Injury 57 (2026) 113598

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Review

Prehospital national early warning score outperforms shock index in predicting mortality and resource utilisation in adult trauma: A systematic review

Alice Tolich [a,b,1,*], Bridget Dicker [a,c,2], Graham Howie [a,3], Verity F. Todd [a,c,4]

[a] Paramedicine Department, School of Acute and Primary Health, Te Wānanga Aronui o Tāmaki Makaurau, Auckland University of Technology (AUT), Auckland, New Zealand

[b] Northern Rescue Helicopter Limited, Auckland, New Zealand

[c] Clinical Evaluation, Research and Insights, Hato Hone St John New Zealand, Auckland, New Zealand

ARTICLE INFO

Keywords:
EMS
Trauma
Mortality
Triage
Transfusion
NEWS
SI

ABSTRACT

Introduction: Early recognition of severely injured trauma patients is essential in the prehospital setting. Emergency Medical Services (EMS) frequently rely on simple physiological measures to guide triage, yet validated prognostic tools for prehospital trauma remain limited. The Shock Index (SI) and National Early Warning Score (NEWS) are physiological scoring systems that may support early risk stratification. This systematic review evaluates the prognostic accuracy of prehospital SI and NEWS for mortality and resource utilisation in adult trauma.

Methods: A systematic search of CINAHL, Medline and Cochrane databases (2015–2025) identified studies reporting associations between prehospital SI or NEWS and overall mortality in adult trauma patients. Paediatric studies, Emergency Department only cohorts, isolated body-region trauma, and modified scoring systems were excluded. Due to substantial heterogeneity in study design, populations and outcome measures, a narrative synthesis was undertaken.

Results: Twenty-two studies met inclusion criteria, with numbers ranging from 184 patients to 1439,221 patients across diverse EMS systems. Across individual studies, prehospital SI showed variable discrimination for mortality, with AUROC values ranging from poor to moderate (0.48–0.79), although elevated SI (>0.9) consistently correlated with increased mortality, transfusion, and critical care needs. Prehospital NEWS demonstrated excellent discrimination for short-term mortality (AUROC 0.87–0.96) and reliably predicted transfusion and resource utilisation. Comparative studies showed NEWS outperforming SI across all mortality endpoints. SI accuracy was reduced in geriatric and isolated TBI populations, with low SI (<0.4) showing potential prognostic value in severe TBI.

Conclusion: Prehospital NEWS provides superior prognostic accuracy compared with SI for predicting mortality and resource utilisation in adult trauma. SI may still assist in identifying patients requiring urgent intervention, but its overall predictive performance is limited. Incorporating NEWS into prehospital trauma assessment may enhance early risk stratification and support EMS decision-making.

Introduction

Trauma remains a primary cause of death globally, particularly prevalent in young adult populations [1]. In addition to mortality, trauma results in chronic disability, psychosocial burdens and significant costs to the healthcare system [2]. Approximately 50% of trauma-related deaths occur in the prehospital setting, with trauma-induced haemorrhage accounting for 50% of deaths within four

* Correspondence to: AUT Paramedicine, Private Bag 92006, Auckland 1142, New Zealand.
E-mail address: alice.tolich@aut.ac.nz (A. Tolich).
[1] https://orcid.org/0009–0005-5275–4909
[2] https://orcid.org/0000–0002-8151–7356
[3] https://orcid.org/0000–0001-6907–8074
[4] https://orcid.org/0000–0003-4786–8272

https://doi.org/10.1016/j.injury.2026.113598
Received 17 June 2026; Received in revised form 6 August 2026; Accepted 10 August 2026
Available online 12 August 2026

hours of injury [3,4]. As the greatest risk of mortality occurs in the first few hours, early recognition and treatment of trauma patients are crucial for improving outcomes [5]. Emergency Medical Services (EMS) occupy a key position for early risk identification in trauma. Prehospital interventions and decisions can significantly influence patient outcomes, such as the destination hospital and the level of trauma care initiated [1]. This is especially important in major haemorrhage, as early blood transfusion can mitigate the progression of trauma-induced coagulopathies, which increase mortality [6]. Despite these factors, there is a deficit of validated scoring tools to assist prehospital prognostication in the setting of trauma.

Assessing injury severity and prognostication in the prehospital environment is challenging due to resource scarcity and hostile conditions [7]. EMS clinicians make time-pressured, critical decisions, often with minimal history, limited assessment, or point-of-care testing [1,4]. Trauma pathologies are dynamic and may involve entrapment, extrication, and treatment delivered en route to definitive care; the constraints of this environment necessitate scoring tools that can reliably predict deterioration without reliance on specialist skills or equipment [8]. In addition to informing treatment, validated prognostication tools could empower EMS to clearly communicate severity of patient condition to help optimise hospital resource allocation [9]. This may signal the requirement for blood transfusion, surgical intervention, or Intensive Care Unit (ICU) admission [10] Historically, a systolic blood pressure below 90 mmHg has been an ad hoc predictor of trauma severity and shock [11]. However, this is a late sign in haemorrhage and may result in under-triage [9]. Furthermore, some patients have vital signs within normal ranges despite significant injury severity [12]. Major trauma is conventionally defined by an Injury Severity Score (ISS) exceeding 12 [13]. However, an ISS is calculated retrospectively following hospital investigation and therefore has no application to the prehospital setting [14].

Scoring systems such as the Shock Index (SI) and National Early Warning Score (NEWS) have the potential to identify patients at risk for deterioration and inform prehospital treatment [8]. The SI is calculated by dividing heart rate by systolic blood pressure and was developed as a tool for detecting haemorrhagic shock (Supplementary Table 1a) [1]. This triage tool has been shown to be a useful indicator of occult haemorrhage, with a SI $>$ 0.9 associated with increased mortality, even when vital signs appear normal [15]. In contrast to SI, the NEWS was initially developed to detect clinical deterioration in acute medical illness. Since its introduction in the United Kingdom, NEWS has influenced care in a wide range of countries across Europe and Australasia [16]. The NEWS also incorporates more physiological parameters: respiratory rate, new oxygen requirement (or evidence of hypercapnic respiratory failure), oxygen saturation, heart rate, blood pressure, temperature, and level of consciousness. Each parameter is assigned a weighted score of 0–3, with the individual scores summed to derive the aggregate NEWS (Supplementary Table 1b) [17]. An elevated NEWS has been associated with a higher incidence of adverse outcomes for undifferentiated patients [18]. It is unclear how the application SI and NEWS could help determine severity of patient condition in the setting of prehospital trauma, or the role they may play as predictors of critical illness and mortality. The aim of this systematic review is to investigate and compare the prognostic power of the SI and NEWS in relation to patient mortality, in the setting of prehospital trauma.

Methodology

Protocol and Registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. The review was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 14 July 2025; CRD420251072971.

Search strategy

A systematic literature search was conducted on 5 August 2025. All searches of CINAHL, Medline and Cochrane databases were performed by the lead author (AT) using the following terms: *prehospital or pre-hospital or EMS or Emergency Medical Services or Para* or ambulance AND trauma or traumatic AND Shock Index or SI or Early warning score or Early Warning Tool or EWS AND mortality or survivability*. The following parameters were also applied to the data base search: articles in English, full text available and published between 2015 and 2025.

Eligibility criteria

Clinical trials and observational studies which reported on the relationship between prehospital SI and EWS were included. Studies were excluded for the following reasons: did not include a trauma population, study of only Emergency Department patient without prehospital data, did not report on mortality, did not use either the SI or a form of New Early Warning Score. Studies that only assessed the following variations to the SI or EWS to assess specific populations were also excluded: Delta Shock Index, Modified Shock Index, Paediatric age adjusted Shock Index, Paediatric Early Warning Score. Studies were also excluded if they exclusively investigated trauma to a specific body region e.g. isolated Traumatic Brain Injury (TBI), or isolated extremity trauma.

Study selection

All articles were screened by AT and at least one other co-author (VT, BD, GH) against the inclusion and exclusion criteria. Rayyan software was utilised to review the title and abstract prior to full text review [19]. Any conflicts were resolved by having a third author screen for eligibility.

Data synthesis and statistical analysis

Due to significant heterogeneity of studies, a narrative synthesis of findings was chosen for reporting on findings. Findings from the selected studies underwent data extraction and synthesis and are presented in a narrative format. Due to heterogeneity in the reporting of the primary outcome (mortality), results were synthesised using multiple effect measures, including odds ratios, absolute risk, relative risk, and the area under the receiver operating characteristic curve (AUROC). AUROC values were extracted where available and interpreted using predefined thresholds: 0.5–0.6 (poor discrimination), 0.6–0.7 (moderate discrimination), 0.7–0.8 (good discrimination), 0.8–0.9 (excellent discrimination), and $>$ 0.9 (outstanding discrimination) for mortality prediction.

