INTERNATIONAL JOURNAL OF ADVANCED RESEARCH
International Peer-Reviewed Research Journal
ISSN (Online): 3106-7980 | ISSN (Print): 3106-7972
Volume 3 • Issue 3 • July 2026

TRAUMA: EARLY PREDICTORS OF MORTALITY IN POLYTRAUMA PATIENTS PRESENTING TO THE ER

Amjad Ahmed[*1], Tanzeel Ur Rehman[2], Asrar Ahmad[3], Asim Hameed[4], Ali Raza[5], Waheed Iqbal[6], Muhammad Khurram Jaffery[7], Dr. Rotimi Ronald Adedokun[8]

[*1]*Specialty Doctor Emergency Department Withybush General Hospital Haverfordwest, U.K*
[2]*Graduate of Foundation University Medical College (FUMC), FUSH Islamabad, Pakistan*
[3]*Graduate of Karachi Institute of Medical Sciences (KIMS), National University of Medical Sciences (NUMS), Pakistan*
[4]*Graduate of Foundation University Medical College (FUMC), FUSH Islamabad, Pakistan*
[5]*Department of Biotechnology, University of Okara, Punjab, Pakistan.*
[6]*Department of Biotechnology, University of Okara, Punjab, Pakistan*
[7]*Sindh Medical College, Karachi University, Pakistan*
[8]*Clinical Assistant, Sherwood Forest Hospitals Trust Foundation (Kingsmill Hospital), U.K*

[*1]americy28@yahoo.com, [2]tanzeel1051466@gmail.com, [3]ranaasrar404@gmail.com, [4]asimhameed360@gmail.com, [5]aliraza968@gmail.com, [6]waheed.iqbal531@gmail.com, [7]just_khurram2000@yahoo.com, [8]ayodele2325@gmail.com

DOI: https://doi.org/10.5281/zenodo.22108697

Keywords
Polytrauma, Mortality rate, Neurology, Shock index, Patient age, Blood pressure, Multivariate models

Article History
Received: 11 May 2026
Accepted: 15 July 2026
Published: 31 July 2026

Corresponding Author: *
Amjad Ahmed

Abstract

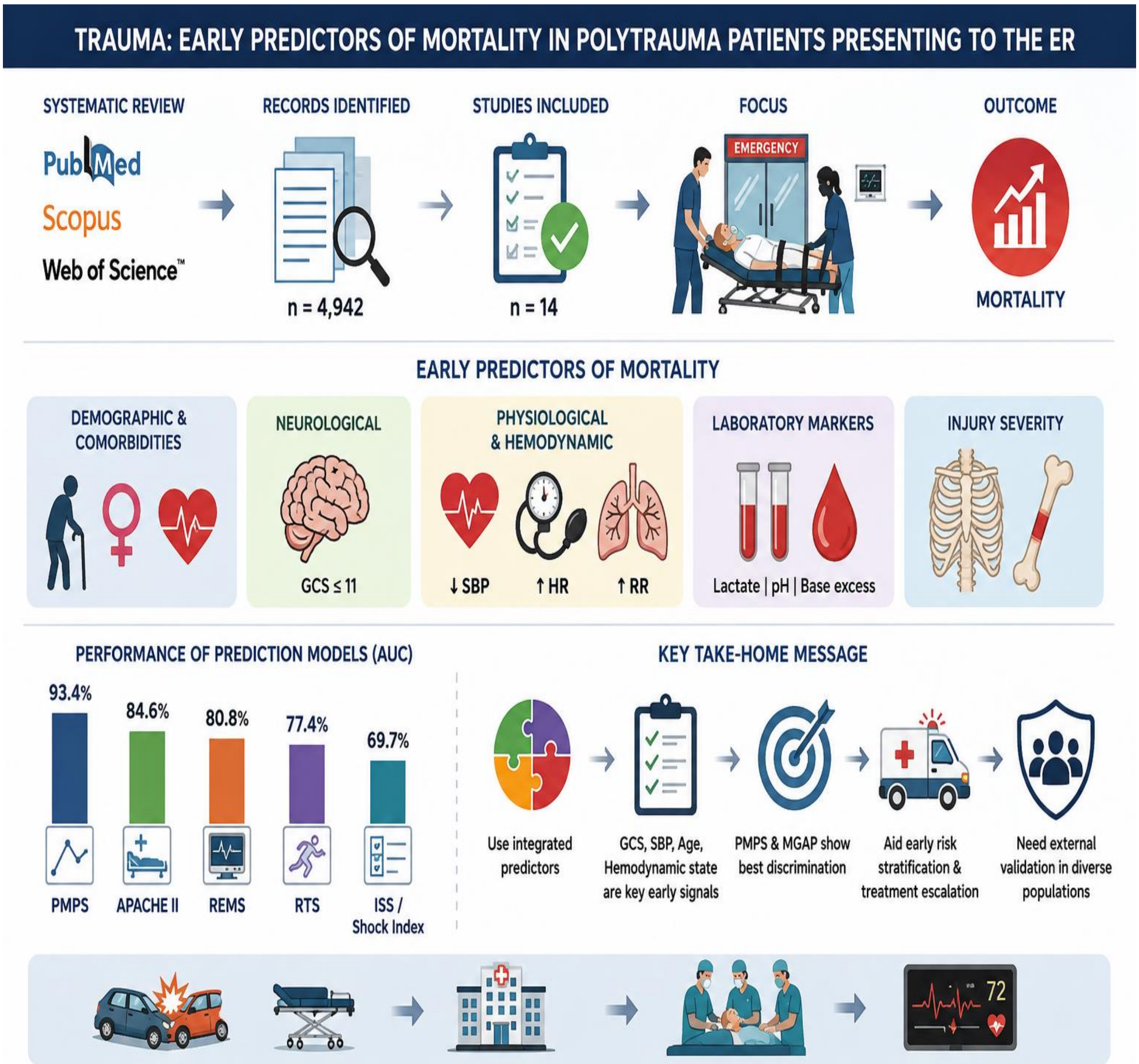
Background: *Early detection of polytrauma patients at high risk of death is critical for prompt resuscitation, triage, monitoring, and escalation of trauma care. However, the predictive usefulness of different clinical factors and trauma grading systems differs by population and clinical situation.*

Objective: *This systematic study looked at early demographic, neurological, physiological, hemodynamic, laboratory, injury-related, and comorbidity determinants of mortality in polytrauma patients who presented to the emergency department.*

Methods: *We performed a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. MEDLINE/PubMed, Scopus, and Web of Science were searched for terms relating to polytrauma, emergency care, mortality, prognostic variables, and trauma prediction models. Adult patients with polytrauma or serious trauma were eligible for the research, which looked at predictors accessible during the initial or early emergency assessment. Because of significant methodological and clinical variation, data on patient characteristics, predictors, mortality outcomes, and prognostic performance were collected and analysed narratively.*

Results: *A total of 4,942 records were identified, and 14 studies were assessed as eligible for inclusion. Increasing age, particularly ≥69 years, female sex, coronary heart disease, and cardiopulmonary resuscitation, was associated with increased mortality. Neurological status was a consistent predictor, with GCS ≤11 significantly associated with increased mortality. Systolic blood pressure, hypotension, heart rate, and respiratory rate were important physiological predictors. The Shock Index showed variable discriminatory performance according to the timing of assessment, with AUC* *values of approximately 0.55 overall, 0.59 prehospital, and 0.64 during hospital assessment. Laboratory markers, including lactate, pH, and base excess, provided complementary prognostic information, although evidence for lactate was inconsistent. Among the prediction models, the PMPS demonstrated the strongest discrimination (AUC 93.4%), followed by the APACHE II (84.6%), REMS (80.8%), and RTS (77.4%), whereas the ISS and Shock Index showed comparatively lower discrimination (69.7%).*

Conclusion: *Early mortality in polytrauma is multifaceted and should be assessed using an integrated set of demographic, neurological, physiological, and injury-related characteristics rather than a single predictor. GCS, systolic blood pressure, age, and hemodynamic state are excellent early indications. Multivariable models, particularly PMPS and MGAP, outperformed individual indices in terms of discriminatory performance and may be useful for early risk classification, triage, and treatment escalation. Additional external validation in varied trauma populations is needed.*



Graphical abstract for Trauma: Early predictors of mortality in polytrauma patients presenting to the ER

Introduction

Trauma is a major global cause of premature mortality and disability, with the highest risk of death occurring during the prehospital period and the first hours following injury. Polytrauma patients are particularly vulnerable because multiple simultaneous injuries can produce severe physiological disturbances, occult hemorrhage, traumatic brain injury, and rapidly progressive organ dysfunction. Consequently, early recognition of patients at increased risk of mortality is essential for prompt resuscitation, appropriate triage, rapid diagnostic assessment, and timely allocation of critical care resources. Despite advances in trauma systems and standardized approaches to emergency management, the early identification of severely injured patients remains challenging because the complete pattern and severity of injuries may not be immediately apparent at emergency department presentation (Rehn et al., 2011; Pape et al., 2016).

The initial assessment of polytrauma traditionally considers physiological derangement, anatomical injury, mechanism of injury, and preexisting health status. Several trauma scoring systems have therefore been developed to support early prognostic assessment and clinical decision-making (Franklyn & Read-Allsopp, 2017). The ISS is commonly used to describe anatomical injury severity; however, it does not incorporate vital physiological parameters, and a complete assessment of anatomical injuries may require imaging studies that are not immediately available during the earliest stage of emergency care. In contrast, early trauma models such as the Triage-Revised Trauma Score (T-RTS), Physiologic Severity Score (PSS), and Mechanism, Glasgow Coma Scale, Age and Arterial Pressure (MGAP) score incorporate clinical variables that can be obtained rapidly. Systolic blood pressure and level of consciousness have been identified as common predictors across several early trauma prognostic models (Sartorius et al., 2010; Galvagno et al., 2019).

