REVIEW ARTICLE

Trauma severity predictors

Preditores de gravidade no trauma

André Luís Antoneli Senju[1], Giovanna Cristina Conti Machado-Kayzuka[2], Luís Expedito Sabage[3], Carlos Antonio Negrato[3], Aguinaldo César Nardi[3], Cezar Kayzuka Cotta Filho[4], Alessandra Mazzo[3]

Highlights

- Trauma is the major cause of quality-of-life loss, for patients and their families, due to the profound economic and social impacts it causes.
- Predict indexes and trauma scores have been studied for over 30 years.
- Physiological variables can be obtained through routine laboratory tests, suggesting the degree of a patient's metabolic severity, such as Base Excess (BE), fibrinogen and other biomarkers.
- Predictor indexes in trauma include anatomical characteristics, physiological, and laboratorial parameters, such as GAP (Glasgow, Age, and Pressure), Injury Severity Score (ISS) and Injury Severity Score (TRISS), performing a complete physiological screening.
- The solidification of gravity indexes may determine the prognosis of the patient, being possible to effectively predict mortality.

ABSTRACT

This review aimed to determine which are the indexes for early detection and evaluation of clinical and physiological deterioration of traumatized patients. A Scoping Review according to the methods proposed by Joanna Briggs Institute (JBI) was performed from February 2018 to December 2018 on LILACS (Literatura Latino-Americana e do Caribe em Ciências da Saúde), National Library of Medicine (PubMed), and SCOPUS databases. Sixty-two studies were included, of which 43 evaluated patients with general trauma. A variety of physiological variables, such as Glasgow Coma Score, Glucose, Days in the Intensive Care Unit, Lactate, and predictor indexes - Injury Severity Score (ISS), Trauma Injury Severity Score (TRISS), Revisited Trauma Score (RTS), and APACHE II were identified. The values observed in the studies among patients were compared to the ones determined by the basic literature, being called Critical Values (CV). The group of gravity indexes, besides clinical and regulatory protocols, found in this review are the solidification of the healthcare process involving the traumatized patient's responses to the actions of the healthcare team. The analysis of these indexes must be emphasized to determine, with greater reliability, the prognosis of the patient. With these data, it may be possible to effectively predict mortality rates.

Keywords: Trauma severity indices, Trauma, Injuries, Biomarkers, Patient scuity, Scoping review.

RESUMO

O objetivo desta revisão é determinar os índices para detecção precoce e avaliação clínica e fisiológica para deterioração de pacientes do trauma. Conduziu-se uma revisão de escopo de acordo com os métodos propostos pelo *Joanna Briggs Institute* (JBI) entre fevereiro de 2018 a dezembro de 2018 nas bases de dados LILACS (Literatura Latina-Americana e do Caribe em Ciências da Saúde), *National Library of Medicine* (PubMed) e SCOPUS. Foram incluídos 62 estudos, dos quais 43 sobre trauma geral. Encontrou-se grande diversidade de variáveis fisiológicas, como Escala de Coma de Glasgow, Glicose, dias em Unidade de Terapia Intensiva, lactato e índices preditores—*Injury Severity Score (ISS), Trauma Injury Severity Score (TRISS), Reviseted Trauma Score (RTS) e APACHE II*. Os valores observados nos pacientes dos estudos encontrados foram comparados com os da literatura básica, sendo denominados Valores Críticos (CV). O grupo de índices de gravidade encontrados neste estudo, além de protocolos reguladores e clínicos, são a solidificação do processo de cuidado envolvendo a resposta das ações da equipe em saúde ao paciente de trauma. A análise desses índices deve ser enfatizada para determinar com maior confiabilidade o prognóstico do paciente. Com esses dados, pode ser possível predizer a taxa de mortalidade com maior acurácia.

Palavras-chave: Índices de gravidade do trauma, Trauma, Lesões acidentais, Biomarcadores, Gravidade do paciente, Revisão de escopo.

[1] University of São Paulo. São Carlos School of Engineering. São Carlos, (SP), Brazil.
[2] University of São Paulo. Ribeirão Preto School of Nurse. Department of Public Health, (SP), Brazil.
[3] University of São Paulo. Medical Course of Bauru, (SP), Brazil.
[4] University of São Paulo. University of São Paulo. Department of Pharmacology, (SP), Brazil.

https://doi.org/10.11606/issn.2176-7262.rmrp.2023.203111

INTRODUCTION

Due to the current epidemiology of trauma, in the last decades, the scenario of care for this condition has, at a worldwide level, undergone necessary changes regarding procedures, evaluation, and quality of services[1].

Trauma is defined as any damage or injury, blunt or penetrating, caused intentionally or not, by external agents such as vehicle crashes, bladed weapons, or firearms. It is the leading cause of death among young people from 1 to 44 years, mostly male, being 25 to 50% of these deaths completely preventable[2,3].