Results

Study selection

A literature search retrieved 755 studies from three databases. After removal of duplicates, 510 studies remained for title and abstract screening. Following abstract review, 449 articles were removed for failing to meet inclusion criteria. Sixty-one studies were sought for retrieval and assessed for eligibility with full text review. Ultimately, 22 studies met the inclusion criteria (Fig. 1).

Assessment of study quality and risk of bias

Assessment of bias was completed using JBI SUMARI software and checklists for Analytical Cross-sectional Studies [20]. All studies were assessed by the lead author (AT) and cross-checked by at least one other author (VT, BD, GH). Any discrepancies were reconciled through discussion, or by a third author assessing bias. Studies were classified as low risk of bias if all checklist criteria were met, moderate risk if one

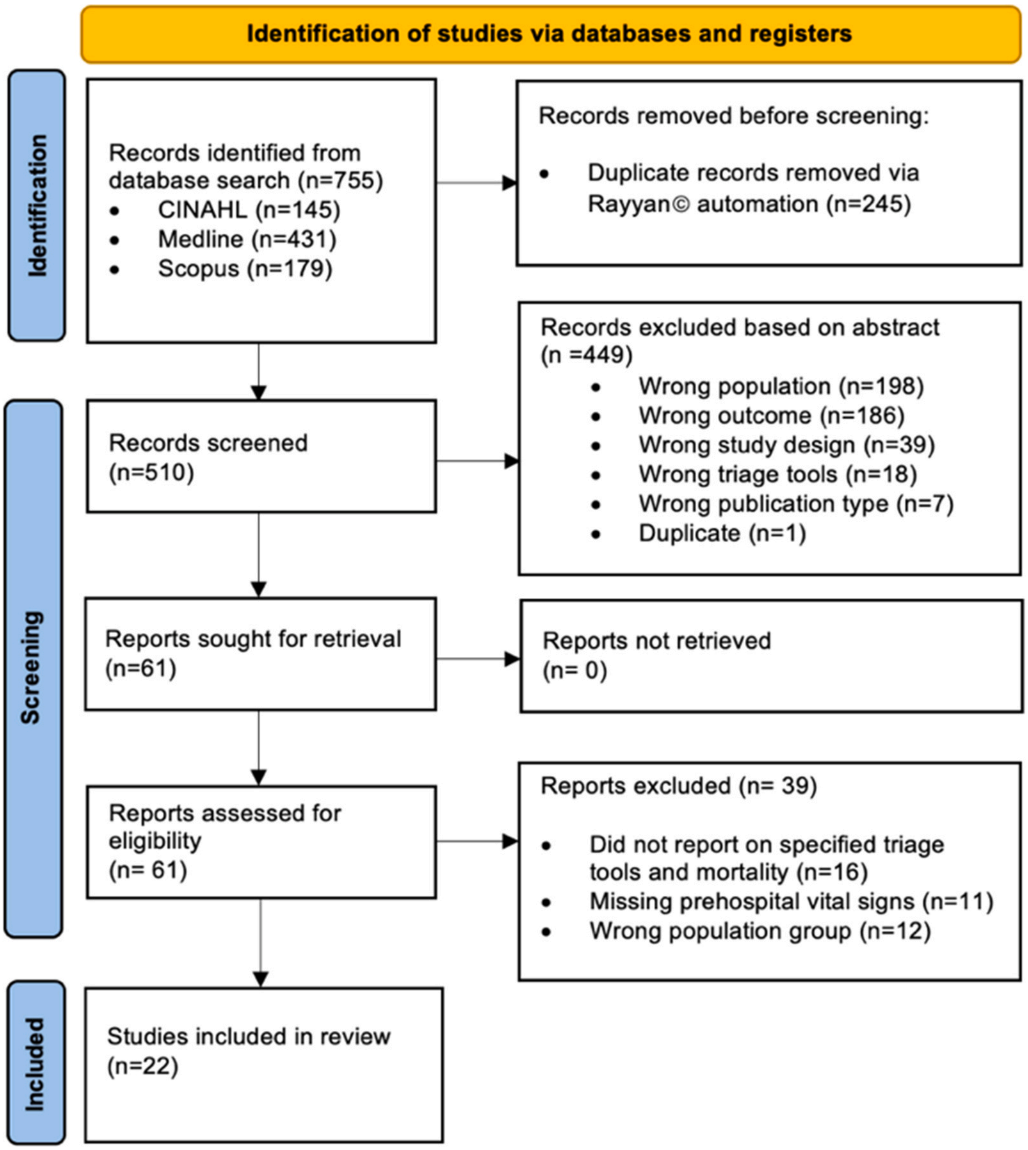

Fig. 1. PRISMA flow diagram. PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analysis.

criterion was unmet, and high risk if multiple criteria were unmet. Four studies were rated high risk [21–24], two were moderate [9,25] and the remaining 16 studies were low risk (Table 1.0). Findings from studies deemed to have a high risk of bias were interpreted with caution and had less weight placed on their results.

Study Characteristics

Of the 22 studies, 17 investigated prehospital SI, three assessed prehospital NEWS and two investigated both the SI and NEWS and their relationship to mortality (Table 2). There was significant variation in the sample size of each study, with the smallest being 184 patients [26] and the largest with 1439,221 [21]. The total number of patients across all studies was 2698,721. Nineteen studies exclusively assessed trauma patients, while three included a subgroup analysis of trauma patients [27–29]. There was a wide geographical distribution of the studies; five from USA [21,23,25,30,31], three from Taiwan [9,10,32] and Spain [8,26,28], two from Finland [7,29], UK [27,33], South Korea [6,34], and one each from Switzerland [22], Germany [24], Japan [35], Turkey [1], and Iran [2]. Three studies reported on data exclusively from a helicopter emergency medical services (HEMS) setting [7,23,29] with the remainder reporting on ground-based EMS. Two articles were cross-sectional observational studies [2,6], three were prospective observational [1,8,28], and the remaining seventeen were retrospective cohort studies. There was also variation in the duration of the selected studies, with the longest covering thirteen years [35] and the shortest only two months [27].

Patient characteristics

As per the inclusion criteria, all studies assessed adult trauma patients who were transported by EMS to hospital. There was variation in the definition of ‘adult’: the youngest population group including patients > 15 years old, while the oldest definition of adult was > 20 years. The median age ranged from 38 [1] to 68 years [28]. Sex demographics were recorded in all studies, with males being overrepresented in every study (53.4–81%). Only thirteen studies recorded a median ISS, and there was significant variation within these values. The highest median ISS was 29 [26], and the lowest was five [25]. Only nine of the 22 studies reported patients with a mean or median ISS> 12, considered the threshold for major trauma.

Table 1
JBI critical appraisal checklist for analytical cross-sectional studies.

Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Risk of bias
April et al.	Yes	Unclear	Yes	Yes	No	No	Yes	Yes	**High**
Björkman et al.	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Chen et al.	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	**Moderate**
Costa et al.	Yes	Unclear	Yes	Yes	No	No	Yes	Yes	**High**
Dezman et al.	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Duke et al.	No	No	Yes	Yes	No	No	Yes	Yes	**High**
Frieler et al.	Yes	Yes	Yes	Yes	No	No	Yes	Yes	**High**
Hosseinpour et al.	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	**Moderate**
Iirola et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Jehan et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Juste et al.	Yes	Yes	Unclear	Yes	Yes	Unclear	Yes	Yes	**Low**
Kim et al.	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	**Low**
Lin et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Martín-Rodríguez et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Medina-Lozano et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Nutbeam et al.	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	**Low**
Silcock et al.	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	**Low**
Wang et al.	Yes	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	**Low**
Yamada et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Yang et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Yüksel et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**
Yousefi et al.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	**Low**

Questions
1: Were the criteria for inclusion in the sample clearly defined?
2: Were the study subjects and the setting described in detail?
3: Were the study subjects and the setting described in detail?
4: Were objective, standard criteria used for measurement of the condition?
5: Were confounding factors identified?
6: Were strategies to deal with confounding factors stated?
7: Were the outcomes measured in a valid and reliable way?
8: Was appropriate statistical analysis used?

Primary Outcomes

Of the studies that assessed the relationship between prehospital SI and mortality, only one showed good discrimination with an AUROC value of 0.79 ($p < 0.001$) [25]. After controlling for confounding factors, the authors found an elevated prehospital SI was a significant independent predictor for 24-hour mortality, in-hospital mortality, blood transfusion requirement, and ICU admission ($p < 0.001$). All other studies demonstrated poor discrimination for prehospital SI and mortality (Table 3). Despite poor AUROC performance for prehospital SI and mortality, studies that assessed adjusted Odds Ratios (OR) all demonstrated a correlation between elevated SI (>0.9) and increased mortality risk [23,29,35]. The exception was Yang et al. [32] who, despite showing an adjusted OR of 1.28 for mortality, failed to meet the threshold for statistical significance ($p = 0.157$). Nonetheless, Jehan et al. [31] found that patients with an elevated prehospital SI had higher mortality rates (12.3% vs 5.2%) and massive transfusion rates (25% vs 0.012%) than patients with a normal prehospital SI ($p < 0.001$). AUROC values were also significant with a score of 0.81 for an elevated prehospital SI to predict the need for blood transfusion, ICU admission, or surgical requirement (Appendix A). These patients were also more likely to need interventional radiology and had rates of in hospital complications [31]. Similarly, Yüksel et al. [1] observed an AUROC value of 0.78 for blood transfusion in ED, and 0.79 for emergency surgical intervention for patients with a prehospital SI > 1.0 ($p < 0.001$).