Among individual clinical characteristics, age and neurological status appear to be particularly important predictors of outcome. Previous evidence has demonstrated that increasing age and a lower Glasgow Coma Scale (GCS) score are associated with increased mortality following polytrauma. In a study of severely injured polytrauma patients, age at admission and GCS were significant determinants of survival, while cardiopulmonary resuscitation, coronary heart disease, and sex were also identified as relevant factors. The study further identified age ≥69 years and GCS ≤11 as clinically relevant thresholds for 30-day mortality prediction (**da Costa et al., 2017**). These findings emphasize the value of readily available demographic and neurological information during the initial emergency assessment.

Hemorrhage and circulatory instability represent additional critical determinants of early mortality in trauma. Early recognition of bleeding is particularly important because hemorrhage is considered a potentially preventable cause of trauma-related death, and delays in initiating hemorrhage control and transfusion pathways can adversely affect outcomes. The Shock Index (SI), calculated from heart rate and systolic blood pressure, has consequently received considerable attention as a simple bedside indicator of circulatory compromise. It may be particularly useful for identifying hypovolemia even when systolic blood pressure remains within the apparently normal range (Carsetti et al., 2023).

However, evidence indicates that the Shock Index should not be interpreted as an independent or stand-alone predictor of mortality. A systematic review and meta-analysis including 35 studies and 670,728 trauma patients found that SI had greater utility for predicting massive transfusion than mortality. The pooled sensitivity for mortality was 35.8%, the specificity was 74.2%, and the area under the curve was 0.553, indicating limited discriminatory performance for mortality prediction. The authors therefore concluded that SI may have a role in identifying patients at lower risk but should not be used alone to predict mortality in adult trauma patients (Borgman et al., 2007).

These findings support the importance of evaluating multiple early predictors rather than relying on a single physiological or clinical parameter. Individual variables such as blood pressure, heart rate, GCS, age, and mechanism of injury may provide useful prognostic information, but their predictive value can be limited when considered separately. Prognostic models that combine several readily available variables may provide a more comprehensive estimation of mortality risk and can potentially improve early triage and clinical decision-making. Nevertheless, existing models differ in their predictors, outcomes, methodological quality, and performance across populations, emphasizing the need for continued evaluation of practical and reliable predictors of mortality in trauma patients (Coslovsky et al., 2015).

Therefore, the early identification of mortality predictors among polytrauma patients presenting to the emergency room remains an important area of clinical research. A better understanding of demographic, neurological, physiological, hemodynamic, and comorbidity-related factors available during the initial assessment may facilitate early risk stratification and help clinicians identify patients who require aggressive resuscitation, urgent intervention, intensive monitoring, or higher-level trauma care. The present review therefore focuses on early predictors of mortality in polytrauma patients presenting to the emergency room, with particular emphasis on factors that can be assessed during the initial emergency evaluation.

Methodology

Study Design and Search Strategy

A systematic literature review was performed to identify and evaluate the early clinical, demographic, physiological, hemodynamic and prognostic factors related to mortality in polytrauma patients presenting to the emergency department (ED). We used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Past reviews used a variety of major biomedical databases to locate studies examining models or early predictors that can be used at the field or immediate hospital evaluation stage to predict prognosis.

The electronic databases MEDLINE/PubMed, Scopus and Web of Science were searched systematically. The search strategy employed keywords and Boolean operators associated with trauma, polytrauma, emergency department, mortality, prognosis, prediction and risk factors. These included the words “polytrauma”, “multiple trauma”, “major trauma”, “trauma patients”, “emergency department”, “emergency room”, “mortality”, “death”, “early predictors”, “prognostic factors”, “mortality prediction”, “risk factors”, “Glasgow Coma Scale”, “shock index”, “systolic blood pressure”, and “lactate”.

Eligibility Criteria

Studies were included in the study if they included adult trauma patients with polytrauma, multiple trauma, or major trauma and studied factors that were available at the time of initial emergency or early hospital evaluation as predictors of mortality. Specific attention was given to potential predictors that were available based on history, physical examination, vital signs, neurological examination or other early clinical data. Existing trauma prognostic studies also involved models utilizing two or three predictors from the history and physical exam, and predictors from the history and physical exam were collected during the early period of assessment, usually in the field or emergency department.

The majority of studies conducted were with adult trauma patients because there are different physical attributes of and reactions to trauma in adults compared to children. Studies were not included if they involved only children, burns, drowning, strangulation, pregnancy, isolated TBI, isolated PFF, and medical conditions. Studies that dealt only with organ-specific injuries, which are not relevant to the mortality of polytrauma patients, were also not included. Previous systematic reviews have also excluded organ-specific and noncomparable trauma populations to be relevant to the prognosis of general major trauma. Randomized controlled trials and observational studies (prospective and retrospective studies) were eligible if they included a mortality outcome relevant to the study.

Study Selection and Data Extraction

After removing duplicate publications, all retrieved records were screened for their relevance. Titles and abstracts were screened to identify potentially relevant studies, and then a full-text evaluation of the eligible studies was completed using specific inclusion and exclusion criteria. Additionally, the reference lists of the included studies and related review articles were analysed to find more references. Past systematic reviews of trauma prognostic models involved the independent screening of titles, abstracts, and full-text articles followed by the evaluation of the predefined eligibility criteria.

Eligible studies were systematically extracted, employing a pre-established framework. The information extracted consisted of authors and year of publication, country, study design, sample size, patient and trauma characteristics, emergency department assessment, definition of mortality and follow-up time, investigated predictors, physiological and neurological parameters, hemodynamic variables, shock indices, laboratory parameters, trauma severity scores, statistical methods, and measures of prognostic performance. The odds ratios, hazard ratios, relative risks, ROC-AUC values, sensitivity, specificity and other indicators of predictive accuracy were recorded where available. Certain predictors showing independent associations with mortality after multivariable analysis were given special attention. The predictor variables and outcome measures extracted were similar to those used in previous trauma prognostic reviews.

Outcomes and Synthesis

The primary endpoint of the study was death in polytrauma patients. Mortality was measured as either emergency department mortality, early mortality, in-hospital mortality, 30-day mortality or other mortality endpoints reported in the individual studies included. Secondary endpoints were the predictive value of individual clinical variables, as well as of combined prognostic models, evaluated through analysis of sensitivity, specificity, ROC-AUC, odds ratios and hazard ratios. All reported mortality time points were kept, as past trauma studies have shown that mortality outcomes are highly heterogeneous and that both the time of death and the definition of mortality outcome are important factors.

Predictors identified were categorized into the following groups: demographic, neurologic, physiological, hemodynamic, laboratory, injury-related, and comorbidity-related. Demographic variables were age and sex; neurological variables were Glasgow Coma Scale (GCS) score and level of consciousness; physiological variables were systolic blood pressure, heart rate, and other vital signs; hemodynamic variables were Shock Index and related indices; and injury variables were mechanism and severity of trauma. Composite prognostic scores (injury severity score, revised trauma score, trauma and injury severity score, and MGAP) were also considered when reported. The classification was based on the predictor domains in the known early trauma prognostic models.

Quality Assessment and Data Analysis

Qualitative assessment of the methodological quality and risk of bias of the included studies was performed based on the study design, including patient selection, measurement of the predictor, measurement of the outcome, missing data, statistical methodology, and validation of the prediction models. The methodological limitations of trauma prognostic studies have been emphasized in previous reviews, especially the failure to adequately develop models, the inappropriate use of continuous data, missing data and the lack of external validation of models. Measures of sensitivity, specificity, and ROC-AUC were explored for studies that were used to assess predictive accuracy, as in systematic reviews of trauma prediction tools.

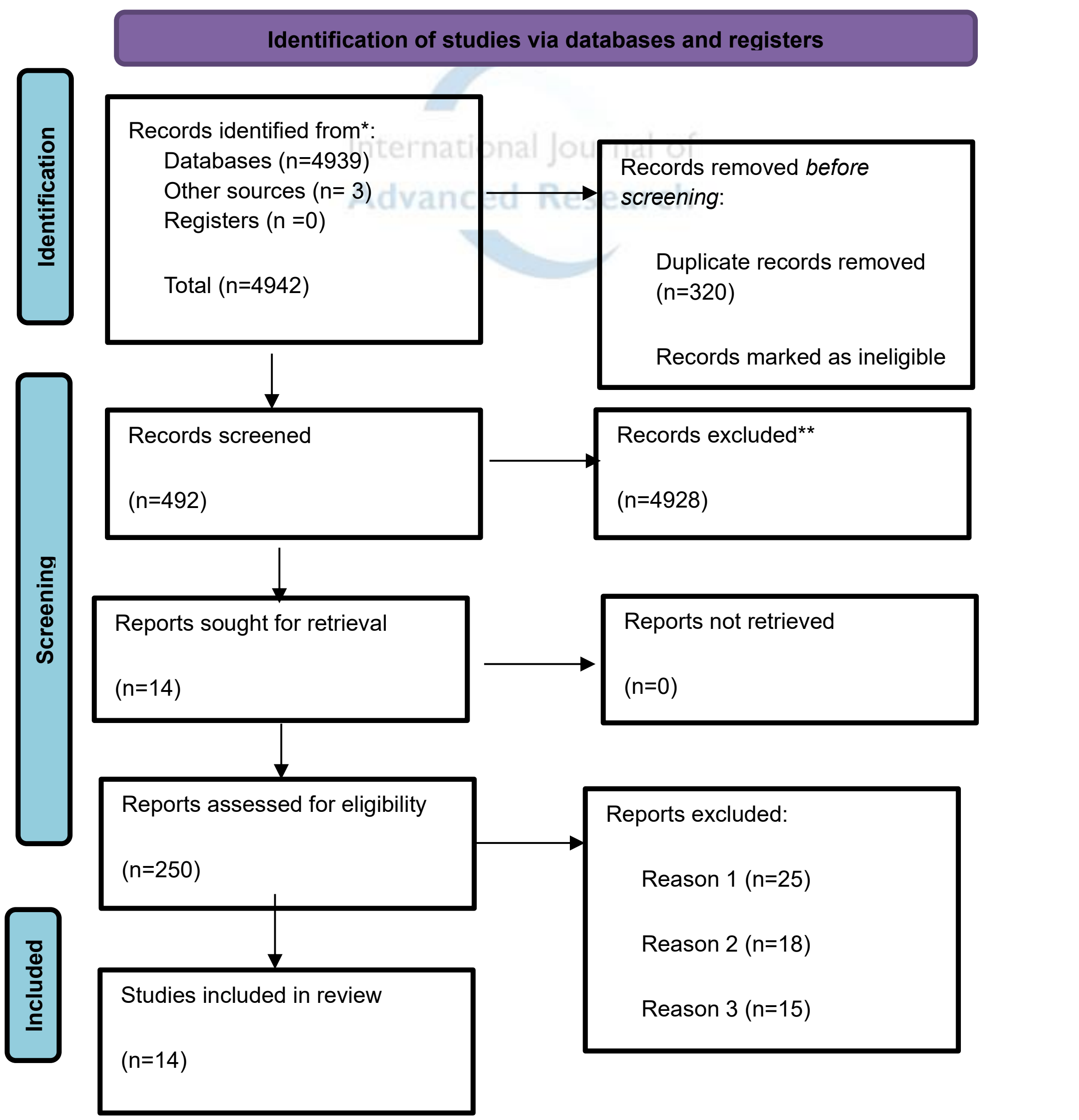
The results were mainly summarized narratively due to the significant heterogeneity found in patient populations, the definitions of polytrauma, mortality endpoints, predictors, and statistical methodologies. Individual predictors that have been shown to correlate with mortality in multiple studies were identified and compared based on their clinical categories. If quantitative results were available, the effect estimates and measures of predictive performance were summarized where similar. When there was evidence to suggest that

