the TRISS algorithm inherently applies separate coefficients for blunt and penetrating mechanisms, the relatively small number of penetrating injuries in our cohort limits the statistical power for subgroup validation. Furthermore, unlike Western countries with high rates of gunshot injuries, penetrating trauma in our setting is predominantly due to stab wounds, which present a distinct clinical profile that may not fully align with Western-derived scoring weights.

Beyond these limitations, the strength of our study lies in the dual-coding approach, which provides direct comparative data rather than relying on software-based conversion. Our findings regarding the region-specific score offsets—specifically the interplay between head injury upgrades and abdominal injury downgrades—offer practical guidance for data harmonization between registries using different AIS revisions. Furthermore, as the AIS15 revision resulted in a statistically significant, although small, shift in the proportion of patients classified as having

severe injuries (ISS ≥15), these findings should be noted when interpreting large-scale trauma trends or establishing long-term institutional benchmarks. This study provides empirical evidence to support registry consistency and facilitate a stable transition between scoring systems in established trauma environments.

Conclusions

Changes between AIS revisions resulted in only modest differences in ISS, primarily affecting minor injuries and having a minimal impact on mortality prediction. These findings suggest that AIS revisions do not substantially alter overall injury severity assessment or outcome prediction. Therefore, AIS05 and AIS15 may yield comparable results in trauma research and registry-based analyses for mortality prediction. However, larger multicenter studies including a greater number of severely injured patients are warranted to fully clarify subtle differences in prognostic performance and further evaluate the indirect impact of AIS revisions on the quality assessment of trauma care.

List of Abbreviations

AIS: Abbreviated Injury Scale

AIS05: AIS 2005 revision

AIS15: AIS 2015 revision

AUROC: area under the receiver operating characteristic curve

IQRs: interquartile ranges

ISS: Injury Severity Score

KTDB: Korean Trauma Data Bank

MAIS: Maximum AIS

NTDB: National Trauma Data Bank

TRISS: Trauma and Injury Severity Score

TRISS05: TRISS2005

TRISS15: TRISS2015

Declarations

Ethics approval and consent to participate: This study was approved by the Institutional Review Board (IRB) of Ajou University Hospital (IRB No. AJOUIRB-DB-2026-123) and performed in accordance with the provisions of the Declaration of Helsinki. The need for obtaining informed consent was waived by IRB of Ajou University Hospital because of the observational nature of the study.

Clinical trial number: not applicable.

Consent for publication: Not applicable

Availability of Data

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Acknowledgements: We would like to thank Editage (www.editage.com) for English-language editing.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or non-profit sectors.

Authors' Contributions

Conceptualization: BH Kang

Methodology: BH Kang, Y Huh

Formal analysis: BH Kang, Y Huh

Investigation: C Min, J Jung

Data Curation: CW Min, J Jung

Writing – Original Draft: BH Kang

Writing – Reviewing & Editing: BH Kang, Y Huh

REFERENCES

1. Lefering R. Trauma scoring systems. Curr Opin Crit Care. 2012;18:637-40.
2. Tohira H, Jacobs I, Mountain D, Gibson N, Yeo A. Systematic review of predictive performance of injury severity scoring tools. Scand J Trauma Resusc Emerg Med. 2012;20:63.
3. Barnes J, Hassan A, Cuerden R, Cookson R, Kohlhofer J. Comparison of injury severity between AIS 2005 and AIS 1990 in a large injury database. Ann Adv Automot Med. 2009;53:83-9.
4. Association for the Advancement of Automotive Medicine. Abbreviated Injury Scale: 2015 revision. 6th ed. Barrington, IL: AAAM; 2018.
5. Palmer CS, Lang J, Russell G, Dallow N, Harvey K, Gabbe B, et al. Mapping Abbreviated Injury Scale data from 1990 to 1998 versions: a stepping-stone in the contemporary evaluation of trauma. Injury. 2013;44:1437-42.
6. 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.
7. Van Ditshuizen JC, Sewalt CA, Palmer CS, Van Lieshout EM, Verhofstad MH, Den Hartog D, et al. The definition of major trauma using different revisions of the abbreviated injury scale. Scand J Trauma Resusc Emerg Med. 2021;29:71.
8. O'Reilly GM, Joshipura M, Cameron PA, Gruen R. Trauma registries in developing countries: a review of the published experience. Injury. 2013;44:713-21.