Of the studies that assessed prehospital NEWS, all reported excellent discrimination for short term mortality, with AUROC levels of 0.87 [6], 0.88 [2], 0.91 [28] and 0.96 [8]. While AUROC values specifically for mortality were not reported, Silcock et al. [27] observed a significantly increased risk of mortality and ICU admission in patients with a prehospital NEWS> 7. This patient group had a 18% absolute risk of death within 48 h, and a 17% absolute risk of death within 30 days ($p = <0.001$). Even at a lower cut-off, Yousefi et al. [2] found a prehospital NEWS score of four or higher was strongly associated with mortality (AUROC: 0.88, $p < 0.001$).

In studies where prehospital SI and NEWS were compared in the same patient cohort, prehospital NEWS was the superior tool. Kim et al. [6] and Martín-Rodríguez et al. [28] compared SI and NEWS and found superior AUROC values for NEWS across 24- and 48-hour mortality (0.63 vs 0.87 and 0.48 vs 0.91 respectively). Additionally, Kim et al. [6] recorded AUROC values of 0.85 for prediction of massive transfusion (MT) in the ED for patients with a prehospital NEWS > 6, compared to 0.73 for a prehospital SI.

Discussion

Accurate and early identification prehospital trauma patients with an increased risk of mortality has the potential to save lives [21]. This systematic review has assessed and compared the predictive value of the SI and NEWS in relationship to mortality in prehospital trauma patients. Analysis of 22 studies showed prehospital NEWS to be consistently superior to prehospital SI for mortality prediction. Timely NEWS also demonstrated better discrimination for in-hospital blood transfusion and resource utilisation. However, there were fewer studies investigating NEWS (17 versus five) therefore further research is needed. Nonetheless, these results confirm that an elevated NEWS in the prehospital setting is strongly associated with mortality, and is an accurate predictor of in-hospital resource utilisation. Therefore, application of the NEWS has the potential to enhance EMS treatment and transport decisions of trauma patients, particularly those with an abnormal score.

The superior performance of the NEWS is likely due to the inclusion of components such as temperature and oxygenation. In trauma, coagulopathy, acidosis, hypocalcaemia and hypothermia are manifestations of dysregulated physiology [36]. Severely injured patients can become hypothermic, both from blood loss and environmental factors, and the inclusion of this component may offer increased predictive value [37]. Additionally, the inclusion of a measurement of oxygen bound to haemoglobin (SpO_2) may reflect compromised perfusion or peripheral

Table 2
Study Characteristics.

Author (Year) Location	Design	Study Duration	Total Sample Size (n)	Inclusion Criteria	Exclusion Criteria	Patient Demographics
April et al. (2024) USA	Retrospective registry-based analysis	1 year	1439,221	Adult trauma patients (>15 years) assessed by EMS.	Patients deceased on EMS arrival, patients on an interfacility transfer.	Median age: 57 for 24 h survivors, 47 for non-survivors Sex: Male 59.1% for 24 h survivors, 74.1% for non-survivors Mean ISS for 24 h survivors: 9, 26 for non-survivors
Björkman et al. (2021) Finland	Retrospective cohort study	7 years	22,433 (Trauma subgroup: 6190)	Adult patients (>18 years) with measured and registered heart rate and systolic blood pressure upon HEMS contact and mortality data available.	Patients with unknown age, missing heart rate or blood pressure, unmeasurable hemodynamic parameters, OHCA.	Median age: 55.8 for survivors; 72.6 for non-survivors Sex: 62.5% male 24 h mortality: 7.5% 30-day mortality: 16%
Chen et al. (2025) Taiwan	Retrospective cohort study	10 years	13,132	Adult trauma patients (>18 years) hospitalised at Tzu Chi Hospital.	Patients with OHCA without ROSC, patients on an interhospital transfer, missing prehospital data.	Median age: 57.9 years Sex: 53.4% male In-hospital mortality: 3.0%
Costa et al. (2022) Switzerland	Retrospective cohort study	4 years	13,222	Adult (>15 years) patients with major trauma (ISS>16) and/or AIS head > 3, admitted to a level one trauma centre.	Patients with isolated burns (including electric shock), choking, hanging and victims of drowning, patients deceased on ED arrival.	Mean age: 58 years Sex: 68% male 24 h mortality: 4.0% 28-day mortality: 11.6% Mean ISS: 22
Dezman et al. (2016) USA	Retrospective registry-based analysis	6 years	17,988	Adult trauma patients (≥18 years) transported by EMS directly from scene of injury with complete prehospital vital signs.	Patients who were deceased within 15 min of ED arrival and those who were on an interfacility transfer.	Mean age 41.6 years; Sex: 69% male In-hospital mortality: 4% Ethnicity: Caucasian: 63.1%, African American: 29.8%, Asian: 0.1%, Hispanic: 3.1%, Native American: 0.8%, Other: 3.1%
Duke et al. (2019) USA	Retrospective registry-based analysis	1 year	636	Adult trauma patients (>18 years) transported by air to a Level I or 2 trauma centre.	Patients on an interfacility transfer, missing prehospital variables, patients deceased prior to ED arrival.	No median age reported Sex: 71% Male In-hospital mortality: 9.0% Mean ISS: 14
Frieler et al. (2022) Germany	Retrospective registry-based analysis	9 years	70,829	Adult trauma patients (>18 years) with EMS transportation and admission to ED.	Transport to non-German hospitals, missing prehospital or ED values to calculate scores, patients on an interfacility transfer, patients with minor injuries.	Mean age: 50.3 Sex: 71.2% Male In-hospital mortality: 10.8% Mean ISS: 17
Hosseinpour et al. (2023) USA	Retrospective cohort study	1 year	750,407	Adult trauma patients (>18 years).	Patients on an interfacility transfer, missing prehospital or ED vitals, patients with isolated TBI (Head-AIS>3) and burn injuries.	Mean age: 53 years Sex: 59.4% male 24 h mortality: 1.2% In-hospital mortality: 2.3% Ethnicity: 71.6% Caucasian Mean ISS: 5
Iirola et al. (2022) Finland	Retrospective observational study	7 years	4108	Adult trauma patients (>18 years) encountered by HEMS units in Finland and transported to a level 1 trauma university hospital.	Not transported to university hospital, patients deceased on scene or on ED arrival, primary diagnosis not trauma.	Median age: 49 years, Sex: 74% male, 30-day mortality: 13.5%
Jehan et al. (2019) USA	Retrospective cohort study	1 year	144,951	Adult trauma patients (>18 years).	Patients on an interfacility transfer or deceased on ED arrival.	Mean age: 45 years, Sex: 61% male In-hospital mortality: SI> 1.0: 12.3%, SI< 1.0:5.2% Ethnicity: 76% Caucasian,7.6% Hispanic Mean ISS: 13
Juste et al. (2021) Spain	Retrospective observational study	4 years	184	Adult (>18 years) trauma patients with high-energy trauma.	Patients with incomplete data, patients who were deceased prior to hospital arrival or died in the ED initial care unit.	Median age: 43 Sex: 81% Male Mortality rate: 25% Median ISS: 29
Kim et al. (2023) South Korea	Cross-sectional observational study	1 year	41,852	Adult trauma patients (>18) treated and transported by EMS with an abnormal Revised Trauma Score.	Patients deceased prior to ED arrival, patients with a DNR, OHCA, patients on an interfacility transfer, patients with incomplete prehospital vital signs.	Median age: 57 Sex: 63.6% Male 24 h mortality: 2.3% In-hospital mortality: 5.6%
Lin et al. (2024) Taiwan	Retrospective cohort study	12 years	5355	Adult (>20 years) trauma patients transported to Tzu Chi Hospital by EMS.	Patients not transported by emergency medical services, missing prehospital information, OHCA, and or insufficient data on vital signs.	No median age reported. Sex: 53.5% Male In-hospital mortality: 3.8% Mean ISS: 9

(continued on next page)

Table 2 (*continued*)