When these patients are admitted to the emergency rooms, they must be quickly and fully evaluated in order to determine the severity of the injury, their prognosis, and how life-threatening the trauma is. Therefore, pre-hospital care should have a brief but effective investigation on the mechanisms of trauma, anatomical regions that were affected and finally, patient stabilization should be achieved as soon as possible[4].

In-hospital evaluation can be done at different moments, such as on admission, after the establishment of a diagnosis, and even during the clinical evolution of a previously defined clinical case. This evaluation is made by trauma indexes, which investigate, in their entirety, through several predictors - such as vital signs and commitment of anatomical regions - the severity of the trauma and the probability of survival of these patients[5].

The services must be individually planned and tailored according to each case; in addition, it is necessary to make a thorough selection of human and material resources available. For the success of the treatment and the improvement of a patient's prognosis, it is also essential the investigation by the first care team of the mechanisms of such trauma so that possible injuries can be identified and treated immediately, allowing the in-hospital team to take prompt action at the time of admission[4].

Some studies have clearly defined the appearance of a Systemic Inflammatory Reaction Syndrome (SIRS) in the evolution of patients with polytrauma[6] due to the fact that this condition can lead to a "serial" failure of vital organs (Multiple Organ Failure Syndrome - MOFS) and cause death. Some studies point to multiple organ failure as the main cause of death that occurs in the first days after trauma[7].

When the Abbreviated Injury Scale (AIS), the first trauma prediction index, emerged in 1971, as well as those that followed it, such as the Injury Severity Score (ISS), the focus of the evaluation was on patient's anatomy. However, with the sharp increase in the number of trauma cases and, mainly with an increase in mortality rates among these patients, it became necessary to identify other possible predictors that also focused on the physiology of the patient instead of only on patient's anatomy, going far beyond vital signs[8].

The role of former predictors was then discussed: were they evaluated in the right way and at the right time? Or, were these predictors that were considered as a gold standard sufficient to estimate the survival of traumatized patients and, consequently, guide better trauma management?[1,9]. Among the various findings regarding this topic, it was concluded that using only vital signs as a prognosis prediction tool might underestimate the severity of a given patient, being more effective in performing more specific tests, such as gasometry, to determine the percentage of available oxygen in the traumatized patient's body. Another frequently used predictor, the Glasgow Coma Scale, used since 1970 to predict the prognosis of patients, began to have a more specific focus regarding airway management, the need for neuroimaging, and the prediction of the length of stay of patients in the hospital or in emergency services[9,10].

However, far beyond the review of existing indexes, researchers developed and incorporated new predictors for trauma patients, which can be obtained through routine laboratory tests, such as fibrinogen, whose low serum levels are capable of determining massive bleeding and/or Base Excess (BE), whose indicative values of low tissue perfusion may suggest the degree of a patient's metabolic severity[4,11]. Since the last decade, new predictors were associated with those scores, which did consider not only anatomical characteristics but also physiological and laboratory parameters, such as GAP (Glasgow, Age, and Pressure)[2], Mechanism GAP (MGAP)[2], Injury Severity Score (ISS)[12], New ISS (NISS)[13], Trauma Injury Severity Score (TRISS)[5,14], and Revisited Trauma Score (RTS)[15].

The importance of performing a complete physiological screening, with a complete physical examination, laboratory tests, and trauma indexes must be emphasized to determine, with greater reliability, the prognosis of the patient. With these data, it is possible to know more precisely the metabolic profile of these patients, which is the most effective predictor of mortality[1,4].

In developing countries, such as Brazil, the use of trauma indexes is not so frequent, and this fact reflects in the high rates of in-hospital deaths and patients' long lengths of stay. According to World Health Organization (WHO), more than 90% of trauma cases arriving in health care emergencies will end in patients' death, which clearly illustrates the need to rethink the way trauma care is offered and the need for more research in this field[2,3,16]. Consequently, it will be possible to identify what attitudes and clinical approaches need to be changed in order to avoid preventable consequences and find out how the team must improve as a whole[3].

Since trauma is the major cause of quality of life loss, for patients and their families, due to the profound economic and social impacts it causes, and also the cause of a large percentage of avoidable deaths, mostly in young people, it is necessary to change the ways these patients are assessed, updating and using all available resources, including the prognosis indicated by the predictors[3,4]. Thus, the present review aimed to determine which are the indexes for early detection and evaluation of clinical and physiological deterioration of traumatized patients.

METHODS

This literature review was conducted according to the method proposed by Joana Brigs Institute (JBI) on Scoping Reviews[17]. This kind of review consists of mapping main concepts, clarifying research areas, and identifying knowledge gaps through feasibility, significance, and adjustments of health care practice. All search and publications access were performed from February 2018 to December 2018.