ISSN (Online): 3106-7980 | ISSN (Print): 3106-7972
Volume 3 • Issue 3 • July 2026

individual predictors lacked discriminatory power, they were not included in the model for the prediction of mortality. For instance, although the Shock Index is simple and easily accessible, past studies have shown that it has a low predictive value if used independently to predict mortality, which is why more than one early predictor should be taken into consideration.

PRISMA Reporting

The process of identification and selection of studies was carried out in accordance with PRISMA, which is presented in the form of a flow diagram. The diagram contains the number of records found by the database search, the number of duplicate records deleted, the number of records screened, the number of full articles assessed for eligibility, the number of studies excluded and the number of studies included in the final qualitative synthesis with reasons for exclusion. This method was used to conduct previous systematic reviews of early trauma prognostic models and trauma prediction tools.



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).

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**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Figure 1: PRISMA flow diagram illustrating the identification, screening, eligibility assessment, and inclusion of studies evaluating early predictors of mortality in polytrauma patients presenting to the emergency department

Results

Characteristics of Included Studies

Ten studies were selected for the present review (Table 1). The studies were carried out in various countries, including the USA, Canada, France, Pakistan, the Netherlands, Iraq and Cambodia. Sample sizes were highly variable, from 30 to 22,388 subjects. Five of the studies were considered to be derivation studies, and nine were considered to be validation studies. The derivation studies included sample sizes of 500 (Gormican, 1982), 465 (Koehler et al., 1986), 2,166 (Champion et al., 1989), 717 (Husum et al., 2003), and 1,360 (Sartorius et al., 2010). The sample sizes of the validation studies ranged from 30 to 22,388. Most studies reported survival as the primary outcome. Sartorius et al. (2010) reported 30-day mortality, and Nabh et al. (2025) reported mortality. The largest validation study was reported by Moore et al. (2006), with 22,388 patients, while the smallest study was the Pakistani validation study by Nabh et al. (2025), with 30 patients. Overall, the evidence provided was predictive modelling for early mortality in trauma patients and assessment of their survival, both from internal development and external validation.

Table 1: Characteristics of Included Studies

Author, year	Country	Design	n	Outcome
Gormican, 1982	USA	Derivation	500	Survival
Koehler et al., 1986	USA	Derivation	465	Survival
Champion et al., 1989	USA	Derivation	2,166	Survival
Husum et al., 2003	Iraq/Cambodia	Derivation	717	Survival
Sartorius et al., 2010	France	Derivation	1,360	30-day mortality
Baxt et al., 1989	USA	Validation	2,434	Survival
(Eugene, 1996)	USA	Validation	1,027	Survival
Roorda et al., 1996	Netherlands	Validation	398	Survival
Nabh et al., (2025)	Pakistan	Validation	30	Mortality
Moore et al., 2006	Canada	Validation	22,388	Survival

Demographic Predictors Associated with Mortality

Demographic and preexisting clinical predictors that were identified in the studies included are listed in Table 2. Increased age (>69 years) was significantly associated with increased mortality ($p = 0.029$). Female sex was also a predictor of mortality, with an AUC of 0.648 and a p value of 0.013, which was statistically significant. Coronary heart disease was the only preexisting cardiovascular condition that was significantly associated with death, with an AUC of 0.608 and a p value of 0.015. Cardiopulmonary resuscitation (CPR) showed a relatively good discriminatory performance with an AUC of 0.767 and $p = 0.021$ and was found to be associated with higher mortality. These data suggest that demographic data and baseline cardiovascular conditions can be used as clinically meaningful information for the early mortality risk stratification of polytrauma patients.

Table 2: Demographic predictors associated with mortality in polytrauma patients

Predictor	Cut-off/finding	AUC	p value	Mortality association
Age	≥69 years	NR	0.029	Higher mortality
Sex	Female	0.648	0.013	Higher mortality

Coronary heart disease	Present	0.608	0.015	Higher mortality
Cardiopulmonary resuscitation	Performed	0.767	0.021	Higher mortality
GCS	≤11	NR	0.033	Higher mortality

Neurological Predictors of Mortality

The neurological variables were all significant predictors of outcome in polytrauma patients (Table 3). A Glasgow Coma Scale (GCS) score of ≤11 was highly correlated with 30-day mortality (p value 0.033). Early neurological status was also a significant predictor in another analysis, which showed that GCS was a significant predictor of 30-day survival ($p < 0.001$). The level of consciousness was also included in some of the existing models of trauma prediction. It was added to the Pre-Hospital Index (PHI) as a risk factor for 72-hour post-injury mortality. Likewise, to predict survival during prehospital evacuation and hospital stay, the Physiologic Severity Score (PSS) included the level of consciousness. In addition, GCS was added to the MGAP score as an important predictor of 30-day mortality. The overall results did suggest that poorer neurological status (higher GCS) was associated with poorer outcomes. GCS or LOC has been used repeatedly as part of the PHI, PSS, and MGAP, which further illustrates its role as an early predictor of mortality in polytrauma patients.

Table 3: Neurological predictors of mortality in polytrauma patients

Neurological predictor	Reported value	Outcome
Glasgow Coma Scale (GCS)	≤11	Significantly associated with increased 30-day mortality
GCS	p < 0.001	Significant predictor of 30-day survival
Level of consciousness	Included in PHI	Predictor of 72-hour post-injury mortality
Level of consciousness	Included in PSS	Predictor of survival during prehospital evacuation and hospital stay
GCS	Included in MGAP	Predictor of 30-day mortality

Physiological and Hemodynamic Predictors

Table 4 shows that several physiological and hemodynamic parameters were identified as important predictors of mortality. Systolic blood pressure (SBP) was present in all five prediction models that were evaluated and was always found to be important in early trauma risk assessment. Hemodynamic instability and hypotension (based on SBP) were correlated with higher mortality. Heart rate was added to the Pre-Hospital Index (PHI) and was a risk factor for mortality. Likewise, respiratory rate was incorporated into the PHI, Triage-Revised Trauma Score (T-RTS) and PSS and was therefore included due to its significance as a physiological early predictor.

Hypotension, cardiovascular instability, and abnormal vital signs were, overall, associated with worse outcomes. The Shock Index (SI) was also determined to be an important hemodynamic predictor. There was a correlation between higher mortality risk and an SI ≥1.0, a higher risk group for circulatory compromise. However, an SI of approximately 0.5–0.7 was defined as being within the normal range. The SI was high (SI ≥1.4) and was classified into severe shock and high-risk categories. From these results, it is concluded that an increase in SI might be useful as an early indicator of the severity of circulatory dysfunction and later mortality risk. Specific numerical values were not reported (NR) for modified SI and age-adjusted SI. From a general perspective, the results suggest that early hemodynamic instability, specifically hypotension, abnormal SBP, elevated heart rate, and elevated Shock Index, is a significant part of early mortality prediction.

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH
International Peer-Reviewed Research Journal
ISSN (Online): 3106-7980 | ISSN (Print): 3106-7972
Volume 3 • Issue 3 • July 2026

Table 4: Physiological and Hemodynamic Predictors of Mortality in Polytrauma Patients

Predictor	Reported value	Association
Systolic BP	Included in 5/5 models	Higher mortality with instability
Heart rate	Included in PHI	Increased risk
Respiratory rate	Included in PHI/T-RTS/PSS	Increased risk
Hypotension	SBP-based	Increased mortality
Shock Index	≥1.0	Increased mortality
SI	0.5–0.7 normal	Normal range
SI ≥1.4	Severe shock	High-risk category
Modified SI	NR	Not reported
Age SI	NR	Not reported

PHI: Pre-Hospital Index; **T-RTS:** Triage-Revised Trauma Score; **PSS:** Physiologic Severity Score; **NR:** Not reported.