Author (Year) Location	Design	Study Duration	Total Sample Size (n)	Inclusion Criteria	Exclusion Criteria	Patient Demographics
Martín-Rodríguez et al. (2019) Spain	Prospective observational cohort study	1 year	1288 (Trauma subgroup: 262)	Adult patients (>18 years) transferred by an ALS EMS unit to the ED.	Patients with social problems or acute psychiatric pathology, OHCA, death before or during EMS transfer, pregnancy, in treatment by palliative care unit, arrival time greater than > 45 min from injury, patients who could not be followed up via electronic medical record and participants who did not consent.	Median age: 68 years Sex: 59.5% male 48 h mortality: 5.4%
Medina-Lozano et al. (2020) Spain	Longitudinal prospective observational study	1 year	346	Adult trauma patients (>18 years) transported by ALS level EMS to hospital.	Patients with OHCA or injuries incompatible with life, pregnancy, patients evacuated by other means of transport, death during transfer, non-consenting patients or for whom follow-up was not possible.	Median age: 50 years Sex: 64.7% Male 48 h mortality: 3.9%
Nutbeam et al. (2024) UK	Retrospective cohort study	7 years	70,027	Adult trauma patients (>16 years) with an ISS > 9 transported by EMS to a hospital in England and Wales, died in hospital or were transferred to another hospital for specialist care.	Patients with isolated mild TBI, superficial scalp injury, patients 65 years or older with femoral neck or single pubic rami fracture, fracture/dislocation of the foot or hand, closed fracture/dislocation of an isolated limb, or skin laceration with minor blood loss.	Mean age: 46 years Sex: 74% Male 24 h mortality: 3% 30-day mortality: 6% Mean ISS: 17
Silcock et al. (2015) UK	Retrospective cohort study	2 months	1684 (Trauma subgroup: 373)	Adult patients (>16) transported by emergency ambulance to the ED.	Pregnancy, patients on an interhospital transfer.	No patient demographics reported. Mixed medical and trauma cohorts.
Wang et al. (2020) South Korea	Retrospective observational study	2 years	1007	Adult trauma patients (>18 years) with blunt or penetrating injuries.	Patients on an interhospital transfer, missing prehospital data, patients with OHCA, burns or electrocution injury.	Median age: 53.0 Sex: 78.6% male 24 h mortality: 3.0% Median ISS: 17
Yamada et al. (2023) Japan	Retrospective cohort study	13 years	89,495	Adult trauma patients (>16 years) transported by EMS to the ED with a normal SI upon arrival.	Patients with burn injury, OHCA, prehospital fluid infusion, hypotension (SBP< 90 mmHg) on ED arrival, bradycardia (HR<40 bpm) on ED arrival, missing vital sign data.	Median age: 64 Sex: 62.0% male 24 h mortality: 1.5% Median ISS: 17
Yang et al. (2022) Taiwan	Retrospective cohort study	10 years	6156	Adult trauma patients (>20 years) in the Taipei Tzu Chi Hospital Trauma Database.	Patients with incomplete prehospital data.	Median age: 61 Sex: 53.3 Male In-hospital mortality: 2.3%
Yüksel et al. (2025) Turkey	Prospective cohort study	6 months	209	Adult trauma patients (>18 years) with high-energy trauma transported to ED by EMS.	Patients with OHCA, pregnancy, those exposed to low-energy trauma, those who did not arrive by ambulance, those who were transferred from another hospital, and non-consenting patients.	Median age: 38 Sex: 79.9% Male 24 h mortality: 4.3% 28-day mortality: 15.3%
Yousefi et al. (2024) Iran	Cross-sectional retrospective cohort study	1 year	4191	Adult trauma patients (>18 years) transported by EMS to a tertiary trauma hospital.	Patients not transported by EMS, missing prehospital vital signs, incomplete prehospital data, drowning, burns and who were deceased prior to ED arrival.	Mean age: 41 Sex: 79.1% male In-hospital mortality: 3.1% Mean ISS: 8.52

Abbreviations.
AIS: Abbreviated Injury Score, **ALS**: Advanced Life Support, **BLS**: Basic Life Support, **DNR**: Do Not Resuscitate, **ED**: Emergency Department, **HEMS**: Helicopter Emergency Medical Services, **HR**: Heart Rate, **ISS**: Injury Severity Score, **OHCA**: Out-of-Hospital Cardiac Arrest, **ROSC**: Return of Spontaneous Circulation, **RR**: Respiratory Rate, **SBP**: Systolic Blood Pressure, **TBI**: Traumatic Brain Injury

vasoconstriction in shocked trauma patients. A low SpO_2 in the setting of trauma may indicate a loss of haemoglobin and hypoxaemia associated with severe haemorrhage [6]. This could explain why prehospital NEWS also demonstrated high AUROC values for blood transfusion prediction.

While AUROC values for prehospital SI and mortality were overall low to moderate, studies that assessed Odds Ratios demonstrated increased odds, relative risk of death and resource allocation for patients with an elevated SI. This suggests that while prehospital SI is the inferior tool for mortality prediction, patients with an elevated SI are still more likely to require interventions such as blood transfusion and surgical intervention (Appendix A). Therefore, an elevated prehospital SI alone can still offer valuable guidance for EMS in regard to transport decisions and activation of trauma teams at ED [1].

EMS Vital Signs

Physiological deterioration is a dynamic process, and the recording of vital signs at a single point in time may under- or over-estimate a patient's shock state. Yamada et al. [35] investigated patients with an elevated SI in the prehospital setting, but a normal SI on ED arrival. Patients with an early elevated prehospital SI had higher mortality than patients who had a normal prehospital SI, despite having a normal SI on ED arrival (aOR: 1.62, 95%CI: 1.31–1.99). This is important as it suggests the first vitals taken by EMS can offer mortality prediction for trauma patients at the earliest stage of their clinical journey. However, only five studies specified exact timings of vital signs used to calculate triage scores. In the case of multiple vital sign recordings, some specified

Table 3
Primary Outcomes and Conclusions.

Study	Outcome	Scores/ Tools		Author Conclusions
April et al. (2024)	Primary: 24 h mortality	SI, BP, RR, HR	**AUROC for preSI and 24 h mortality: 0.60** (95% CI)	Prehospital SBP and preSI (>0.9) offered the best predictor of mortality among trauma patients when compared to HR and SBP. A threshold of 0.8 may be more appropriate for older patients. This study highlights the need for better methods to guide resuscitation as initial vital signs have limited accuracy in predicting subsequent mortality.
Björkman et al. (2021)	Primary: 24 h mortality	SI	**Odds Ratios for PreSI and 24 hr mortality** PreSI 0.9−1.3: uOR 2.6 (95% CI; 1.6−4.3) PreSI > 1.3: uOR 4.4 (95% CI; 2.7−7.20)	An elevated preSI is associated with an increased risk of short-term mortality. Increased mortality was observed in the extreme highs and lows of SI in trauma patients. For trauma patients with neurological injury, a low SI was associated with an increased mortality risk. Predictive value was limited due to overlap between survivors and non-survivors.
Chen et al. (2025)	Primary: In-hospital mortality, ICU admission, hospital LOS	SI, dSI	**AUROC for preSI and 30-day mortality:** 0.49 (95% CI; 0.465−0.533, p < 0.001) **Adjusted ORs for preSI and mortality:** 1.36 (95% CI; 1.028−1.816, p = 0.031)	PreSI was a significant predictor of in-hospital mortality, ICU admission, and prolonged hospital stay but only in patients without chronic disease and patients with TBI. Trends observed with repeated SI scoring (dSI) offered superior predictive value compared to preSI alone.
Costa et al. (2022)	Primary: 24 h mortality, MT	SI, BATT, ABC, TASH score	**AUROC for preSI and 24 h mortality: 0.53** (95% CI; 0.50−0.56)	In major trauma, preSI has low sensitivity and discrimination for early mortality and MT prediction when compared to other scores. Due to the high negative likelihood ratio rates, preSI may not be suitable for early identification of life-threatening bleeding.
Dezman et al. (2016)	Units of pRBCs used within 2 h of arrival, MT, ICU LOS, in-hospital mortality (not further defined)	SI, Pre-hospital vital sign computer modelling	**AUROC for preSI and mortality: 0.51** (p < 0.001)	PreSI was the best-performing univariate vital sign across most outcomes. PreSI alone has moderate predictive value for transfusion but poor for mortality. Computer modelling with several prehospital vital signs outperformed SI for mortality prediction.
Duke et al. (2019)	Primary: In-hospital mortality (not further defined)	SI, ISS, GCS	**Odds Ratios for preSI and mortality: uOR: 3.13** (95% CI; 1.44−6.75, p = 0.004)	PreSI is a significant independent predictor of mortality in helicopter-transported trauma patients, though GCS and ISS showed stronger associations. Patients with an elevated preSI had approximately threefold higher odds of in-hospital mortality compared with those with normal values.
Frieler et al. (2022)	Primary: In-hospital mortality (not further defined) Secondary: blood transfusion	SI, SIA, rSIG, rSIG/A	**AUROC for preSI and mortality: 0.48** (95% CI; 0.47- 0.49)	PreSI showed moderate prediction of early blood transfusion but poorly predicted early mortality. PreSI may be especially useful if point-of-care-ultrasound technology is not available to identify acute hypovolaemia.
Hosseinpour et al. (2023)	Primary: 24 h and in-hospital mortality, 24 h blood transfusion, ICU and hospital LOS	SI, dSI	**AUROC for preSI and 24 h mortality: 0.79** AUROC for preSI and in hospital mortality: 0.71 **Adjusted OR's for preSI and 24 h mortality: aOR1.01** (95% CI; 1.016−1.019, p < 0.001)	PreSI was independently associated with higher rates of 24 h mortality, in-hospital mortality, blood product transfusion requirements, ICU and hospital length of stay.
Iirola et al. (2022)	Primary: 30-day mortality	SI, SIA, SI/G, SIA/G, SS	**AUROC for preSI and 30-day mortality**: **Trauma without TBI: 0.54*** (95% CI; 0.45 – 0.62) All patients: 0.40* (95% CI; 0.38−0.42)	PreSI alone performed poorly in predicting 30-day mortality. However, prediction was improved with the addition of GCS. This finding is most likely explained by patient selection resulting in a high number of TBI patients—with a markedly high mortality rate.
Jehan et al. (2019)	Primary: Blood transfusion, need for IR or surgery. Secondary: ED disposition, overall complications, hospital and ICU LOS, ventilator days and mortality.	SI, HR, SBP	**PreSI and Mortality** Mortality in ED: • SI< 1: 0.8% (p = <0.001) • SI> 1: 3% (p = <0.001) Overall mortality rate: • SI < 1: 5.2% (p = <0.001) • SI> 1: 12.3% (p = <0.001)	PreSI was a better indicator of predicting hospital resource utilization compared to the prehospital SBP and HR. A preSI > 1 was associated with: higher massive transfusion, higher IR intervention, higher operative intervention and higher rates of complications. This has implications for patient triage and trauma system design.
Juste et al. (2021)	Primary: requirement for MT. Secondary: hospital LOS, ICU LOS, and 7-day mortality.	SI	**PreSI in the 7-day mortality group: median 0.78** (IQR 0.55−1.31) **PreSI in the Alive at 7 days**	PreSI was not significantly associated with 7-day mortality. However, preSI was significantly associated with blood transfusion.