The guiding question, "Which critical values and predictors are used in order to determine patients' severity?" was defined for the search and selection of the studies. This question was built using the PICO strategy, which consists of a mnemonic method for the words Patient, Intervention, Comparison, and Outcome[18]. In this way, "P" was defined as patients, "I" as critical values and predictors, "C" was not included, and "O" as patients' severity.

For the literature search, descriptors and their synonyms were used according to Medical Subject headings (MeSH). The controlled descriptors were: "patients", "trauma", "predictive value of tests", and "severity of illness index". The Boolean operators AND, NOT and OR were used between descriptors. Not controlled descriptors were "patient", "injury OR injuries", "critical values", "predictive model", "risk of mortality" and "severity".

For analysis purposes, we included research performed with trauma victims that addressed the critical values and predictors used to determine their severity, which may be of a quantitative and/or qualitative focus that answered the guiding question, regardless of the area of knowledge to which it was linked. Secondary studies, non-scientific studies, information from websites, advertisements in the media and research found in duplicate in different databases were excluded.

The search was performed on LILACS (*Literatura Latino-Americana e do Caribe em Ciências da Saúde*), National Library of Medicine (PubMed) and SCOPUS databases. Included articles were exclusively original studies and reviews, written in English and published in indexed sources.

After the search and selection, the studies were analyzed with the help of an instrument built by the authors according to JBI instructions, with the identification of the publication database, journal, authors' names, country, year of publication, study area, objectives, methods, samples, main results, and conclusions. For the results presentation, publications were called studies and ordered from 1 to 62 in decreasing chronological order.

RESULTS

Following a database search, 4,143 potential studies were identified. After reading the title, abstract, and keywords, 89 studies were selected, and three were excluded for being also found in more than one database. The full texts of the 86 remaining articles were read, and 25 were excluded for not answering the guiding question. Another study was included after reading the references of selected articles. Using the described methodology, a literature search found 62 articles that met all criteria. This process is shown in Figure 1.

Our sample comprised 62 (100%) studies, of which 60 (96,77%) were from the medical area and two (3,23%) had an interdisciplinary approach. These studies were published from 1987 to 2017 and were conducted with patients from Europe, Asia, Africa, and America. Three studies were from Brazil. Many studies (25.8%) were performed between 2013 and 2017. Regarding the study method, the majority