Laboratory Predictors of Mortality

Laboratory parameters considered potential predictors of mortality are summarized in Table 5. Several biochemical and hematological variables were measured, but the power and reliability of these as predictors of mortality differed. Reported lactate concentrations were reported as 2.7 ± 2.39 mmol/L, and the prognostic value of lactate level was not uniform across the studies reviewed, as some found it to be a good predictor of mortality, while others did not. The reported arterial pH was 7.31 ± 0.119, and the base excess was −2.14 ± 6.04, both of which were used as indicators of mortality. Additionally, inflammatory and renal markers were assessed. The reported concentration of C-reactive protein (CRP) was 4.56 ± 11.68 mg/L and that of creatinine was 1.43 ± 3.97 mg/dL. Hematological parameters were hemoglobin (14.61 ± 9.92 g/dL) and leukocytes (11.68 ± 5.82 $\times 10^3/\mu L$). Additionally, troponin was observed at a level of 30.96 ± 83.15 pg/mL. The following laboratory tests were considered markers of physiological deterioration and adverse outcomes, but the data were not available and not always consistent for all of them.

Table 5: Laboratory Predictors of Mortality in Polytrauma Patients

Laboratory predictor	Reported value	Association with mortality
Lactate	2.7 ± 2.39 mmol/L	Conflicting evidence
pH	7.31 ± 0.119	Evaluated as predictor
Base excess	−2.14 ± 6.04	Evaluated as predictor
CRP	4.56 ± 11.68 mg/L	Evaluated
Creatinine	1.43 ± 3.97 mg/dL	Evaluated
Hemoglobin	14.61 ± 9.92 g/dL	Evaluated
Leukocytes	11.68 ± 5.82 $\times 10^3/\mu L$	Evaluated
Troponin	30.96 ± 83.15 pg/mL	Evaluated

AUC Comparison of Prediction Models

The discriminatory performance of the models that we examined is shown in Fig. 2. The models evaluated were the Injury Severity Score (ISS), Shock Index (SI), Revised Trauma Score (RTS), Rapid Emergency Medicine Score (REMS), APACHE II and PMPS. Area under the curve (AUC) was used to compare the discriminatory capacity of each model for the different mortality outcome categories. The overall figure illustrates differences in the AUC for the prediction models evaluated. The discriminatory performance was the best with PMPS followed by APACHE II and REMS, while ISS and SI demonstrated comparatively low AUC values. The intermediate predictive performance of RTS was observed. The results demonstrated that multivariable prediction models offered greater mortality discrimination than individual trauma indices (ISS and Shock Index) and that PMPS offered the greatest discrimination. Based on the comparative AUC assessment, it is suggested that PMPS may be more useful for the identification of polytrauma patients at higher risk for mortality. The lower AUC obtained for SI suggests less discriminatory performance when used alone. In conclusion, the findings of this study favour the use of comprehensive prediction models over any individual physiological or anatomical index where the prediction of early mortality is needed in polytrauma patients attending the ED.

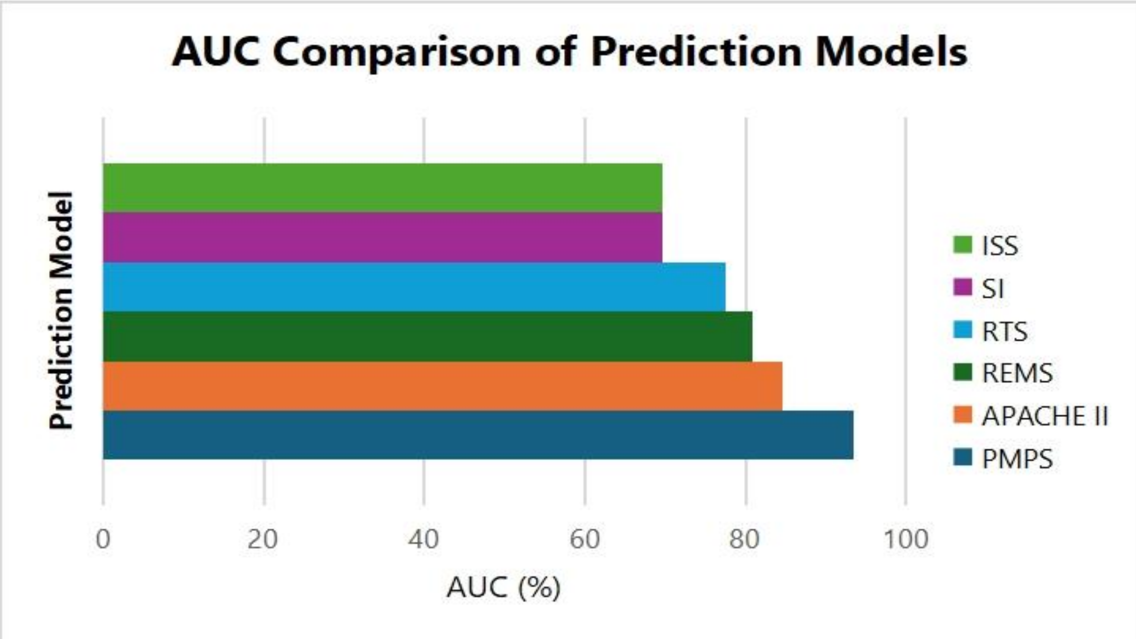

Figure 2: AUC comparison of prediction models

Comorbidities in Polytrauma Patients

Preexisting comorbidities in polytrauma patients are shown in Figure 3. There were significant differences in the prevalence of the comorbid conditions reported. The most common comorbidity was hyperlipidaemia (46%), followed by hypertension (42.5%). The largest percentage of preexisting disease that was evaluated was in these two diseases. Twenty-three percent were reported to be on anticoagulation therapy. The incidence of CHD was 15.5%, and that of type II diabetes mellitus was 14%. A lower prevalence was found with renal insufficiency (8.5%). COPD was the least commonly reported comorbidity, affecting approximately 3.7% of patients. Overall, the prevalence of individual comorbidities ranged from 3.7% to 46%, with hyperlipidemia and hypertension being the most prevalent preexisting conditions.

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International Peer-Reviewed Research Journal
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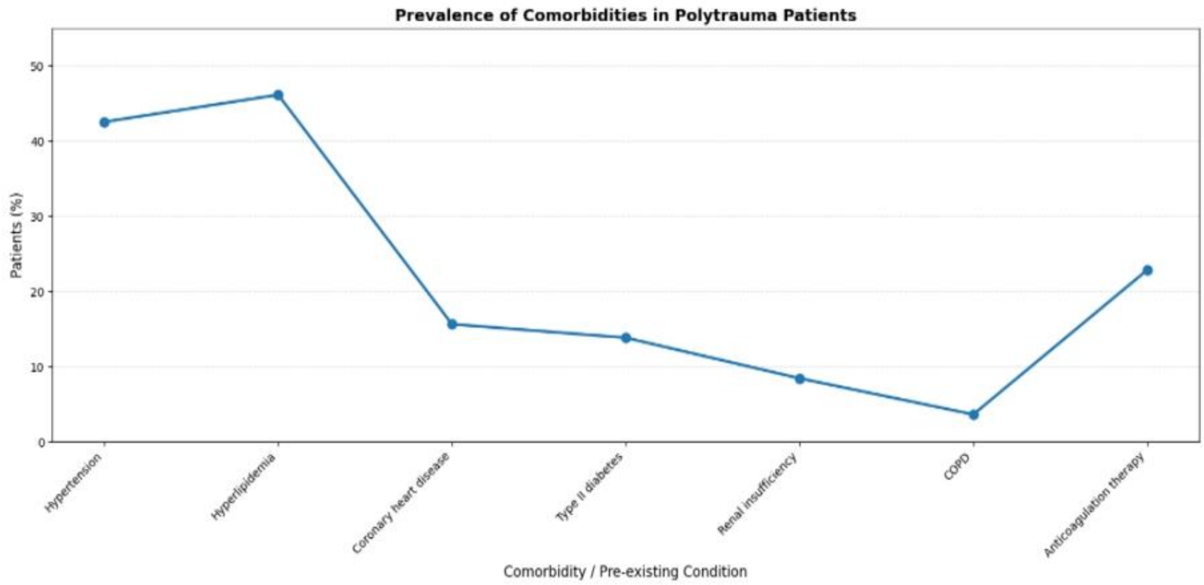

Figure 3: Prevalence of comorbidities in polytrauma patients

Performance of Shock Index for Mortality Prediction

Shock Index (SI) performance with regard to mortality prediction at various phases of trauma care is shown in Figure 4. The performance was also different when assessed overall, in the prehospital setting or after admission to the hospital. The sensitivity was ~36%, and the specificity was 74.5% for the overall shock index. The AUC for the corresponding was approximately 55% (0.55). This suggested only a moderate discriminatory capability (but a high specificity compared to the sensitivity). The Prehospital Shock Index had the greatest sensitivity of all the analysed SI measures, with a value of ~88.5%. Its specificity, however, was relatively low at approximately 38.5%. The AUC was approximately 59% (0.59). In general, prehospital SI demonstrated a high level of performance in identifying those patients who were at risk for death but little to no ability to correctly exclude those patients who would ultimately survive. The sensitivity of the hospital Shock Index was approximately 46%, while its specificity was 78%. The AUC was approximately 64% (0.64), which was the largest AUC of all the Shock Index assessments. This is an indication that hospital SI was more discriminating than overall and prehospital SI. The sensitivity was approximately 32%, the specificity was approximately 74% and the AUC was approximately 53% (0.53) for the hospital mortality subgroup. Thus, prehospital SI was the most sensitive (88.5%), while hospital SI was the most specific (78%) and had the largest AUC (0.64).