(continued on next page)

Table 3 (*continued*)

Study	Outcome	Scores/ Tools		Author Conclusions
			group: median 0.77 (IQR 0.63−0.92), p = 0.71	
Kim et al. (2023)	Primary: MT. Secondary: 24 h mortality.	SI, MSI, pre-rSIG, NEWS	**AUROC for preSI and 24 h mortality: 0.63** (95% CI; 0.615–0.655) **AUROC for preNEWS and 24 h mortality: 0.86** (95% CI; 0.856–0.874)	Although preNEWS uses more variables, it is a strong predictor of 24 h mortality and MT in trauma and should be used in triage decisions. Patients with a preNEWS of 6 or higher, should be transported to a trauma centre to improve outcomes. PreSI had inferior predictive ability for mortality compared to preNEWS.
Lin et al. (2024)	Primary: Mortality (24 h 3-day, 7-day). Secondary: ICU admission, and an extended hospital LOS (>30-days).	SI, SIAVPU, mSI, aSI	**AUROC for preSI and 24 h mortality: 0.53** (95% CI; 0.434−0.631) AUROC for preSI and 3 day mortality: 0.51 (95% CI; 0.437−0.589) AUROC for preSI and 7 day mortality: 0.49 (95% CI; 0.434−0.555)	PreSI AUROC values were consistently lower than those for the modified SI, age-adjusted SI, and SI multiplied by AVPU score (SIAVPU), which showed significantly better predictive performance across all outcomes.
Martín-Rodríguez et al. (2019)	Primary: 48 h mortality	SI, GAP, RTS, NEWS2	**AUROC for preSI and 48 h mortality: 0.48** (95% CI; 0.32−0.46, p = 0.814) **AUROC for preNEWS2 and 48 h mortality: 0.91** (95% CI; 0.88−1.0, p < 0.001)	The use of the NEWS2 as a prehospital triage system presents a very high predictability of mortality for trauma patients. PreSI performed poorly in comparison. PreNEWS2 is easy to obtain and is a reliable score to aid in the initial assessment of patients and determine their level of triage effectively.
Medina-Lozano et al. (2020)	Primary: incidence of SAEs at the scene, during transfer, or at ED. Secondary: ICU admission, early mortality (within 48 h) and total SAEs.	NEWS2, TREWS, MRWEMS, Prehospital Index.	**AUROC for preNEWS and 48 h mortality: 0.96** (95% CI; 0.89−1.00, p < 0.001)	PreNEWS2 is of 8 or above is highly accurate for detecting serious adverse events and early mortality (<48 h). A preNEWS2 score of 4 or above was highly accurate for predicting ICU admission in trauma patients. NEWS2 is suitable for routine use in EMS.
Nutbeam et al. (2024)	Primary: Mortality (24 h and 30-day). Secondary: need for trauma intervention.	SI, sBATT, BATT, ABC Kampala Trauma score, MGAP, T-RTS	AUROC for preSI and 24 h mortality: **0.61** (95% CI; 0.59–0.63)	In patients with trauma following MVC, preSI performed poorly for prediction of early mortality. The sBATT score significantly outperformed preSI in predicting 24 h mortality.
Silcock et al. (2015)	Primary Survival to discharge or 30-days. Secondary: Death within 48 h of hospital admission, ICU admission within 48 h, a composite adverse outcome of death or ICU admission within 48 h.	NEWS	**Absolute and Relative Risk for preNEWS:** 48 h mortality absolute risk: 0.18 (p < 0.001) 30-day mortality absolute risk: 0.17 Relative risk: 8.38 (95% CI; 2.79 – 25.21, p < 0.001)	Elevated preNEWS in trauma patients is associated with significantly increased risk of early mortality and ICU admission. Trauma patients with a preNEWS> 7 had a 17% absolute risk of death within 30-days and an 18% absolute risk of death within 48 h Calculation of preNEWS prior to transfer to hospital is straightforward and has potential to facilitate earlier recognition of at-risk patients, allowing earlier involvement of appropriate ED and critical care staff.
Wang et al. (2020)	Primary: MT, 24 h mortality	SI, MSI,	AUROC for preSI and 24 h mortality: 0.58 (95% CI; 0.553–0.615)	PreSI showed low accuracy for predicting 24 h mortality, but moderate accuracy for predicting massive transfusion. PreSI may be more useful than MSI because it can be more easily calculated and no difference was found between the two scores.
Yamada et al. (2023)	Primary: 24 h mortality Secondary: invasive haemostatic intervention, blood transfusion within 24 h, head surgery, and in-hospital mortality.	SI	Odds Ratios for preSI and 24 h mortality: **uOR: 1.95** (95% CI; 1.64−2.31) **Adjusted ORs for preSI and 24 hr mortality:** **aOR: 1.62** (95% CI; 1.31−1.99)	Among the trauma patients with normal SI upon ED arrival, an abnormal preSI was associated with higher 24 h mortality than normal preSI. Patients with a preSI > 0.9 had an increased requirement for blood transfusion within 24 h, even if their SI was normal on ED arrival.
Yang et al. (2022)	Primary: In-hospital mortality (not further defined). Secondary: ICU admission, prolonged hospital stay (≥14 days)	SI, MSI, ASI, and SIAVPU	**AUROC for PreSI for in hospital mortality: 0.53** (95% CI; 0.479 – 0.590, p = 0.156) Adjusted ORs for in hospital mortality: 1.28 (95% CI; 0.909−1.805, p = 0.157)	SI was a poor predictor of mortality and P values not meeting value for statistical significance. This may be because SI reflects initial haemodynamic state, but not long-term physiologic reserve or complications that unfold following injury.
Yüksel et al. (2025)	Primary: Blood transfusion, surgical intervention, 24 h and 28-day mortality	SI, MSI, ASI, REMS, and TREWS	**AUROC for preSI and 24 h mortality: 0.66** (95% CI; 0.441−0.879, p > 0.05) **AUROC for preSI and 28-day mortality: 0.53** (95% CI; 0.347−0.717, (p > 0.05)	Elevated preSI (>1.0) and MSI are effective for predicting blood replacement and emergency surgery. However, they were not the most effective scores for predicting 24 h and 28-day mortality.
Yousefi et al. (2024)	Primary: 72-hour mortality	NEWS2, RTS, and TRISS	**AUROC for preNEWS and 72 h mortality:** 0.88 (p < 0.001).	PreNEWS2 is a quick and accurate tool for prehospital mortality prediction. Considering the time consumption and ease of use, NEWS2 seems to

(*continued on next page*)

Table 3 (*continued*)

Study	Outcome	Scores/ Tools	Author Conclusions
			be an accurate and swift scoring system in predicting mortality based on prehospital data set.