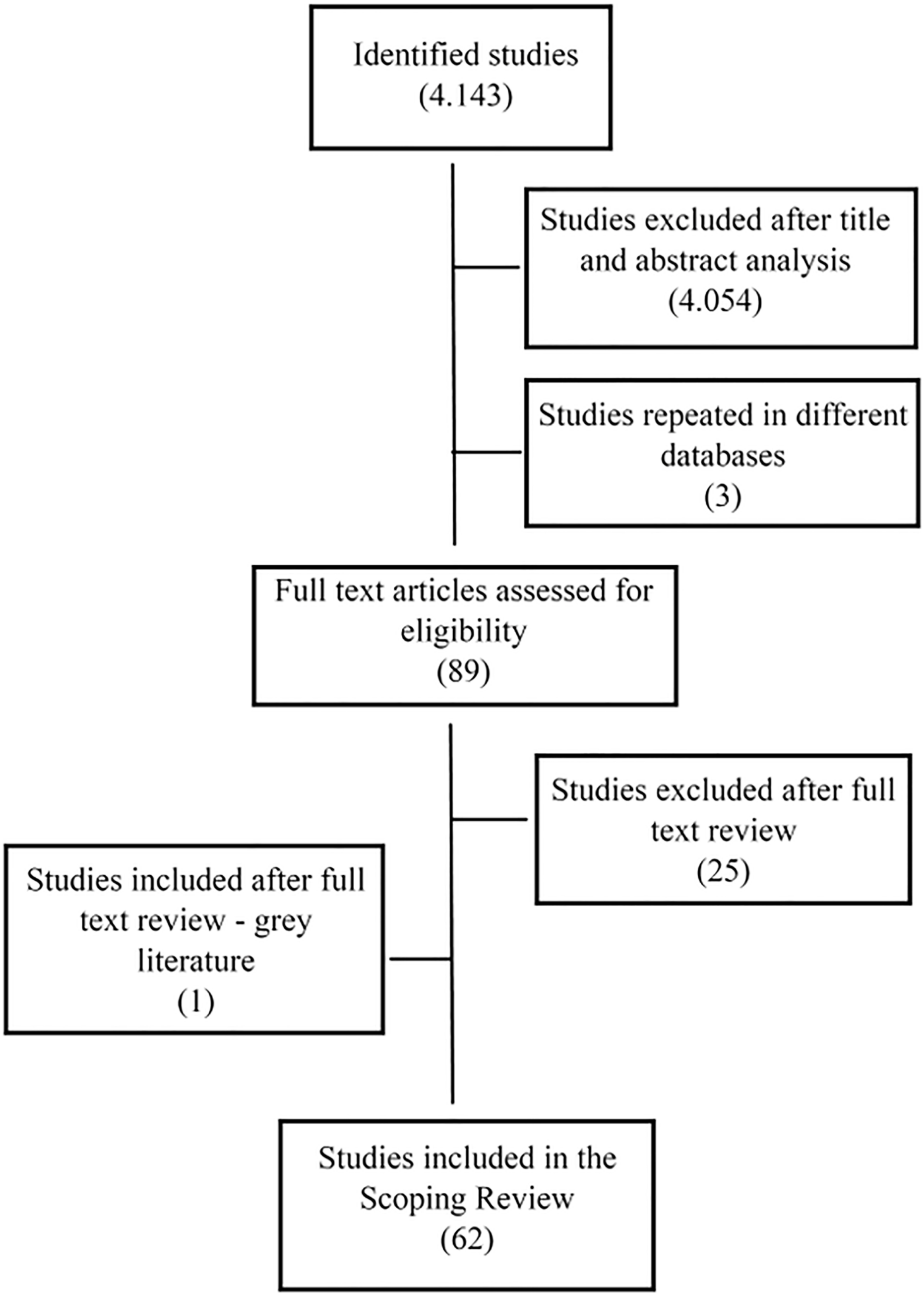

Figure 1. Flowchart of the selection and inclusion process of articles.

of them, 42 (67,7%) were descriptive, 16 (25,8%) were methodological, three (4,8%) were narrative reviews, and one (1,6%) was a clinical trial. Regarding sample characteristics, 43 (68,3%) studies evaluated patients with general trauma, five (8,0%), patients with polytrauma, five (8,0%), patients with trauma admitted to Intensive Care Units, four (6,4%), patients with specific trauma categories, two (3,2%), patients with other severe types of trauma, and three (4,8%), articles did not present the trauma specificity since they were narrative reviews. Studies identification, year of publication, country, authors, sample size, method, and trauma category are shown in Table 1.

Table 1

Included studies according to year of publication, country, authors, sample size, method and trauma category.

YEAR	COUNTRY	AUTHORS	METHOD	SAMPLES	TRAUMA	References
2017	Japan	ISHIKAWA et al.	RDS	151	General trauma	[19]
2016	USA	WEEKS et al.	PDS	4,716	General trauma	[8]
2016	Netherlands	LAM et al.	PMS	3,737	General trauma	[5]
2016	Iran	SALEHPOUR et al.	PDS	80	Traumatic Brain Injury	[20]
2016	Czech republic	BEITL	PDS	93	Polytrauma	[21]
2016	Egypt	SAAD et al.	RDS	282	Polytrauma	[22]
2015	Japan	OHMORI et al.	RDS	252	General trauma	[23]
2015	USA	DEZMAN et al.	PDS	18,304	General trauma	[9]
2015	England	RAIMUNDO et al.	RDS	790	Acute kidney injury	[24]
2015	USA	BROWN et al.	RMS	33	General trauma	[25]
2014	Tunisia	KAHLOUL et al.	PDS	1,136	General trauma	[26]
2014	USA	PARSIKIA et al.	RDS	1,941	General trauma	[27]
2014	England	HAGEMO et al.	PDS	1,133	General trauma	[11]
2014	Turkey	AHUN et al.	PDS	100	Severe trauma	[2]
2014	Singapore	HAN et al.	PDS	300	Traumatic Brain Injury	[28]
2013	USA	MAJERCIK et al.	RDS	9,583	General trauma	[29]
2012	USA	GOODMANSON et al.	RDS	104,015	General trauma	[30]ww
2011	Australia	MITRA et al.	RMS	1,680	General trauma	[31]
2010	USA	BAHRAMI et al.	RDS	72	General trauma	[32]
2010	USA	FUEGLISTALER et al.	PDS	506	General trauma	[33]
2010	USA	SCHLUTER et al.	RMS	2,350,596	General trauma	[14]
2010	USA	BOCHICCHIO et al.	PMS	2,200	Intensive Care Unit Patients	[34]
2009	Switzerland	KREUTZIGER et al.	RMS	1,675	Polytrauma	[35]
2009	USA	JASTROW et al.	PDS	48	General trauma	[36]
2009	USA	BEILMAN et al.	PDS	359	General trauma	[37]
2009	USA	DOSSETT et al.	PDS	1,019	General trauma	[38]
2009	USA	CANNON et al.	RDS	2,445	General trauma	[39]
2008	USA	DOSSETT et al.	PDS	991	General trauma	[40]
2008	Brazil	CALVETE et al.	PDS	40	General trauma	[41]
2008	USA	DUANE et al.	RDS	134	General trauma	[42]
2008	USA	OSLER et al.	RMS	702,229	General trauma	[43]
2008	India	HONARMAND et al.	PDS	110	General trauma	[44]
2008	USA	WAHL et al.	CT	531	Intensive Care Unit Patients	[45]