9. Kim J, Heo YJ, Kim Y. Comparison of trauma mortality prediction models with updated survival risk ratios in Korea. J Korean Med Sci. 2025;40.

10. Bland JM, Altman DG. Statistical methods for assessing agreement between two methods of clinical measurement. Lancet. 1986;1:307-10.

11. Rutledge R, Osler T, Emery S, Kromhout-Schiro S. The end of the Injury Severity Score (ISS) and the Trauma and Injury Severity Score (TRISS): ICISS, an International Classification of Diseases, ninth revision-based prediction tool, outperforms both ISS and TRISS as predictors of trauma patient survival, hospital charges, and hospital length of stay. J Trauma. 1998;44:41-9.

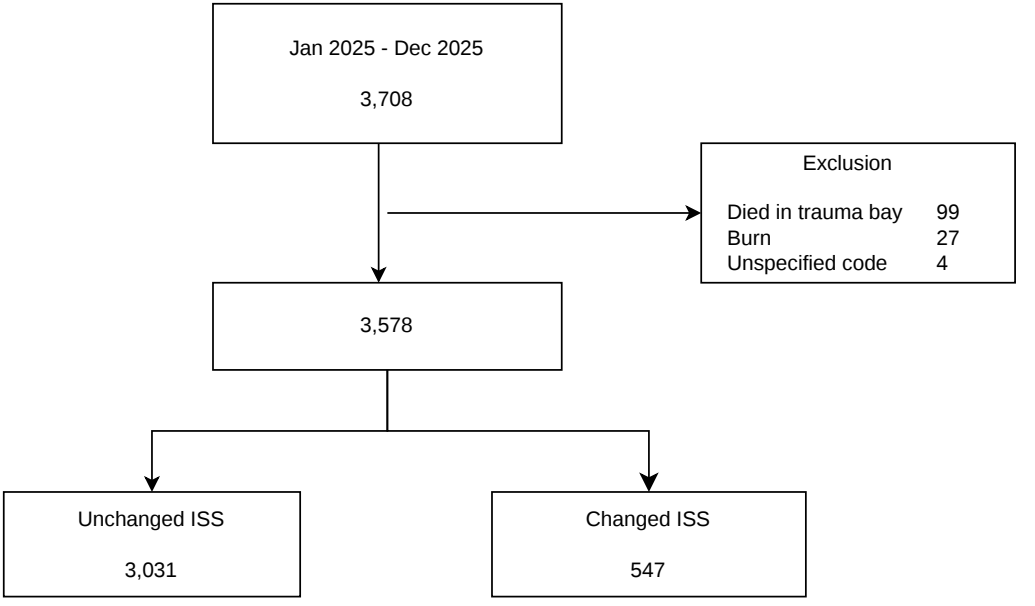
12. Loftis KL, Price J, Gillich PJ. Evolution of the abbreviated injury scale: 1990-2015. Traffic Inj Prev. 2018;19 Suppl 2.