Abbreviations. ABC score : Assessment of Blood Consumption score, **ASI**: Age-adjusted Shock Index, **aOR:** Adjusted Odds Ratio, **uOR:** Unadjusted Odds Ratio, **BATT:** Bleeding Audit for Trauma and Triage, **BP**: Blood Pressure, **dSI**: Delta Shock Index, , **ED SI:** Emergency Department Shock Index, **GCS**: Glascow Coma Score, **ICU**: Intensive Care Unit, **IR**: Interventional Radiology; **LOS**: Length of Stay, **MGAP**: Mechanism/GCS/Age/Pressure score, **MREMS**: Modified Rapid Emergency Medicine Score, **MSI**: Modified Shock Index, **MT/MTP**: Massive Transfusion Protocol (defined as ≥10 units of packed red blood cells within 24 h, or ≥3 units within 1 h of ED arrival), **NEWS2:** National Early Warning Score 2, **OR**s: Odds Ratios **PHI:** Prehospital Index, **pRBCs**: Packed Red Blood Cells**, PreSI**: Prehospital Shock Index, **Pre-NEWS:** Prehospital National Early Warning Score, **REMS**: Rapid Emergency Medicine Score, **RTS**: Rapid Trauma Score / Revised Trauma Score (for triage), **SAE**: Serious Adverse Event (defined as advanced airway management and/or need for vasoactive drugs), **sBATT**: Simplified Bleeding Audit for Trauma and Triage, **SI**: Shock Index, **SIA**: Shock Index multiplied by Age, **SIA/G**: Shock Index multiplied by Age divided by Glasgow Coma Scale (GCS), **SIAVPU**: Shock Index multiplied by Alert, Verbal, Pain, Unresponsive score, **SI/G**: Shock Index divided by Glasgow Coma Scale (GCS), **SS**: Shock Index divided by Oxygen Saturation, **TREWS**: Triage in Emergency Department Early Warning Score, **TRISS**: Trauma and Injury Severity Score
*Values were approximated from a non-quantitatively labelled graph, introducing potential imprecision.

that the first set was used [29], while others chose the set with the lowest blood pressure [34]. Chen et al. [9] reported that the median transport time for EMS in their study was seven minutes, resulting in a smaller time window for recording repeat vital signs. Surprisingly, Juste et al. [26] recorded their preSI values on ED arrival which may limit the application of their findings to a true prehospital setting. Lastly, very few studies reported on interventions or treatments performed by EMS (e.g. crystalloid or vasopressor administration), therefore, the effects these interventions had on vital signs and scoring systems is unclear.

Older Population Groups

Geriatric populations have higher baseline blood pressure due to an increased incidence of cardiovascular disease. Prescribed antihypertensive medicines such as beta and calcium channel blockers reduce the sympathetic response in the setting of shock. Six studies performed a subgroup analysis in older adults. Both Yang et al. [32] and Chen et al. [9] concluded that the association between SI and mortality in the geriatric population and those with cardiovascular disease were weaker when compared to younger patients. These findings consistent with Lin et al. [10] who observed that prehospital SI performed poorly in this patient group, but this could be mitigated with the application of an age adjusted SI (aSI). In contrast, Frieler et al. [24] observed that an age adjustment caused a decrease in the predictive value of SI from 0.72 to 0.65 respectively. Again, no studies investigating NEWS performed a subgroup analysis for these scoring systems for mortality in older patient groups. However, clinicians should be aware of the potential for false negative prediction for SI and NEWS in geriatric trauma patients.

Traumatic Brain Injury (TBI)

Although they may co-present in polytrauma, the pathophysiology of TBI is distinct from haemorrhage. Patients with isolated TBI may confound SI and NEWS due to Cushing's reflex. Cushing's reflex causes an increased sympathetic output resulting in hypertension and parasympathetic mediated bradycardia [6]. Eight studies reported on the prevalence of severe TBI in their patient group, with seven having over 20% of patients with TBI. Chen et al. [9] performed a subgroup analysis of trauma patients, in which 24.6% suffered a severe, isolated TBI (AIS>3) and demonstrated that prehospital SI was a less accurate predictor of mortality. Similarly, Iirola et al. [7], (38.5% of patients with isolated, severe TBI) found that prehospital SI AUROC values improved following removal of this patient group, confirming the confounding effect on prehospital SI scores. Of note, two studies identified a low prehospital SI (<0.4) as predictor of mortality in severe, isolated TBI. Björkman et al. [29] hypothesised that a low SI indicated the activation of Cushing's reflex, consistent with an increasing intracranial pressure. Yamada et al. [35] found that in isolated TBI, patients with a prehospital SI < 0.4 suffered higher mortality and were more likely to require neurosurgical intervention. These findings suggest that a low SI value could offer prognostic utility in this TBI patient population. Unfortunately, no studies investigating NEWS included a subgroup analysis to comment on the influence TBI may have on prognostication. Similar to TBI, Spinal Cord Injury (SCI) with neurogenic shock causes deranged sympathetic activity which inhibits tachycardia. Bradycardia occurs due to an unopposed parasympathetic response in patients with SCI at or above the sixth thoracic vertebra [38]. The incidence of SCI and concomitant TBI ranges from 25 to 60%, criteria dependent [32]. Although no studies specifically commented on SCI, it would be reasonable to consider that polytrauma patients with suspected SCI may demonstrate similar false negative SI values observed in TBI patients. Further studies are warranted to fully understand the effects of TBI and SCI have on the efficacy on scoring tools which include heart rate as a component.

Limitations and Considerations

Study Characteristics

Significant heterogeneity was observed between the design and methodology of included studies, which may reduce the clinical utility of findings. Studies were observational in design (both retrospective and prospective), and none randomised exposure or treatment allocation, increasing the risk of unmeasured confounders. Additionally, the primary outcome of mortality was reported using a wide range of effect measures, including AUROC, adjusted odds ratios, and relative or absolute risk. This heterogeneity may limit direct comparison between studies or complicate assessment of the clinical utility of prehospital scoring systems. For example, prehospital SI generally demonstrated poor discrimination for mortality when assessed using AUROC yet showed significant association when evaluated using odds ratios or relative risk measures. This discrepancy likely reflects the differing properties of these metrics, where SI may be associated with mortality without effectively discriminating between survivors and non-survivors. Previous studies have demonstrated low sensitivity but relatively higher specificity, resulting in false negatives that reduce AUROC performance [39]. Therefore, despite statistically significant adjusted odds ratios in patients with elevated prehospital SI, its utility as a predictive tool for mortality remains limited. This raises questions as to whether observed associations reflect genuine predictive capability or are influenced by the choice of statistical measure. As discussed earlier, only nine studies had median ISS above 12, therefore the generalisability to a true major trauma population is limited. In regard to bias, four studies were deemed to have high risk of bias following critical appraisal and their results were interpreted with caution. From a clinical perspective, all studies excluded patients who died prior to ED arrival. While a NEWS or SI value in the peri-arrest trauma patient may offer limited clinical utility, the exclusion of this patient cohort unique to the prehospital setting highlights the deficit of evidence-based guidance to support EMS decision making in critically unwell trauma patients.

Application to Clinical Practice and Future Research

With only two components, the calculation of the SI is rapid and relatively simple, yet offers limited prognostic power for mortality. In contrast, the NEWS involves a more complex weighting of seven parameters but offers excellent prognostic power. Although NEWS-based approaches are widely used within healthcare systems in the United Kingdom, Europe, and Australasia, their implementation is not routine internationally. This may limit their adoption in EMS unfamiliar with early warning scores, or in resource-limited settings where the equipment required to obtain all parameters (e.g. tympanic temperature measurement) are not routinely available [17]. Regarding the logistical demands of triage tools, a ward-based study found clinicians took a mean of three minutes and 35 seconds to record the observations needed to calculate NEWS [40]. While the generalisability of these findings to the less controlled prehospital environment has not been tested, it is not unreasonable to suggest that EMS teams could task a clinician to calculate a NEWS within four minutes. Additionally, the development of smartphone applications with integrated Early Warning Score calculators has further enhanced the accessibility and ease of implementation of these tools for EMS clinicians in high-income countries [41,42]. Given the potential prognostic value, the modest time and staffing required for NEWS calculation are likely worthwhile. In particularly time pressured, resource poor situations, a simple prehospital SI value may be sufficient to predict the need for blood transfusion, [1,6,22,24,30,34] however prehospital NEWS is the more comprehensive triage tool for mortality prediction [2,6,8,28]. Accurate assessment of patient severity flows on to on-scene treatment, treatment en route, urgency of transport, choice of destination hospital, and alerting of hospital-based specialist trauma services. Further investigation into the impact of SI versus NEWS on paramedic practice is warranted. A multi-centre prospective study which compares a prehospital SI cohort with a prehospital NEWS cohort should be conducted. Outcomes such as feasibility of on scene score calculation, accuracy of triage tool and application to prehospital care warrant investigation.

Conclusion

While no triage tool can replace thorough clinical assessment, accurate scoring systems can empower prehospital clinicians to predict clinical trajectory and anticipate the needs of trauma patients. This review identified a substantial quantity of literature investigating prehospital triage tools and their relationship to mortality in trauma patients. Due to significant heterogeneity across studies, findings should be interpreted cautiously. Nonetheless, a clear trend emerged: prehospital NEWS offers excellent discrimination, better than prehospital SI, for mortality, blood transfusion and ICU admission in selected trauma patients. While an elevated prehospital SI was also associated with increased mortality risk, it did not perform well in terms of predictive performance. However, prehospital SI accurately predicted blood transfusion and surgical intervention, which could influence destination decisions. Due to the inclusion of HR and BP in each of these tools, both the SI and NEWS may underestimate shock in the setting of isolated TBI and in geriatric populations. Further research is required to understand the role of these tools in EMS decision making, and their impact on patient care in major trauma.