2008	USA	GIANNOUDIS et al.	PDS	48	General trauma	[46]
2007	USA	BOCHICCHIO et al.	PDS	896	General trauma	[47]
2007	Switzerland	FISCHLER et al.	PDS	960	Traumatic Brain Injury, and Polytrauma	[48]
2006	USA	BOUAMRA et al.	RMS	100,399	General trauma	[49]
2006	USA	MOORE et al.	RDS	22,388	General trauma	[15]
2005	USA	SUNG et al.	PDS	1,003	Intensive Care Unit Patients	[50]
2004	Austria	REITER et al.	PMS	5,538	Intensive Care Unit Patients	[51]
2004	USA	MILLER et al.	RDS	516	Intensive Care Unit Patients	[52]
2003	USA	YENDAMURI et al.	RDS	738	General trauma	[53]
2003	USA	MACLEOD et al.	RDS	20,103	General trauma	[54]
2003	France	CEROVIĆ et al.	PDS	98	Severe trauma	[55]
2003	Brazil	WHITAKER et al.	RDS	1,533	General trauma	[13]
2003	Germany	HENSLER et al.	PDS	137	General trauma	[56]
2002	USA	KUHLS et al.	RMS	9,539	General trauma	[57]
2002	USA	CLARK et al.	RMS	2,646	General trauma	[58]
2002	USA	EL-MASRI et al.	RDS	190	General trauma	[59]
2001	Hong Kong	RAINER et al.	PDS	164	General trauma	[60]
2000	USA	BALOGH et al.	PMS	558	General trauma	[12]
2000	USA	RIXEN et al.	PDS	80	Polytrauma	[61]
2000	USA	DIRUSSO et al.	RMS	10,609	General trauma	[62]
1999	Germany	KERNER et al.	PDS	51	Polytrauma	[63]
1999	USA	HURR et al.	RDS	113	General trauma	[64]
1999	Brazil	JÚNIOR et al.	NR	-	-	[65]
1998	England	WYATT et al.	NR	-	-	[66]
1995	USA	MILHAM et al.	PMS	1,708	General trauma	[67]
1994	USA	SAUAIA et al.	PMS	8,838	General trauma	[68]
1993	USA	RUTLEDGE et al.	PDS	428	General trauma	[69]
1992	USA	VASSAR et al.	PMS	1,018	General trauma	[70]
1987	USA	BOYD et al.	NR	-	-	[71]

RDS: Retrospective Descriptive Study; PDS: Prospective Descriptive Study; PMS: Prospective Methodological Study; RMS: Retrospective Methodological Study; CT: Clinical Trial; NR: Narrative Review.

A variety of predictor indexes were identified. Tables 2 and 3 show the identification of studies according to the physiological variables and predictor indexes that were used. Among the analyzed studies, a relevant sample size with good results and conclusions was found, pointing to the effectiveness of the selected studies.

Several methodological studies use mathematical models for the prediction of clinical outcomes, using trauma indexes and physiological variables already known in medical practice but not statistically explored. In this sense, some variables were highlighted. Of the 15 tested variables, some showed a significant difference in the Critical Values (CV) found in the literature, separating survivors and non-survivors, and some did not show this difference (Table 4).

DISCUSSION

The use of predictors and critical values have been used in developed countries for a long time,

Table 2
Identification of the included articles according to the physiological variables of traumatized patients.

STUDY ID	VARIABLE	STUDY ID	VARIABLE
[19, 20, 23, 27, 38, 45, 52, 55, 57, 58, 61, 62, 67, 68]	Glasgow Coma Score	[23, 54]	Activated partial thromboplastin time
[20, 22, 34, 35, 42, 45, 47, 50, 52, 53]	Glucose	[24, 41]	Hemoglobin
[27, 33, 41, 50, 53, 55, 59]	Days in Intensive Care Unit	[24]	Oxygen saturation
[9, 21, 22, 24, 27, 42, 55, 61]	Lactate	[24]	Mean arterial pressure
[27, 33, 41, 50, 53, 59, 63]	Hospitalization time	[62]	Hematocrit
[11, 19, 22, 36, 52, 61, 68]	Base Excess (BE)	[29]	Red cell distribution width (RDW)
[9, 41, 58, 62]	Systolic arterial pressure	[68]	Bilirubin
[9, 41, 62, 63]	Heart rate	[56]	Procalcitonin
[11, 19, 23]	Fibrinogen	[56]	Neopterin
[23, 36, 54]	Prothrombin time / INR	[40]	Estradiol
[37, 38, 63]	Temperature	[41]	Partial pressure of carbon dioxide ($PaCO_2$)
[38, 41, 68]	Creatinine	[41]	Partial pressure of oxygen (PaO_2)
[27, 62]	Respiratory rate	[63]	Leukocytes
[36, 54]	Platelets		N-Terminal Pro-C-Type
[41, 67]	Arterial pH	[32]	Natriuretic Peptide (NT-proCNP)

helping to establish the severity of trauma in general and estimating the probability of survival according to clinical, physiological, and anatomical parameters. As shown in Figure 2, the Health Information System (HIS) has been the most widely used and internationally disseminated index; however, it depends on the interpretation of a qualified professional trained to perform this assessment[19].