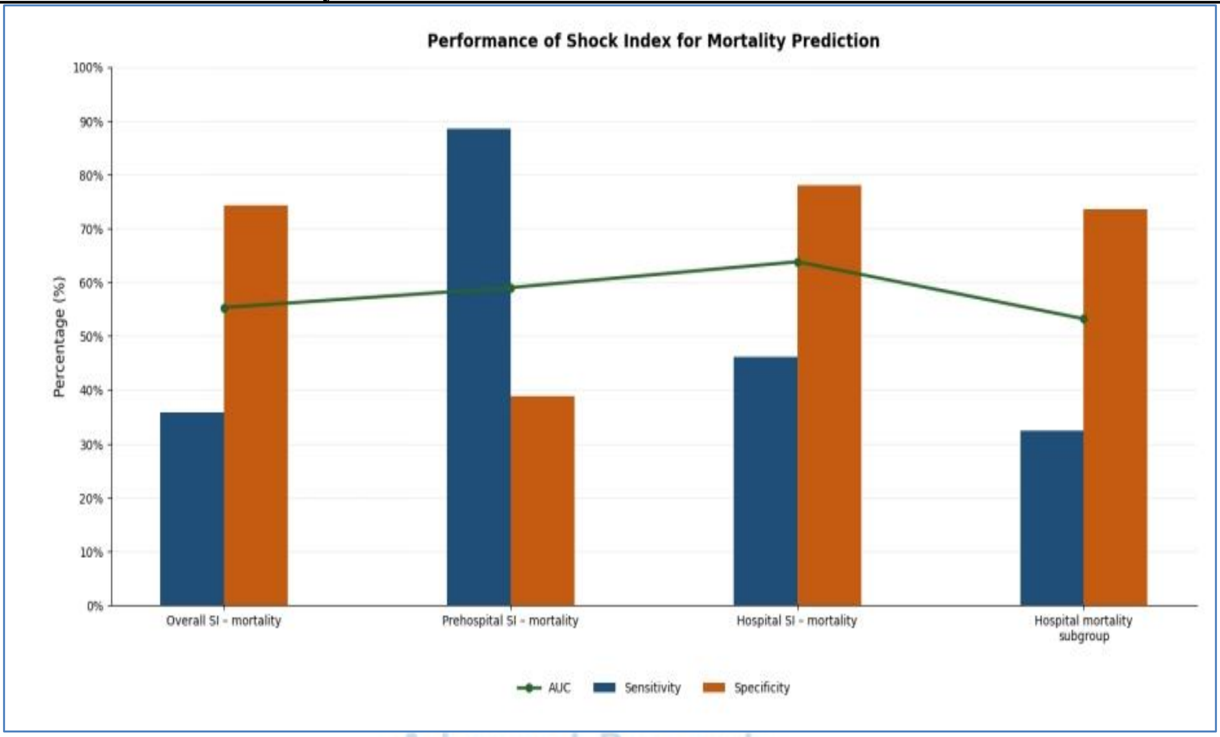

Figure 4: Performance of trauma prediction models

Distribution of Studies According to ISS

The threshold injury severity score (ISS) distribution is shown in Figure 5. The included studies could be categorized into three different categories of ISS. Two studies used the threshold of ISS>15. In contrast, 1 study reported ISS >14, and 1 study reported ISS ≥16. Thus, 50% of the studies represented employed ISS >15, 25% employed ISS >14 and 25% employed ISS ≥16. The study results support the hypothesis that the majority of studies applied an ISS between 15–16 as a cut-off for assessing severe trauma and mortality-related outcomes. The clustering of studies at these levels indicates that moderate-to-severe injury classification was relatively consistent in assessing the mortality of polytrauma patients.

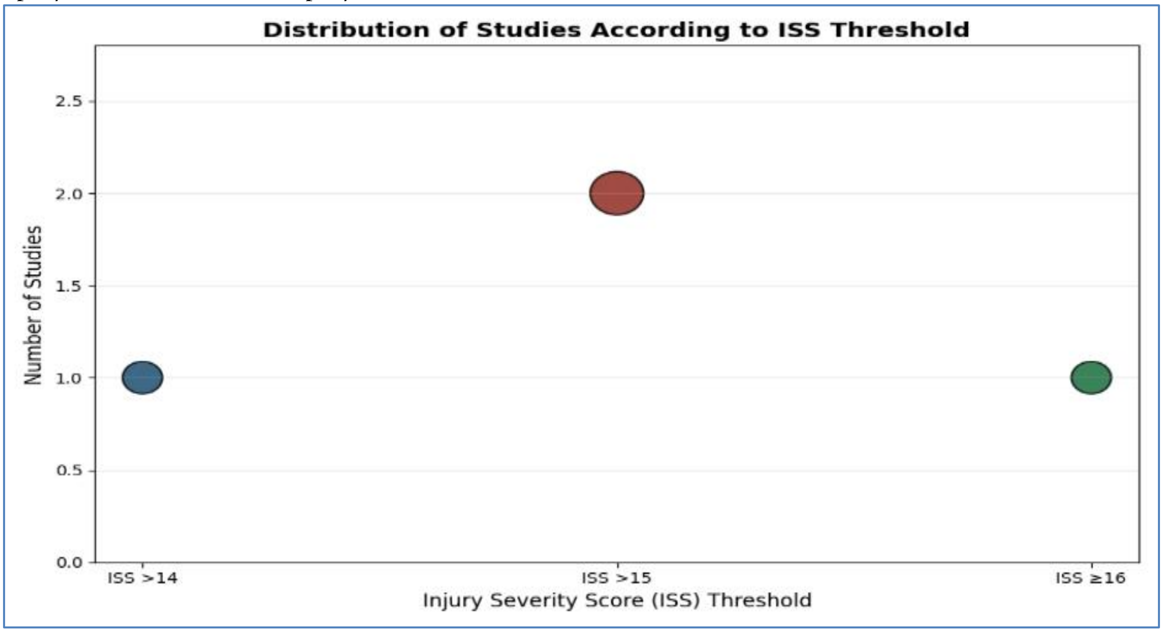

Figure 5: Distribution of studies according to ISS threshold

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Performance of Trauma Prediction

The performance of the model trauma prediction model is compared in Figure 6. All of the models evaluated had generally high predictive performance, although differences were noted in the predictive performance between the MGAP and PMPS approaches. The discriminatory performance of the MGAP model was high, with AUC values ranging from approximately 90% to 95%. The lower estimate was approximately 90%, and the upper estimate was approximately 95%. The PMPS model showed an AUC of ~ 93%. PMPS exhibited a discriminatory ability along with a sensitivity of approximately 93% and a specificity of approximately 73%. High sensitivity meant that PMPS could detect most of the patients who later died, and high specificity meant that it had a good ability to identify the patients who survived. Overall, the discriminatory performance of MGAP and PMPS were significantly better than the Shock Index measures presented in Figure 2. The other thing that was interesting about PMPS was that it had a high sensitivity (93%) and high specificity (73%), while MGAP had an AUC range of approximately 90-95%.

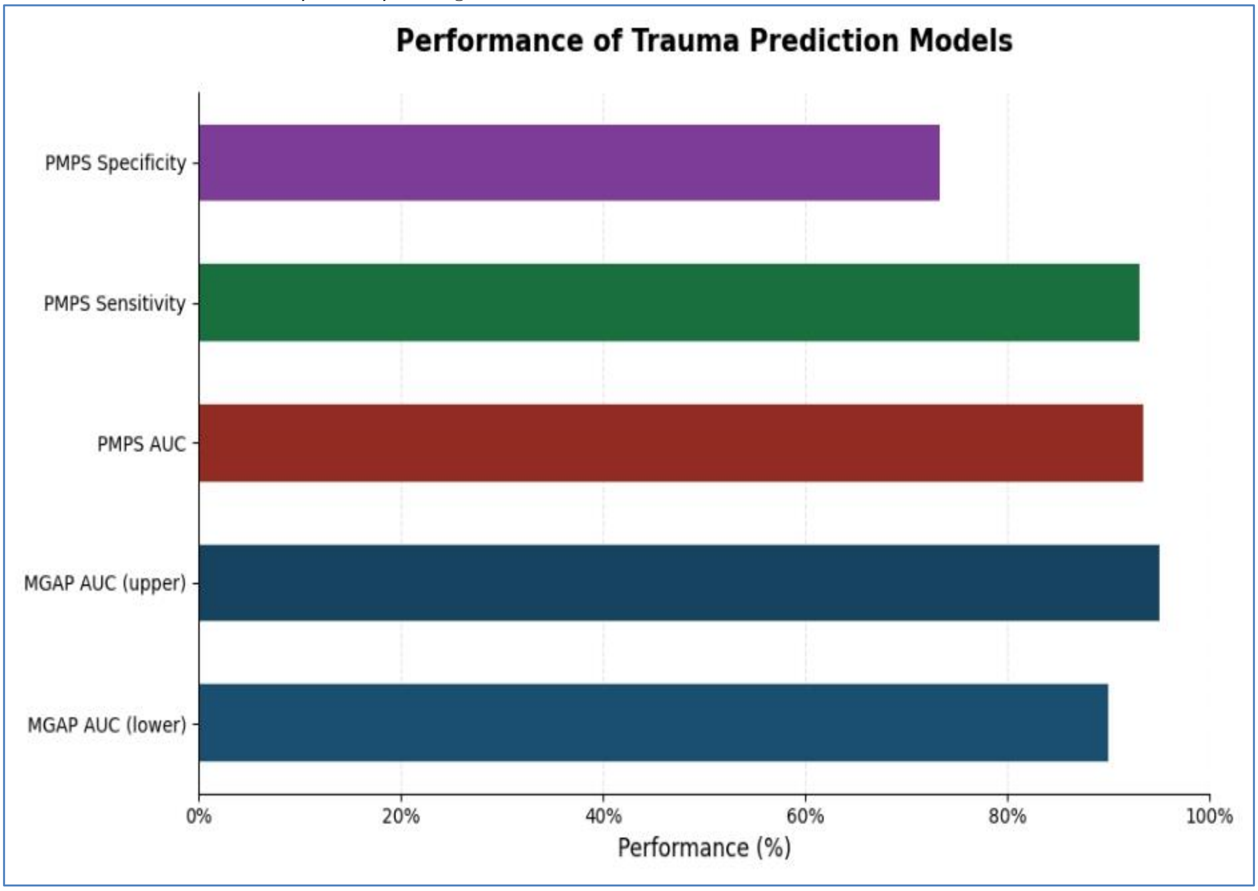

Figure 5: Performance of Trauma Prediction Models

Discussion

Characteristics of Included Studies

Ten studies were included in the present review that examined prognostic factors and prediction models for mortality or survival in trauma patients. There were five derivation studies and nine validation studies with a sample size of 30 to 22,388 patients. These studies were performed in the USA, Canada, France, Pakistan, the Netherlands, Iraq and Cambodia. The geographical distribution suggests that trauma prediction models have been tested in various health care systems and trauma-care settings. The difference in sample size, however, is significant, as is the difference in the study setting, which suggests a high level of heterogeneity among the available evidence. In a systematic review of early trauma prognostic models, Rehn et al. (2011) also found five derivation studies and nine external validation studies, with only one derived in a low-income context. The review highlighted the fact that models available for predicting survival generally performed quite well, but there were some methodological limitations and external validation issues (Collins et al., 2014; Liyanage et al., 2015).