Ethics statement

This systematic review is based exclusively on previously published studies, all of which had obtained their own ethical approvals and patient consent.

CRediT authorship contribution statement

Alice Tolich: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Bridget Dicker:** Writing – review & editing, Supervision. **Graham Howie:** Writing – review & editing, Supervision. **Verity Todd:** Writing – review & editing, Supervision, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Secondary Outcomes and Trauma mechanisms

Secondary outcomes and trauma mechansisms.

Study	Trauma Type/Mechanism	AUROC & Odds Ratios for MT, ICU admission, Resource utilisation
April et al. (2024)	**24 h Survivors:** MVC: 38.2% Fall: 50.1% Firearm: 4.9% Stabbing: 4.2% Other: 2.5% **Non survivors:** MVC: 38.65 Fall: 24.9% Firearm: 32.6% Stabbing: 3.0% Other: 0.8%	-
Björkman et al. (2021)	**Trauma type** Blunt: 85.6% Penetrating:13.2% Other: 1.2% **Trauma with TBI: 24%**	-
Chen et al. (2025)	**Trauma type** Blunt: 96.8%	**AUROC for preSI and ICU admission: 0.54** (95% CI; 0.534–0.558, $p < 0.001$)

(continued on next page)

(*continued*)

Study	Trauma Type/Mechanism	AUROC & Odds Ratios for MT, ICU admission, Resource utilisation
	Penetrating: 3.2% **Mechanism** MVC: 54.6% High fall: 8.8% Low fall: 29.8% Other: 6.8% **Isolated TBI (Head AIS >3): 20.8%**	**Adjusted Ors for preSI and ICU admission: aOR1.62** (95% CI; 0.310−2.006, $p < 0.001$)
Costa et al. (2022)	**Mechanism** MVC: 30% Falls: 55% Gun shots and stabbings: 2% Other: 13% **Trauma with TBI (Head AIS>3): 68%**	**AUROC for preSI and MT: 0.71** (95% CI; 0.68−0.73)
Dezman et al. (2016)	**Trauma type** Blunt: 61.8% Penetrating: 7.3% Inhalation/poisoning: 0.8% Other: 1.4% Not recorded: 28.7%	**AUROC for preSI and MT: 0.76** ($p < 0.001$)
Duke et al. (2019)	**Trauma type** Blunt: 86% Penetrating: 9% Burns/other: 5%	-
Frieler et al. (2022)	**Trauma type** Blunt: 91.5% Penetrating trauma/other: 4% Other: 4.5% **Mechanism** Falls: 35.6% MCV: 23.3% Motorcycle crash: 13.7% Bicycle crash: 8.7% Pedestrian incidents: 6.5	**AUROC for preSI and blood transfusion: 0.73** (95% CI; 0.72 - 0.74)
Hosseinpour et al. (2023)	**Trauma type** Blunt: 87.5% Penetrating/other: 12.5% **Mechanism** Fall: 41.2% MVC: 31% Firearm injuries: 4.8% Pedestrian incident: 4.7%	**AUROC for preSI and MT: 0.68**
Iirola et al. (2022)	**Trauma type** Blunt: 92% Penetrating: 8.0% **Isolated TBI (Head AIS>3): 38.5%**	**-**
Jehan et al. (2019)	**Trauma Type** Blunt: 84.7% Penetrating/other: 15.3%	**AUROC for preSI and resource utilization: 0.81**
Juste et al. (2021)	No injury type or mechanism reported.	-
Kim et al. (2023)	**Trauma type** Blunt: 3.6% Penetrating: 3.4% Other: 1.6 **Mechanism** MVC: 53.3% Fall: 37.8%	**AUROC for preSI and MT: 0.70** (95% CI; 0.687–0.719) **AUROC for preNEWS and MT: 0.83** (95% CI; 0.824–0.845)
Lin et al. (2024)	**Trauma type** Blunt: 97.5% Penetrating: 2.5% **Mechanism** MVC: 62.7% Low falls: 23.1% High falls: 6.2% Other: 8.0% **Isolated TBI: 16.5%**	-
Martín-Rodríguez et al. (2019)	No type or mechanism reported.	-
Medina-Lozano et al. (2020)	**Trauma type** Blunt: 96.8% Penetrating: 3.2% **Body region** Spinal and head trauma: 33.5% Thoracic trauma: 23.1% Abdominal and pelvic trauma: 11.3% Orthopaedic trauma: 21.7% Burns: 10.4%	**AUROC for preNEWS and ICU admission: 0.80** (95% CI; 0.74−0.87, $p < 0.001$)

(*continued on next page*)

(*continued*)

Study	Trauma Type/Mechanism	AUROC & Odds Ratios for MT, ICU admission, Resource utilisation
Nutbeam et al. (2024)	**Injury type** Blunt: 100% **Mechanism** MVC: 100% (study only included patients were involved in motor vehicle collisions) **Isolated TBI (Head AIS>3) 22%**	-
Silcock et al. (2015)	**Mechanism (trauma subgroup)** Falls: 16.5% Assault: 3% Injury: 2% MVC: 1.5% Hazardous exposure: 0.2% Penetrating trauma: 0.2% Burn subject: 0.1% Eye problem: 0.1%	-
Wang et al. (2020)	**Trauma type** Blunt: 92.5% Penetrating: 7.5% **Mechanism** MVC: 20.5% Motorcycle collision: 19.9% Pedestrian collision: 2.3% Blunt trauma by object: 18.3% Ground level fall: 1.2% Fall from height: 30.5% Penetrating trauma: 7.4%	AUROC for preSI and MT: **0.77** (95% CI; 0.746–0.798)
Yamada et al. (2023)	**Trauma type** Blunt: 96.7% Penetrating: 1.9% Unknown: 0.6% Other: 0.2% Missing: 0.6% **Isolated severe TBI (Head AIS>3): 27.9%**	**Adjusted OR's for preSI and blood transfusion within 24 h: aOR: 2.27** (95% CI; 2.11−2.45)
Yang et al. (2022)	**Trauma type** Blunt: 96.3% Penetrating: 3.7% **Mechanism** MVC: 42.65% Low fall: 37.4% High Fall: 11.6% Other: 8.4%	**-**
Yüksel et al. (2025)	**Mechanism** Pedestrian accidents: 31.6% MVC: 30.6% Falling from a height: 21.1% Gunshot wounds: 4.8% Other: 12%	**AUROC for preSI and MT: 0.78** (95% CI; 0.663−0.903, $p < 0.001$) **AUROC for preSI and Emergency surgical intervention: 0.79** (95% CI; 0.664−0.904, $p < 0.001$)
Yousefi et al. (2024)	**Mechanism** MVC: 61.1% Fall: 25.5% Firearms: 0.7% Human or animal assault: < 0.1% Other: 12.7%	

AIS: Abbreviated Injury Score, ICU: Intensive Care Unit, MT: Massive Transfusion, MVC: Motor Vehicle Collision, preNEWS: Prehospital National Early Warning Score, preSI: Prehospital Shock Index, TBI: Traumatic Brain Injury.

Appendix B. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.injury.2026.113598.

References

[1] Yüksel M, Ay MO, Çalışkan FB, Kılıç A, Özdal MT, Aydoğan A, et al. "Are prehospital shock, modified shock, age-adjusted shock indices and some scoring systems effective in predicting the prognosis of high-energy trauma Patients?". Int Emerg Nurs 2025;83:101678.

[2] Yousefi MR, Karajizadeh M, Ghasemian M, Paydar S. Comparing NEWS2, TRISS, and RTS in predicting mortality rate in trauma patients based on prehospital data set: a diagnostic study. BMC Emerg Med 2024;24(1):163.

[3] Gaessler H, Helm M, Kulla M, Hossfeld B, Riedel J, Kerschowski J, et al. Prehospital predictors of the need for transfusion in patients with major trauma. Eur J Trauma Emerg Surg 2023;49(2):803–12.

[4] Puzio TJ, Kalkwarf K, Cotton BA. Predicting the need for massive transfusion in the prehospital setting. Expert Rev Hematol 2020;13(9):983–9.

[5] Kovar A., Carmichael H., McIntyre Jr R.C., Mago J., Gladden A.H., Peltz E.D., et al. The extremity/mechanism/shock index/GCS (EMS-G) score: a novel pre-hospital scoring system for early and appropriate MTP activation. The American Journal of Surgery. 2019;218(6):1195–1200.