In the bibliographic search for this study, it was possible to identify that such indexes have been used and scientifically explored since 1987, and in the last five years, there has been a growing interest in this topic, motivated by the great expansion of Electronic Health Records (EHR) that give a wider availability of patients' information[20]. Consequently, there has also been a growing implementation of HIS, which brings information and knowledge, enabling the improvement of the decision-making process of health professionals[21]. These two facts can also explain the increase in retrospective methodological studies from 2000 on, with the predominance of data exploitation made available by the many implemented EHR and HIS.

New indexes have emerged, which perform anatomical and physiological analyses, such as the Base deficit Injury Severity Score (BISS). Similarly, there is a growing body of scientific evidence, with an increase in descriptive studies that focus on the analysis of physiological variables through measurements of vital signs and laboratory tests, demonstrated in several studies that establish a starting point for proposing indexes, such as GAP, MGAP, ISS, NISS, TRISS, and RTS. Thus, confirming the previously highlighted evidence, these indexes were applied to this research sample, resulting in good levels of prognosis prediction, with emphasis on TRISS (AUC = 0.957).

The prothrombin time values are part of the routine check of the hematological system regarding coagulation, and evaluate the extrinsic coagulation pathway[22,23]. The procedure consists of three variables: prothrombin time (PT), control time (CT), and international normalized ratio (INR) – with a CV >1,2.

The Activated Partial Thromboplastin Time (APTT) refers to the time of thrombin clot formation after the exposure of the blood to the vascular wall collagen[22,23]. A CV >34s was found in our studies.

Another important clotting factor is platelets. Thrombocytopenia impairs coagulation and is usually present in the setting of critical patients with disseminated intravascular coagulation, which leads to multiple organ failure[22]. The CV for platelets was <101.000/mm^3.

Table 3
Identification of the included articles according to the predictor indexes of traumatized patients.

STUDY ID	TRAUMA SCORE	DEFINITION
[2, 8, 9, 11-13, 19, 23, 25-27, 29, 31-40, 42-45, 48, 50, 52, 53, 55, 57, 59-64, 67-69, 72]	Injury Severity Score (ISS)	Anatomic trauma score determined by physical examination, radiological tests, surgery, and autopsy.
[2, 5, 14, 22, 31, 33, 35, 38, 40, 49, 51, 55, 57, 67, 70, 72]	Trauma Injury Severity Score (TRISS)	Association between ISS and Revisited Trauma Score (RTS), combining physiological and anatomical parameters, age, and trauma mechanism.
[2, 8, 15, 26, 31, 33, 35, 41, 49, 55, 57, 67, 72]	Revisited Trauma Score (RTS)	Physiological trauma score determined by Glascow Coma Scale (GCS), systolic arterial blood pressure (SABP), and respiratory rate.
[24, 32, 34, 37, 38, 40, 41, 63, 64, 69, 70]	APACHE II	Physiological score used in the intensive care unit.
[15, 23, 33, 35, 43, 58, 64, 67]	Abbreviated Injury Scores (AIS)	Determined by injury severity and location. The body is divided into 6 parts and each injury is rated from 1 to 6 according to severity.
[12, 13, 26, 31, 44, 46]	New Injury Severity Score (NISS)	Determined by the 3 most severe injuries in polytraumatic patients.
[26, 32, 33, 48, 51]	SAPS II	Score for predicting mortality based on physiological parameters.
[24, 33, 41]	SOFA	Physiological score used in intensive care unit determined by fraction of inspired oxygen, partial pressure of oxygen (PaO2), mechanic ventilation use, platelet, bilirubin, GCS, SABP, creatinine, and urine volume.
[5, 35, 72]	A Severity Characterization of Trauma (ASCOT)	Determined by GCS, SABP, respiratory rate, and trauma mechanism.
[39, 55]	Shock Index	Score based on the ratio of heart rate and SABP.
[15, 55]	T-RTS	RTS variation, used for first screening.
[46]	SIRS	Determined by temperature, heart rate, respiratory rate, and neutrophils numbers
[2]	GAP (Glasgow, Age, Pressure)	Determined by GCS, age, and SABP.
[2]	MGAP (Mechanism GAP)	Extended version of GAP by considering the mechanism of trauma.
[5]	Base deficit and Injury Severity Score (BISS)	Determined by the association of RTS with indicators of physiological stress following injury.
[61]	Kampala Trauma Score (KTS)	Trauma score determined by age, SABP, respiratory rate, neurological assessment, and traumatic injuries severity according to AIS.
[69]	Trauma Score (TS)	Determined by physiological parameters, and used for first screening.
[22]	Acute Physiology And Chronic Health Evaluation IV	Evolution of APACHE. Includes comorbidities, mechanical ventilation use, PaO2, and oxygen inspired pressure.