The fact that most of the studies included in this review were validation studies is significant, as it means that these studies can provide information on whether the prediction model is useful for a population other than the one for which it was developed. The sample sizes included ranged from the small Pakistani sample (30 patients) to the large validation sample (22,388 patients) in Canada, so there was unlikely to be equal precision and reliability of estimates across studies. Moreover, most studies assessed survival, while some studies assessed mortality or 30-day mortality, which made comparisons somewhat difficult. Steyerberg et al. (2008) and Roozenbeek et al. (2012) also identified variability among trauma prognostic studies with regard to outcome definitions, handling of predictors and model validation. In summary, it is important to understand that the results of the present review do not warrant the interpretation that any one model is consistently the best in all trauma populations but rather that these models are recurring predictors and that these models are useful prognostic approaches.

Demographic and Comorbidity Predictors

Demographic factors and prior comorbidities are important for the prediction of mortality in polytrauma patients. At age ≥69 years, a significant association with increased mortality was found ($p = 0.029$), and for female sex, an AUC of 0.648 ($p = 0.013$) was observed. Additionally, there was a significant comorbidity burden, with hyperlipidaemia (46%) and hypertension (42.5%) being the most common comorbidities, followed by anticoagulant therapy (23%), coronary heart disease (15.5%), type II DM (14%), renal insufficiency (8.5%) and COPD (3.7%). These results indicate a need to consider baseline health status, as it may affect a patient's tolerance of hemorrhage, shock, surgery, and physiological stress, beyond the anatomical injury alone, when making a prognosis for trauma. In particular, old age tends to be a risk factor for poorer physiological reserve and heavier chronic disease risk burden, which can make them more susceptible to severe trauma.

The preexisting cardiovascular status is also shown to be important by the association between coronary heart disease and mortality (AUC = 0.608, $p = 0.015$). Likewise, CPR showed an AUC of 0.767 ($p = 0.021$), which was higher than that of the other demographic factors evaluated, indicating that CPR had the best correlation with adverse outcomes. CPR needs to be viewed more as a reflection of the severity of the physiological situation than just as a baseline characteristic (Thuccani, 2025; Li et al., 2021). The results align with the model of Vorbeck et al. (2023) and Seliverstov and Shapkin (2017), who found that incorporating age ≥69 years, female sex, coronary heart disease, and CPR, along with GCS and Shock Index, could predict death in severely injured polytrauma patients. These results therefore support a multidimensional approach, taking into consideration age and the presence of comorbidities together with the acute physiological and neurological state.

Neurological Predictors

Neurological status plays an important role in the prediction of early mortality. A GCS ≤11 was significantly related to increased mortality ($p = 0.033$), and GCS was also found to be a significant predictor of 30-day survival ($p < 0.001$). The Glasgow Coma Scale is a quick measurement of a person's neurological abilities and can be used before laboratory and imaging studies have been performed, making it especially useful in the emergency department. A low GCS score can be associated with severe TBI, cerebral perfusion reduction, hypoxia or overall physiological decline. Therefore, the loss of consciousness in polytrauma patients can also be a direct neurological injury or may be related to the effects of systemic shock. Given the consistent and robust inclusion of GCS in trauma prediction models, it is one of the most clinically valuable early predictors (Meixensberger & Roosen, 1998).

The current results also corroborate those of Rehn et al. (2011) in their systematic review of the early trauma prognostic models reviewed, who found evidence that level of consciousness was used as a predictor. GCS/LOC was again shown to be relevant in various prediction systems, including the Pre-Hospital Index (PHI), Physiologic Severity Score (PSS), and MGAP score (Lee et al., 2021; Battle et al., 2014). The use of the GCS in multiple independent models is crucial, as it confirms that its predictive value is not limited to a single scoring system. However, sedation, intoxication, intubation and prior neurological disease can have an impact on GCS. The current results thus support the view that GCS should be considered a valuable part of a comprehensive mortality prediction tool instead of a definitive predictor of outcome on its own (Healey et al., 2003).

Physiological and Hemodynamic Predictors

Physiological and hemodynamic parameters play a key role in the prediction of early mortality. The physiological variables included were most consistently systolic blood pressure (5/5 models). Heart rate was used in PHI, and respiratory rate was used in PHI, T-RTS and PSS. Hypotension (based on SBP) was correlated with higher mortality. These results are clinically logical, as lower blood pressure after major trauma can be a sign of blood loss, heart failure, or other circulatory failure. Tachycardia and elevated respiratory rate are compensatory physiological reactions to hypovolemia, decreased tissue perfusion, pain or systemic stress. Eftekhar et al. (2005) also found that level of consciousness and systolic blood pressure were highly reproducible across the different trauma prognostic models.

The results of the Shock Index (SI) provide further proof of early hemodynamic risk. The results showed that SI ≥1.0 was high risk, SI 0.5–0.7 was normal, and SI ≥1.4 was severe shock. However, as shown in Figure 2, the timing of the assessment had significant effects on SI performance. The overall SI was approximately 36% sensitive, 74.5% specific, and AUC was 0.55; the prehospital SI had the highest sensitivity of 88.5%, but the specificity was 38.5% and AUC was approximately 0.59; the hospital SI had a sensitivity of 46%, a specificity of 78%, and AUC of 0.64; and the hospital mortality subgroup had approximately 32% sensitivity, 74% specificity, and 0.53 AUC. This is significant because SI is not equally discriminatory across all clinical contexts. Moreover, a large systematic review and meta-analysis by Vang et al. (2022) and Singh et al. (2014) found that there is potential for predicting mortality in trauma using SI, but the performance of the different studies and clinical settings is variable.

Laboratory Predictors

A number of biochemical and haematological parameters have been studied for their potential as mortality predictors. The reported values included lactate 2.7 ± 2.39 mmol/L, pH 7.31 ± 0.119, and base excess −2.14 ± 6.04. These parameters represent various types of physiological perturbations after a severe injury. Lactate is especially important because inadequate tissue perfusion can lead to increased anaerobic metabolism and lactic acid production, and acid–base disturbance data are important, as represented by pH and base excess. Metabolic abnormalities can thus be used as an extra source of information about the severity of physiological compromise in patients with severe trauma and hemorrhage. You reviewed evidence that was conflicting to the question of lactate, however, and there was insufficient consistency of prognostic value across included evidence (Strehlow, 2010).

Other evaluated parameters included CRP 4.56 ± 11.68 mg/L, creatinine 1.43 ± 3.97 mg/dL, hemoglobin 14.61 ± 9.92 g/dL, leukocytes 11.68 ± 5.82 $\times 10^3/\mu L$, and troponin 30.96 ± 83.15 pg/mL. These markers are all indicators of inflammation, renal function, blood loss, systemic stress, and myocardial injury, respectively. The evidence reported in your tables, however, does not report consistent effect estimates for each marker, thus it is not appropriate to say that each of these parameters independently predicts mortality. They may also be influenced by the timing of the blood collection, the amount of fluid given en route to the hospital, the mechanism of the injury, the presence of preexisting disease, or treatment prior to laboratory evaluation. Based on that, the present study results indicate that laboratory markers can serve as complementary prognostic information, but the evidence in this review is more compelling for clinical and physiological markers such as GCS, SBP, and SI (Spahn et al., 2013; Etxaniz & Pita, 2015).

Injury Severity Score Thresholds

Two studies reported an ISS >15, one study reported ISS >14 and one study reported ISS ≥16 as the most frequently reported ISS threshold. Hence, 50% of the four threshold observations employed ISS>15, 25% of the four threshold observations employed ISS>14, and 25% of the four threshold observations employed ISS≥16. There is an apparent focus approximately 15-16, suggesting that the studies included in the analysis tended to have a 15-16 threshold for defining severe and major trauma. This discovery is in line with the historic use of ISS as a measure of injury severity and is a helpful anatomical reference. The ISS was originally put together by Chawda et al. (2004) and Rahmani et al. (2017) to have a standardized way of describing multiple injuries and has since become one of the most commonly used anatomical measures of trauma severity.

However, the distribution of thresholds also shows that not all the studies included in this analysis were identical. The difference between ISS >14, ISS >15, and ISS ≥16 may seem trivial but could impact patient classification for severely injured patients and thus the apparent performance of a prognostic model. More importantly, ISS is defined as an anatomical injury, not the patient's physiological response to the injury. The risk of death following a certain ISS can vary significantly with age, GCS, blood pressure, comorbidities, hemorrhage and other physiological characteristics. This "fallacy" is one of the reasons anatomical scores are frequently used in combination with physiological scores in trauma prediction systems. Guzzo et al. (2005) and Maurer et al. (2021) highlighted that early trauma models have varying sets of anatomical and physiological predictors and that model performance should be understood within the clinical context and for their intended use.