[6] Kim AY, Wi DH, Lee JH, Kim KH, Park JH, Kim YJ, et al. Prehospital National Early Warning Score as a predictor of massive transfusion in adult trauma patients. Am J Emerg Med 2023;73:125–30.

[7] Iirola T, Björkman J, Laaksonen M, Nurmi J. Predictive value of shock index variants on 30-day mortality of trauma patients in helicopter emergency medical services: a nationwide observational retrospective multicenter study. Sci Rep 2022; 12(1):19696.

[8] Medina-Lozano E, Martín-Rodríguez F, Castro-Villamor MÁ, Escudero-Cuadrillero C, del, Vegas Pozo, López-Izquierdo C. R. Accuracy of early warning scores for predicting serious adverse events in pre-hospital traumatic injury. Injury 2020;51(7):1554–60.

[9] Chen Y-L, Wu T-H, Liu C-Y, Wang C-H, Tsai C-H, Chung J-Y, et al. Delta shock index in the emergency department as a predictor of clinical outcomes in traumatic injury. Am J Emerg Med 2025;92:10–7.
[10] Lin P-C, Wu M-Y, Wang C-H, Tsai T-Y, Tu Y-C, Liu C-Y, et al. Prehospital shock index multiplied by the alert/verbal/painful/unresponsive score as a predictor of clinical outcomes in traumatic injury. Prehosp Emerg Care 2024;28(5):669–79.
[11] Henry S, Brasel K, Stewart RM. Advanced Trauma Life Support. Chicago: American College of Surgeons. 10th edition.,. Chicago, Illinois, USA: American College of Surgeons (ACS) Course Manual,; 2018. p. 145–96.
[12] Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: utility and limitations. Open Access Emerg Med 2019:179–99.
[13] Montoya L, Kool B, Dicker B, Davie G. Epidemiology of major trauma in New Zealand: a systematic review. NZ Med J (Online) 2022;135(1550):86–110.
[14] Jokšić-Mazinjanin R, Marić N, Đuričin A, Gojković Z, Vasović V, Rakić G, et al. Prehospital trauma scoring systems for evaluation of trauma severity and prediction of outcomes. Medicina 2023;59(5):952.
[15] Kheirbek T, Martin TJ, Cao J, Hall BM, Lueckel S, Adams CA. Prehospital shock index outperforms hypotension alone in predicting significant injury in trauma patients. Trauma Surg Acute Care Open 2021;6(1).
[16] Riccalton V, Threlfall L, Ananthakrishnan A, Cong C, Milne-Ives M, Le Roux P, et al. Modifications to the National Early Warning Score 2: a Scoping Review. BMC Med 2025;23(1):154.
[17] Abbott TEF, Cron N, Vaid N, Ip D, Torrance HDT, Emmanuel J. Pre-hospital National Early Warning Score (NEWS) is associated with in-hospital mortality and critical care unit admission: A cohort study. Ann Med Surg (Lond) 2018;27:17–21.
[18] Wei S, Xiong D, Wang J, Liang X, Wang J, Chen Y. The accuracy of the National Early Warning Score 2 in predicting early death in prehospital and emergency department settings: a systematic review and meta-analysis. Ann Transl Med 2023;11(2):95.
[19] Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. Syst Rev 2016;5(1):210.
[20] Moola S, Munn Z, Sears K, Sfetcu R, Currie M, Lisy K, et al. Conducting systematic reviews of association (etiology): The Joanna Briggs Institute's approach. JBI Evid Implement 2015;13(3):163–9.
[21] April MD, Fisher AD, Rizzo JA, Wright FL, Winkle JM, Schauer SG. Early Vital Sign Thresholds Associated with 24-Hour Mortality among Trauma Patients: A Trauma Quality Improvement Program (TQIP) Study. Prehosp Disaster Med 2024;39(2):151–5.
[22] Costa A, Carron P-N, Zingg T, Roberts I, Ageron F-X. Registry ST. Early identification of bleeding in trauma patients: external validation of traumatic bleeding scores in the Swiss Trauma Registry. Crit Care 2022;26(1):296.
[23] Duke M, Tatum D, Sexton K, Stuke L, Robertson R, Sutherland M, et al. When minutes fly by: what is the true "golden hour" for air care? Am Surg 2018;84(6):862–7.
[24] Frieler S, Lefering R, Gerstmeyer J, Drotleff N, Schildhauer TA, Waydhas C, et al. Keeping it simple: the value of mortality prediction after trauma with basic indices like the reverse shock index multiplied by Glasgow coma scale. Emerg Med J 2022;39(12):912–7.
[25] Hosseinpour H, Anand T, Bhogadi SK, Colosimo C, El-Qawaqzeh K, Spencer AL, et al. Emergency Department Shock Index Outperforms Prehospital and Delta Shock Indices in Predicting Outcomes of Trauma Patients. J Surg Res 2023;291:204–12.
[26] Juste LP, Gómez MK, Burguera AB, García RR, García LP, Tejada IM. Prehospital and hospital shock indices as predictors of massive blood transfusion during the initial treatment of polytrauma patients. Emergencias 2021;33(1):29–34.
[27] Silcock DJ, Corfield AR, Gowens PA, Rooney KD. Validation of the National Early Warning Score in the prehospital setting. Resuscitation 2015;89:31–5.
[28] Martín-Rodríguez F, López-Izquierdo R, del Pozo Vegas C, Benito JFD, Rodríguez VC, Rasilla MND, et al. Accuracy of national early warning score 2 (NEWS2) in prehospital triage on in-hospital early mortality: a multi-center observational prospective cohort study. Prehosp Disaster Med 2019;34(6):610–8.
[29] Björkman J, Raatiniemi L, Setälä P, Nurmi J. Shock index as a predictor for short-term mortality in helicopter emergency medical services: A registry study. Acta Anaesthesiol Scand 2021;65(6):816–23.
[30] Dezman ZD, Hu E, Hu PF, Yang S, Stansbury LG, Cooke R, et al. Computer modelling using prehospital vitals predicts transfusion and mortality. Prehosp Emerg Care 2016;20(5):609–14.
[31] Jehan F, Con J, McIntyre M, Khan M, Azim A, Prabhakaran K, et al. Pre-hospital shock index correlates with transfusion, resource utilization and mortality; the role of patient first vitals. Am J Surg 2019;218(6):1169–74.
[32] Yang Y-C, Lin P-C, Liu C-Y, Tzeng I-S, Lee S-J, Hou Y-T, et al. Prehospital shock index multiplied by AVPU scale as a predictor of clinical outcomes in traumatic injury. Shock 2022;58(6):524–33.
[33] Nutbeam T, Stassen W, Foote E, Ageron F-X. Derivation and validation of the simplified BleedingAudit Triage Trauma (sBATT) score: a simplified trauma score for major trauma patients injured in motor vehicle collisions. BMJ Open 2024;14(12):e090517.
[34] Wang I-J, Bae B-K, Park S-W, Cho Y-M, Lee D-S, Min M-K, et al. Pre-hospital modified shock index for prediction of massive transfusion and mortality in trauma patients. Am J Emerg Med 2020;38(2):187–90.
[35] Yamada Y, Shimizu S, Yamamoto S, Matsuoka Y, Tsutsumi Y, Tsuchiya A, et al. Prehospital shock index predicts 24-h mortality in trauma patients with a normal shock index upon emergency department arrival. Am J Emerg Med 2023;70:101–8.
[36] Dupuy C, Martinez T, Duranteau O, Gauss T, Kapandji N, Pasqueron J, et al. Comparison of the lethal triad and the lethal diamond in severe trauma patients: a multicenter cohort. World J Emerg Surg 2025;20(1):2.
[37] Forristal C, Van Aarsen K, Columbus M, Wei J, Vogt K, Mal S. Predictors of hypothermia upon trauma center arrival in severe trauma patients transported to hospital via EMS. Prehosp Emerg care 2020;24(1):15–22.
[38] Wulf MJ, Tom VJ. Consequences of spinal cord injury on the sympathetic nervous system. Front Cell Neurosci 2023;17:999253.
[39] Carsetti A, Antolini R, Casarotta E, Damiani E, Gasparri F, Marini B, et al. Shock index as predictor of massive transfusion and mortality in patients with trauma: a systematic review and meta-analysis. Crit Care 2023;27(1):85.
[40] Wong D, Bonnici T, Knight J, Gerry S, Turton J, Watkinson P. A ward-based time study of paper and electronic documentation for recording vital sign observations. J Am Med Inform Assoc 2017;24(4):717–21.
[41] National Ambulance Sector Clinical Working Group, [NASCWG]. National Ambulance Sector Clinical Working Group. *Early Warning Score* CPG EAS 1.26 2026. Available from: https://cpg.stjohn.org.nz/tabs/tools/page/ews-calculator.
[42] Ambulance Victoria Clinical Practice Guidelines, [AVCPG]. Advanced Life Support / Mobile Intensive Care Ambulance Clinical Practice Guidelines [Version 3.13.2]. 2026. Available from: https://cpg.ambulance.vic.gov.au/#/tabs/tab-2/calc-news2.