[31]	Coagulopathy of Severe Trauma (COAST)	Evaluates the compression of nerves and blood vessels, temperature, SABP, abdominal internal trauma, and thoracic decompressions for identifying acute coagulopathy.
[48]	Mortality Probability Model (MPMII)	Evaluates neurological status, renal function, infections, mechanic ventilation use, prothrombin time, urine debt and use of vasoactive drugs.
[13]	IMPACT	Score for traumatic brain injury evaluation. Determined by age, GCS, pupillary reflex computed tomography (TC), and glucose and hemoglobin levels.
[13]	CRASH	Determined by age, GCS, pupillary reflex, injury severities, and TC.

Table 4
Comparasion chart of Critical Values (CV) between the results from the included articles (sample) and the basis literature.

Variable	Literature		Sample	
INR	1,2		1,2	
TTPA	> 38 s		> 34 s	
Platelets	< 150.000/mm^3		< 101.000/mm^3	
Fibrinogen	200 – 400 mg/dl		190 – 310 mg/dl	
Creatinine	-		> 1,2 mg/dl	
Lactate	-		> 2 mM/l	
Hemoglobin	< 12 g/dl		< 12 g/dl	
Hematocrit	< 35%		< 35%	
RDW	> 14,5%		> 12,3%	
pH	7,35 – 7,45		7,35 – 7,45	
BE	< -3 mEq/l		< -6 mEq/l	
PO_2	-		< 86 mmHg	
	ISS ≤ 8	9 < ISS <16	17 < ISS < 24	ISS ≥ 24
RR	> 21 ipm	< 18 ipm	-	< 17 ipm
Temperature	-	-	-	< 35°C
Glucose	-	> 170 mg/dl	> 170 mg/dl	> 170 mg/dl

INR: International Normalized Ratio; APTT: Activated Partial Trombloplastin Time; RDW: Red cell Distribution Width; BE: Base Excess; PO_2: Oxygen Pressure; RR: Respiratory Rate; ISS: Injury Severity Score; ipm: incursions per minute.

Fibrinogen level is another variable related to blood clotting factors that showed a statistically significant difference between the groups of survivors and non-survivors (CV <190 and >310mg/dl, respectively). This protein, produced in the liver, has an increased synthesis in response to injuries, infections, and inflammation in order to improve coagulation and is transformed into fibrin when combined with thrombin. However, extremely high levels of fibrinogen can trigger a condition of disseminated intravascular coagulation, which is also related to thrombocytopenia[24].

On the other hand, clinical conditions that present afibrinogenaemia predisposes patients to bleed and hemorrhages[24]. Thus, there is a need for rigid control of fibrinogen levels, which are metabolized in the liver. In addition, the hepatic function should be evaluated through the measure of direct and total bilirubin levels. Some studies conducted with traumatized patients found an increase in bilirubin levels that were related to liver failure. However, bilirubin levels were tested between groups of survivors and non-survivors, and no statistically significant differences were found[25].

The kidneys play an important role in human metabolism, and consequently, the evaluation of renal function is crucial in clinical practice and in traumatized patients. Among known renal function biomarkers, high creatinine levels indicate renal dysfunction, which is related to systemic failure, and even death[26]. The CV for creatinine was >1,2mg/dl. Lactate is another important biomarker of kidney function. It is produced by several types of cells and is found to be increased when inadequate oxygen levels are present; it is excreted by the kidneys and high levels are found when renal failure is present and also in cases of hypoxia and lactic acidosis[27]. The CV found for lactate was >2mM/l.

Regarding oxygen transport, the main blood component involved is hemoglobin, and the monitoring of its levels can be used to determine oxygen transport efficacy. The CV found (<12g/dl) was a good predictor between survivors and non-survivors. The hematocrit values are obtained by the percentage of erythrocytes in the total blood and are also indicators of the hemoglobin levels and, therefore, can be used to evaluate the availability of oxygen transport and CV <38% are related to poor prognosis[28].