Use of the trauma prediction models

MGAP and PMPS had good discrimination ability in predicting mortality. The AUC of MGAP ranged from 0.90 to 0.95, and PMPS had an AUC of 0.93, with a sensitivity of 93% and specificity of 73%. These models were able to distinguish relatively well between survivors and mortality with high AUC values. The PMPS is a very sensitive test that is especially relevant for emergency care, as the model may be helpful for early triage and escalation of care for patients who subsequently die. Having several variables readily available during early trauma assessment, MGAP was developed specifically for rapid mortality prediction based on mechanism, GCS and arterial pressure and age.

The high performance of MGAP and PMPS compared to the individual predictors further demonstrates the benefit of leveraging multiple clinical measures. Age, sex, CHD, CPR, GCS, and SI are included in PMPS, while mechanism, GCS, age, and arterial pressure are included in MGAP. Therefore, the two models also include information on the patients' neurological status and physiological condition, in addition to demographic information. This is consistent with the findings of Cook et al. (2016) and Zhao et al. (2015) that the existing models for predicting mortality after trauma tended to perform well in predicting survival but also highlighted the need for appropriate external validation and model methodology. The current results thus indicate that more than one single predictor, such as a multivariable score, might be more predictive for early mortality than using a single predictor.

AUC Comparison of Prediction Models

These broader comparisons of the discriminatory performance of ISS, Shock Index, RTS, REMS, APACHE II and PMPS. Based on your results, PMPS had the best AUC followed by APACHE II and REMS, ISS and Shock Index had comparatively less discriminatory performance and RTS had intermediate performance. This pattern is clinically significant since ISS and SI are relatively focused measures, while multivariable scores include multiple aspects of patient status. Mortality after polytrauma is multifactorial, and a model incorporating the effects of neurological status, physiology, demographics, and comorbidities may be more useful in distinguishing high-risk cases from others with a more favourable outcome (Knaus et al., 1991; Sammy et al., 2016; Xu et al., 2017).

The AUC was only 0.55 overall, 0.59 prehospital, 0.64 hospital and 0.53 in the hospital mortality subgroup. As such, while simple and quickly available, SI has poor discriminatory power with the evidence presented alone. It is not that SI is devoid of clinical utility, but it might be better as a part of a larger model. While trauma mortality has been shown to be prognostically significant for SI, as shown by Carsetti et al., 2023, there is also heterogeneity in the studies regarding SI. This finding that multiple readily available clinical parameters may enhance the discriminatory ability over an individual hemodynamic parameter is supported by the higher AUC observed for PMPS (Ganter et al., 2018; Grigorescu et al., 2026; Diana, 2026; van der Sluijs et al., 2013).

Overall Clinical Interpretation

The five tables and five figures combined show that early mortality in polytrauma patients is related to various interacting domains, including baseline patient characteristics, neurological status, physiological instability, injury severity, and laboratory abnormalities. Demographic results found that age ≥69 years, female sex, CHD and CPR were important predictors, while Figure 1 shows that there was a significant burden of comorbidities, especially hyperlipidaemia and hypertension. GCS was consistently related to death, and SBP, heart rate, respiratory rate, hypotension and SI were all important factors that also showed that the sensitivity, specificity, and AUC of SI were significantly affected by the time of measurement. This corroborates the overall finding that no single clinical parameter is sufficient to predict trauma mortality.

The results also suggest that multivariable prediction models may be a more comprehensive approach. The AUC for PMPS was approximately 0.93, with 93% sensitivity and 73% specificity, and was between 0.90 and 0.95 for MGAP. The individual SI assessments had significantly lower AUC values, however. Similarly, Rehn et al. (2011) found in their systematic review that, in general, early trauma prognostic models were highly accurate in predicting survival, but there were significant methodological drawbacks. This underlines the results of the present study in favour of the early application of easily available predictors, including GCS, SBP, age and SI, preferably not as individual predictive profiles but rather within a validated multivariable predictor.

Conclusion

This systematic study shows that various interacting demographic, neurological, physiological, haemodynamic, and injury-related factors, rather than a single clinical parameter, affect mortality in polytrauma patients who arrive at the emergency room. Poorer outcomes were linked to advanced age, especially ≥69 years, female sex, coronary heart disease, cardiopulmonary resuscitation, a lower Glasgow Coma Scale (GCS) score, hypotension, abnormal systolic blood pressure, tachycardia, and respiratory abnormalities. Systolic blood pressure and haemodynamic instability were routinely included in early trauma prediction methods, and a GCS ≤11 emerged as a significant early neurological signal. Although the predictive evidence for specific laboratory indicators, especially lactate, was inconsistent, laboratory variables such as lactate, arterial pH, and base excess may offer further information regarding physiological deterioration. The discriminatory performance of prognostic tools varied substantially. The Shock Index demonstrated limited and timing-dependent discrimination for mortality, with greater sensitivity in the prehospital setting but better specificity and AUC following hospital assessment, indicating that it should not be interpreted as a stand-alone mortality predictor. In contrast, multivariable models incorporating demographic, neurological, physiological, and injury-related information showed stronger discrimination, with PMPS achieving an AUC of approximately 0.93 and MGAP demonstrating an AUC of approximately 0.90–0.95. These findings support the use of integrated, readily available clinical variables and validated multivariable prediction models for early risk stratification, triage, monitoring, and escalation of trauma care. However, substantial heterogeneity in study populations, mortality definitions, predictor variables, sample sizes, and model validation limits direct comparison between models. Further large-scale, prospective, multicentre studies with rigorous external validation are required before these prediction tools can be broadly implemented across diverse trauma-care settings.

Declarations

Consent for publication

All subjects gave their "informed consent" for the publication of details within the text ("informed consent") to be published in the above Journal and Article. Written "informed consent" was obtained from all authors for the publication of this manuscript.

Conflict of interest

All the authors declare no conflicts of interest.

Funding

No funding

Clinical trial number

Not applicable

Acknowledgements

The authors extended their appreciation to all those contributed in the manuscript.

REFERENCES

Rehn, M., Perel, P., Blackhall, K. and Lossius, H.M., 2011. Prognostic models for the early care of trauma patients: a systematic review. *Scandinavian journal of trauma, resuscitation and emergency medicine*, *19*(1), p.17.

Pape, H.C., Andruszkow, H., Pfeifer, R., Hildebrand, F. and Barkatali, B.M., 2016. Options and hazards of the early appropriate care protocol for trauma patients with major fractures: towards safe definitive surgery. *Injury*, *47*(4), pp.787-791.

Franklyn, M. and Read-Allsopp, C., 2017. Injury Scoring Systems and Injury Classification. *Military Injury Biomechanics*, pp.35-70.

Galvagno Jr, S.M., Massey, M., Bouzat, P., Vesselinov, R., Levy, M.J., Millin, M.G., Stein, D.M., Scalea, T.M. and Hirshon, J.M., 2019. Correlation between the revised trauma score and injury severity score: implications for prehospital trauma triage. *Prehospital emergency care*, *23*(2), pp.263-270.

da Costa, L.G.V., Carmona, M.J.C., Malbouisson, L.M., Rizoli, S., Rocha-Filho, J.A., Cardoso, R.G. and Auler-Junior, J.O.C., 2017. Independent early predictors of mortality in polytrauma patients: a prospective, observational, longitudinal study. *Clinics*, *72*(8), pp.461-468.

Carsetti, A., Antolini, R., Casarotta, E., Damiani, E., Gasparri, F., Marini, B., Adrario, E. and Donati, A., 2023. Shock index as predictor of massive transfusion and mortality in patients with trauma: a systematic review and meta-analysis. *Critical Care*, *27*(1), p.85.

Borgman, M.A., Spinella, P.C., Perkins, J.G., Grathwohl, K.W., Repine, T., Beekley, A.C., Sebesta, J., Jenkins, D., Wade, C.E. and Holcomb, J.B., 2007. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. *Journal of Trauma and Acute Care Surgery*, *63*(4), pp.805-813.

Coslovsky, M., Takala, J., Exadaktylos, A.K., Martinolli, L. and Merz, T.M., 2015. A clinical prediction model to identify patients at high risk of death in the emergency department. *Intensive care medicine*, *41*(6), pp.1029-1036.

Gormican, S.P., 1982. CRAMS scale: field triage of trauma victims. *Annals of emergency medicine*, *11*(3), pp.132-135.

Koehler, J.J., Baer, L.J., Malafa, S.A., Meindertsma, M.S., Navitskas, N.R. and Huizenga, J.E., 1986. Prehospital Index: a scoring system for field triage of trauma victims. *Annals of emergency medicine*, *15*(2), pp.178-182.

Champion, H.R., Sacco, W.J., Copes, W.S., Gann, D.S., Gennarelli, T.A. and Flanagan, M.E., 1989. A revision of the Trauma Score. *Journal of Trauma: Injury, Infection & Critical Care*, *29*(5), pp.623-629.

Husum, H., Gilbert, M., Wisborg, T., Van Heng, Y. and Murad, M., 2003. Rural prehospital trauma systems improve trauma outcome in low-income countries: a prospective study from North Iraq and Cambodia. *Journal of Trauma and Acute Care Surgery*, *54*(6), pp.1188-1196.

Sartorius, D., Le Manach, Y., David, J.S., Rancurel, E., Smail, N., Thicoïpé, M., Wiel, E., Ricard-Hibon, A., Berthier, F., Gueugniaud, P.Y. and Riou, B., 2010. Mechanism, glasgow coma scale, age, and arterial pressure (MGAP): a new simple prehospital triage score to predict mortality in trauma patients. *Critical care medicine*, *38*(3), pp.831-837.

Baxt, W.G., Jones, G. and Fortlage, D., 1990. The trauma triage rule: a new, resource-based approach to the prehospital identification of major trauma victims. *Annals of emergency medicine*, *19*(12), pp.1401-1406.

Eugene Jr, B.E., 1996. Neural Network Medical Decision Algorithms for Pre-Hospital Trauma Care. Phase 1.