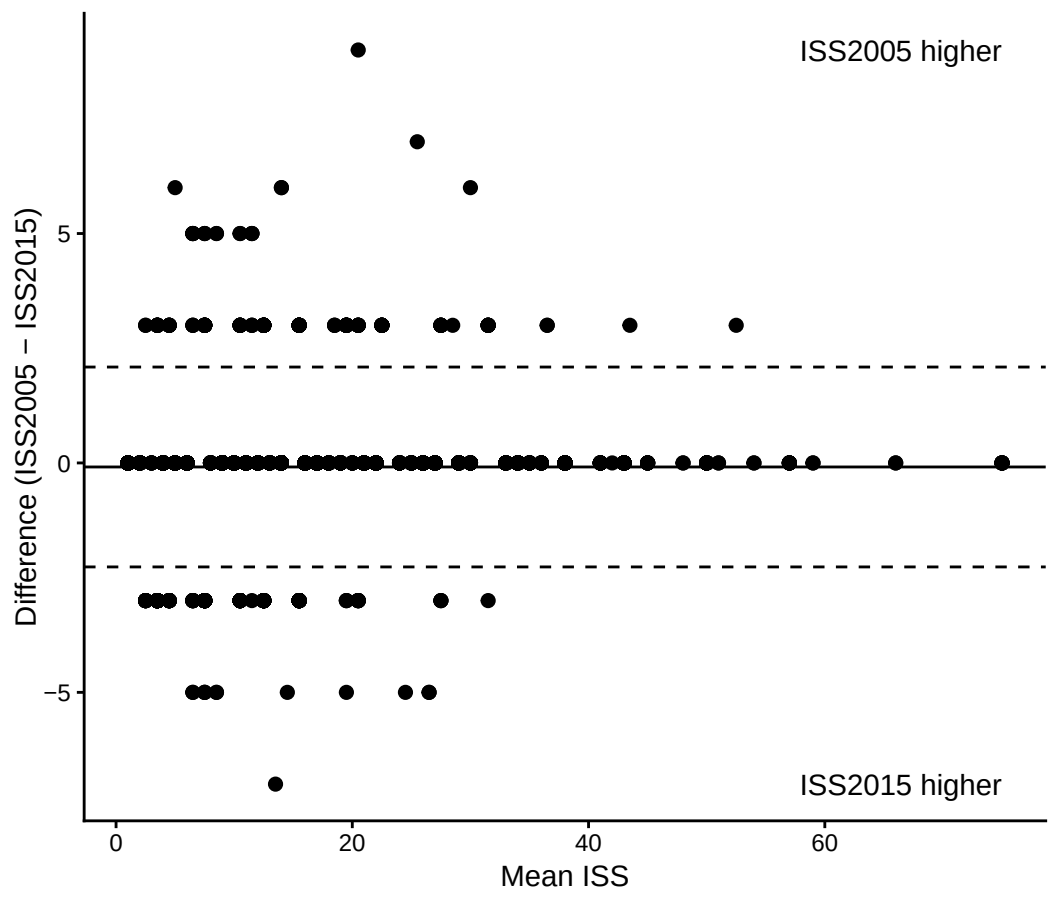
13. Hsu SY, Wu SC, Rau CS, Hsieh TM, Liu HT, Huang CY, et al. Impact of adapting the Abbreviated Injury Scale (AIS)-2005 from AIS-1998 on injury severity scores and clinical outcome. Int J Environ Res Public Health. 2019;16:5033.

14. Li YH, Yeung JHH, Hung KKC, Lai CY, Leung LY, Cheng CH, et al. Impact of AIS 2015 versus 1998 on injury severity scoring and mortality prediction—single centre retrospective comparison study. Am J Emerg Med. 2022;60:73-7.

15. Skaga NO, Eken T, Hestnes M, Jones JM, Steen PA. Scoring of anatomic injury after trauma: AIS 98 versus AIS 90—do the changes affect overall severity assessment? Injury. 2007;38:84-90.

16. Garthe E, States JD, Mango NK. Abbreviated injury scale unification: the case for a unified injury system for global use. J Trauma. 1999;47:309-23.


Jan 2025 - Dec 2025
3,708
Exclusion
Died in trauma bay 99
Burn 27
Unspecified code 4
3,578
Unchanged ISS
3,031
Changed ISS
547


ISS2005 higher
ISS2015 higher
Difference (ISS2005 – ISS2015)
5
0
−5
0
20
40
60
Mean ISS