Some physiological conditions can present alterations in the color, shape, and size of red blood cells, which may indicate specific types of anemia. One of these conditions, iron deficiency anemia, is a consequence of inadequate iron levels that are related to several clinical conditions. Iron deficiency can impair hemoglobin formation resulting in the synthesis of smaller red blood cells[29]. The measure of red blood cells size variation is called the Red cell Distribution Width (RDW), whose CV is >12,3%[30]. Anemia is characterized by below-normal circulating erythrocyte mass, which impairs oxygen transport capacity[29]. Thus, when the RDW values are high, generally above 14.5%, the patient has macrocytic anemia, and when below 80%, it indicates the presence of microcytic anemia, leading to a reduction in the effective oxygen transport[31].

Carbon dioxide (CO_2) is another important gaseous component measured in arterial blood that is commonly performed for patient monitoring. The measure of CO_2 levels allows the evaluation of changes in the chemical balance of the body due to acidosis or alkalosis. Acidosis is present when low pH levels are found, and alkalosis, when high levels are present. Normal pH levels range from 7.35 to 7.45. Acidosis and alkalosis reflect changes in the body's homeostasis, resulting in protein denaturation. In order to avoid these unwanted effects, the organism itself is responsible for compensating for small variations through a bicarbonate buffer system[32].

BE is another important index obtained through the difference between the sum of all bases. The CV for BE is <-6mEq/l. The measure of BE allows the determination of retention or loss of bases. The levels of pH were found to be related to death prediction. The same occurs with oxygen pressure levels, which allows the assessment of oxygen exchange between the alveoli and capillaries and has shown to be a good prognostic indicator[33].

However, considering the compensatory mechanisms discussed above, fixed reference values are not enough to establish reliable prognostic estimates. Practical affiliations are known to exist between CO_2 pressure (PCO_2) and bicarbonate (HCO_3) concentrations, in which different ranges of normality for PCO_2 should be considered (CV <85mmHg), depending on different HCO_3 concentration values. In the same way, different mean values between groups of survivors and non-survivors regarding respiratory rate (RR) obtained different cutoff points for different levels of severity determined by the ISS (Table 4)[32,33].

As happens with RR, the patient's temperature showed a significant difference between the means of groups of survivors and non-survivors according to the severity determined by the ISS ≥24 CV <35ºC, respectively.

Ultimately, it is known that the metabolic response to stress caused by traumatic events can cause hyperglycemia. This rise is multifactorial, resulting from the release of glucose by the liver. However, some adverse effects are related to this increase, such as the association between hyperglycemia and with a higher propensity to infections and changes in immune functions[34]. In the studied sample, there was a difference between glycemic levels that resulted in death or discharge, ISS ≥9 (CV >170mg/dl). However, for mild hyperglycemia, classified according to the ISS, no significant differences were found (Table 4).

Study Limitations

Although the analysis of the results found points to the contribution of this study in the predictors of severity scores of the trauma patient, it is understood that its limitation is related to the evaluation of the three decades of published material since, with the advance of technology, trauma management has significantly changed and will keep changing in faster rates.

CONCLUSION

The clinical and regulatory protocols are guidelines that characterize the most frequent clinical trauma scenarios that appear in the various health services at different levels of care and define the criteria and resources to be used for referral of patients among the health services network aiming to reduce the risk of preventable deaths and the risks of temporary or permanent sequelae due to the loss of the optimal therapeutic window.

Added to the physiological indexes and variables, these protocols assist in the definition of therapies in different services that set up the care network. In effect, the health care process involves a series of medical decisions, and the statistical algorithm is a solidification of how these decisions should be ordered, prioritized, and addressed to certain specific conditions of the patient, thus defining the appropriate behaviors and the expected response of actions for the best prognosis.

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Acknowledgments:
Acknowledgment for the Interunit Graduate Program in Bioengineering - EESC-IQSC-FMRP - University of São Paulo for the support as a master's student and Foment by CAPES.

Declaration of interest:
The authors declare no conflicts of interest.

Authors' contribution:
Conceptualization: ALAS, AM; Data curation: ALAS, GCCM, LES, CAN, ACN; Formal analysis: ALAS, GCCM, LES, CKCF; Funding acquisition: ALAS, AM; Investigation: ALAS, GCCM, LES, AM; Methodology: ALAS, GCCM, AM; Project administration: ALAS, AM; Resources: ALAS, AM; Software: ALAS, GCCM, AM; Visualization: ALAS, GCCM, LES, CAN, CAN, CKCF, AM; Roles/Writing – original draft: ALAS, GCCM, LES, CAN, CKCF, AM; Writing – review & editing: ALAS, GCCM, LES, CAN, CAN, CKCF, AM; Supervision: AM; Validation: AM.

Corresponding Author:
Alessandra Mazzo
amazzo@usp.br

Editor:
Prof. Dr. Felipe Villela Gomes

Received in: oct 02, 2022
Approved in: nov 29, 2022