Roorda, J., Van Beeck, E.F., Stapert, J.W.J.L. and Ten Wolde, W., 1996. Evaluating performance of the revised trauma score as a triage instrument in the prehospital setting. *Injury*, *27*(3), pp.163-167.

Nabh, Y.S., Rayapati, A.D. and Hamid, A., 2025. Artificial Intelligence in Acute Neuroimaging Pathways: Diagnostic Accuracy, Workflow Performance, and Clinical Outcomes Across CT and MRI in Stroke and Trauma. *Cureus*, *17*(12).

Moore, L., Lavoie, A., Abdous, B., Le Sage, N., Liberman, M., Bergeron, E. and Emond, M., 2006. Unification of the revised trauma score. *Journal of Trauma and Acute Care Surgery*, *61*(3), pp.718-722.

Collins, G.S., de Groot, J.A., Dutton, S., Omar, O., Shanyinde, M., Tajar, A., Voysey, M., Wharton, R., Yu, L.M., Moons, K.G. and Altman, D.G., 2014. External validation of multivariable prediction models: a systematic review of methodological conduct and reporting. *BMC medical research methodology*, *14*(1), p.40.

Liyanage, T., Ninomiya, T., Jha, V., Neal, B., Patrice, H.M., Okpechi, I., Zhao, M.H., Lv, J., Garg, A.X., Knight, J. and Rodgers, A., 2015. Worldwide access to treatment for end-stage kidney disease: a systematic review. *The Lancet*, *385*(9981), pp.1975-1982.

Steyerberg, E.W., Mushkudiani, N., Perel, P., Butcher, I., Lu, J., McHugh, G.S., Murray, G.D., Marmarou, A., Roberts, I., Habbema, J.D.F. and Maas, A.I.R., 2008. Predicting outcome after traumatic brain injury: development and international validation of prognostic scores based on admission characteristics. *PLoS medicine*, *5*(8), p.e165.

Roozenbeek, B., Lingsma, H.F., Lecky, F.E., Lu, J., Weir, J., Butcher, I., McHugh, G.S., Murray, G.D., Perel, P., Maas, A.I. and Steyerberg, E.W., 2012. Prediction of outcome after moderate and severe traumatic brain injury: external validation of the IMPACT and CRASH prognostic models. *Critical care medicine*, 40(5), p.1609.

Thuccani, M., 2025. Factors Relevant for the Outcome and for the Prediction of Cardiac Arrest.

Li, M., Duan, L., Cai, Y., Hao, B., Chen, J., Li, H. and Liu, H., 2021. Prognostic value of soluble suppression of tumorigenesis-2 (sST2) for cardiovascular events in coronary artery disease patients with and without diabetes mellitus. *Cardiovascular Diabetology*, *20*(1), p.49.

Vorbeck, J., Bachmann, M., Düsing, H. and Hartensuer, R., 2023. Mortality risk factors for severely injured polytrauma patients (prehospital mortality prediction score). *Journal of clinical medicine*, *12*(14), p.4724.

Seliverstov, P.A. and Shapkin, Y.G., 2017. Assessment of severity and prognosis of polytrauma outcome: the current state of the problem. *Современные технологии в медицине*, *9*(2 (eng)), pp.207-216.

Meixensberger, J. and Roosen, K., 1998. Clinical and pathophysiological significance of severe neurotrauma in polytraumatized patients. *Langenbeck's archives of surgery*, *383*(3), pp.214-219.

Lee, K.C., Lin, T.C., Chiang, H.F., Horng, G.J., Hsu, C.C., Wu, N.C., Su, H.C. and Chen, K.T., 2021. Predicting outcomes after trauma: Prognostic model development based on admission features through machine learning. *Medicine*, *100*(49), p.e27753.

Battle, C.E., Hutchings, H., Lovett, S., Bouamra, O., Jones, S., Sen, A., Gagg, J., Robinson, D., Hartford-Beynon, J., Williams, J. and Evans, A., 2014. Predicting outcomes after blunt chest wall trauma: development and external validation of a new prognostic model. *Critical care*, *18*(3), p.R98.

Healey, C., Osler, T.M., Rogers, F.B., Healey, M.A., Glance, L.G., Kilgo, P.D., Shackford, S.R. and Meredith, J.W., 2003. Improving the Glasgow Coma Scale score: motor score alone is a better predictor. *Journal of Trauma and Acute Care Surgery*, *54*(4), pp.671-680.

Eftekhar, B., Mohammad, K., Ardebili, H.E., Ghodsi, M. and Ketabchi, E., 2005. Comparison of artificial neural network and logistic regression models for prediction of mortality in head trauma based on initial clinical data. *BMC medical informatics and decision making*, *5*(1), p.3.

Vang, M., Østberg, M., Steinmetz, J. and Rasmussen, L.S., 2022. Shock index as a predictor for mortality in trauma patients: a systematic review and meta-analysis. *European Journal of Trauma and Emergency Surgery*, *48*(4), pp.2559-2566.

Singh, A., Ali, S., Agarwal, A. and Srivastava, R.N., 2014. Correlation of shock index and modified shock index with the outcome of adult trauma patients: a prospective study of 9860 patients. *North American journal of medical sciences*, *6*(9), p.450.

Strehlow, M.C., 2010. Early identification of shock in critically ill patients. *Emergency Medicine Clinics*, *28*(1), pp.57-66.

Spahn, D.R., Bouillon, B., Cerny, V., Coats, T.J., Duranteau, J., Fernández-Mondéjar, E., Filipescu, D., Hunt, B.J., Komadina, R., Nardi, G. and Neugebauer, E., 2013. Management of bleeding and coagulopathy following major trauma: an updated European guideline. *Critical care*, *17*(2), p.R76.

Etxaniz, A. and Pita, E., 2015. Management of bleeding and coagulopathy following major trauma. *Revista Española de Anestesiologia y Reanimacion*, *63*(5), pp.289-296.

Chawda, M.N., Hildebrand, F., Pape, H.C. and Giannoudis, P.V., 2004. Predicting outcome after multiple trauma: which scoring system?. *Injury*, *35*(4), pp.347-358.

Rahmani, F., Ebrahimi Bakhtavar, H., Shams Vahdati, S., Hosseini, M. and Mehdizadeh Esfanjani, R., 2017. Evaluation of MGAP and GAP trauma scores to predict prognosis of multiple-trauma patients. *Trauma Monthly*, *22*(3), p.e100073.

Guzzo, J.L., Bochicchio, G.V., Napolitano, L.M., Malone, D.L., Meyer, W. and Scalea, T.M., 2005. Prediction of outcomes in trauma: anatomic or physiologic parameters?. *Journal of the American College of Surgeons*, *201*(6), pp.891-897.

Maurer, L.R., Bertsimas, D., Bouardi, H.T., El Hechi, M., El Moheb, M., Giannoutsou, K., Zhuo, D., Dunn, J., Velmahos, G.C. and Kaafarani, H.M., 2021. Trauma outcome predictor: an artificial intelligence interactive smartphone tool to predict outcomes in trauma patients. *Journal of Trauma and Acute Care Surgery*, *91*(1), pp.93-99.

Cook, A.C., Joseph, B., Inaba, K., Nakonezny, P.A., Bruns, B.R., Kerby, J.D., Brasel, K.J., Wolf, S.E., Cuschieri, J., Paulk, M.E. and Rhodes, R.L., 2016. Multicenter external validation of the Geriatric Trauma Outcome Score: a study by the Prognostic Assessment of Life and Limitations After Trauma in the Elderly (PALLIATE) consortium. *Journal of trauma and acute care surgery*, *80*(2), pp.204-209.

Zhao, F.Z., Wolf, S.E., Nakonezny, P.A., Minhajuddin, A., Rhodes, R.L., Paulk, M.E. and Phelan, H.A., 2015. Estimating geriatric mortality after injury using age, injury severity, and performance of a transfusion: the geriatric trauma outcome score. *Journal of palliative medicine*, *18*(8), pp.677-681.

Knaus, W.A., Wagner, D.P., Draper, E.A., Zimmerman, J.E., Bergner, M., Bastos, P.G., Sirio, C.A., Murphy, D.J., Lotring, T., Damiano, A. and Harrell Jr, F.E., 1991. The APACHE III prognostic system: risk prediction of hospital mortality for critically III hospitalized adults. *Chest*, *100*(6), pp.1619-1636.

Sammy, I., Lecky, F., Sutton, A., Leaviss, J. and O'Cathain, A., 2016. Factors affecting mortality in older trauma patients—a systematic review and meta-analysis. *Injury*, *47*(6), pp.1170-1183.

Xu, D., Yin, L.X. and Luo, P., 2017. Factors affecting mortality in older trauma patients–A systematic review and meta-analysis. *Injury*, *48*(6), p.1275.

Ganter, M.T., Geisen, M., Hartnack, S., Dzemali, O. and Hofer, C.K., 2018. Prediction of fluid responsiveness in mechanically ventilated cardiac surgical patients: the performance of seven different functional hemodynamic parameters. *BMC anesthesiology*, *18*(1), p.55.

Grigorescu, B.L., Azamfirei, L., Bora, S., Bica, D., Săplăcan, I., Gergo, R. and Veres, M., 2026. Physiological Data Integration and Predictive Modelling in Intensive Care. *Life*, *16*(8), p.1254.

Diana, G., 2026. NON-INVASIVE ASSESSMENT OF VASCULAR HEALTH USING PHOTOPLETHYSMOGRAPHIC SENSORS: From In Vitro Arterial Stiffness to In Vivo Vascular Aging Characterization.

van der Sluijs, K.F., Tuip-de Boer, A.M., de Beer, F.M., Bos, L.D., Straat, M., Wieske, L., van Vught, L.A., Huson, M.A., Horn, J., Schultz, M.J. and Wieland, C.W., 2013. WHOLE BLOOD MICRORNA PROFILING REVEALS POTENTIAL BIOMARKERS OF SEPSIS. *Cutting-edge Research_*, *380*, p.437.