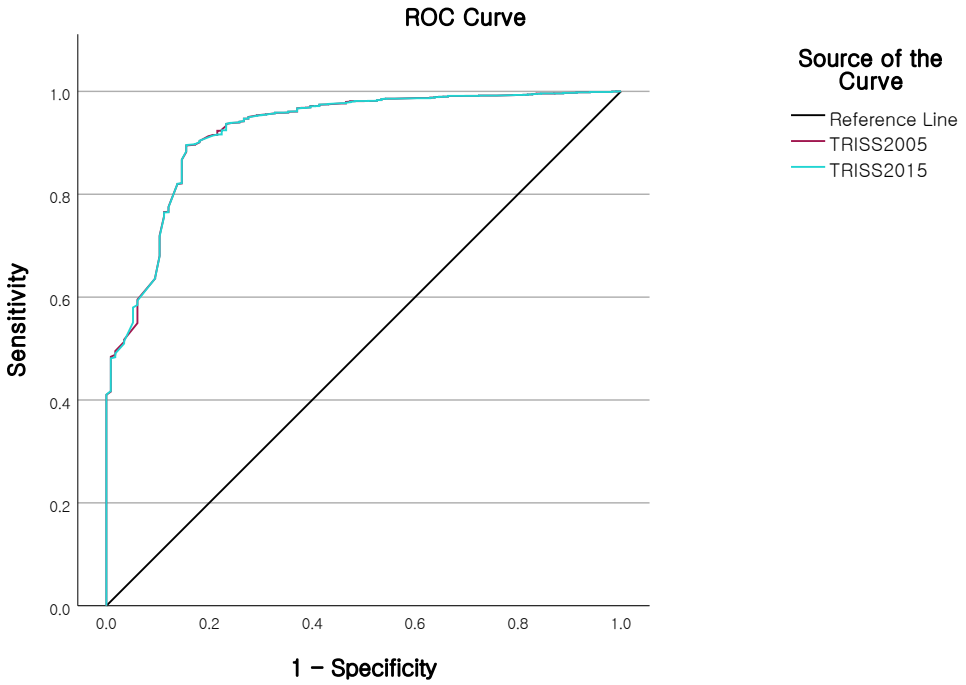

ROC Curve
Sensitivity
1 – Specificity
0.0
0.2
0.4
0.6
0.8
1.0
Source of the Curve
Reference Line
TRISS2005
TRISS2015

Figure Legends

Figure 1. Study scheme.

Figure 2. Bland–Altman plot for ISS derived from AIS 2005 and AIS 2015.

Bland–Altman plot comparing ISS derived from AIS 2005 and AIS 2015. Differences were calculated as ISS2005 minus ISS2015; positive values indicated a higher ISS in AIS 2005. The mean difference (bias) was −0.09, with 95% limits of agreement from −2.27 to 2.09.

Figure 3. ROC curves for TRISS based on AIS 2005 and AIS 2015.

ROC curves for TRISS based on AIS 2005 and AIS 2015. Both models showed identical AUROC values of 0.922, indicating similar predictive performance.

Table 1. General characteristics of the included patients

	N=3,578
Age (years)	54 [33 – 69]
Sex (male)	2,577 (72.0%)
Injury Mechanism	
Traffic accident	1,771 (49.5%)
Fall	785 (21.9%)
Ground fall	466 (13.0%)
Machine	65 (1.8%)
Penetrating	196 (5.5%)
Other blunt	220 (6.2%)
Unknown	75 (2.1%)
Type of admission	
Direct	2,781 (77.7%)
Transfer	797 (22.3%)
Initial vital signs	
Systolic blood pressure (mmHg) (n=3,515)	128 [110 – 147]
Heart rate (/min) (n=3,559)	88 [76 – 103]
Respiratory rate (/min)	20 [18 – 22]
Glasgow Coma Scale (n=3,487)	15 [14 – 15]
Mortality	131 (3.66%)

Variables are presented as number (percentages) or median [interquartile range].

Table 2. Injury severity changes according to region

Version	AIS 2005	AIS 2015	P
Injury Severity Score (ISS)	10 [5 – 19]	10 [5 – 18]	<0.001
ISS >15	1,294 (36.2%)	1,303 (36.4%)	<0.001
Number of patients with AIS changes (n = 545)			
Body Region			
Head and neck	364	Increased	296
		Decreased	68
Face	0	-	-
Chest	16	Increased	0
		Decreased	16
Abdomen	156	Increased	3
		Decreased	153
Extremities	9	Increased	9
		Decreased	0
External	0	-	-
Number of patients with ISS changes 152 increased, 265 decreased			

AIS, Abbreviated Injury Scale.

ISS, Injury Severity Score.

Table 3. Detailed changes in AIS scores

	AIS 2005	AIS 2015	n	AIS 2005	AIS 2015	n
Region	Increased		308	Decreased		237
Head and neck	1	2	295	5	4	1
	2	3	0	4	3	1
	3	4	1	3	2	14
	4	5	0	2	1	52
Chest	1	2	0	5	4	0
	2	3	0	4	3	0
	3	4	0	3	2	1
	4	5	0	2	1	15
Abdomen	1	2	0	5	4	0
	2	3	3	4	3	0
	3	4	0	3	2	0
	4	5	0	2	1	153
Extremities	1	2	0	5	4	0
	2	3	9	4	3	0
	3	4	0	3	2	0
	4	5	0	2	1	0

No changes occurred in the face and external regions.

AIS, Abbreviated Injury Scale.