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Performance of *Trauma and Injury Severity Score* (TRISS) adjustments: an integrative review

Desempenho dos ajustes do *Trauma and Injury Severity Score* (TRISS): revisão integrativa
Rendimiento de los ajustes de *Trauma and Injury Severity Score* (TRISS): revisión integrativa

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ABSTRACT

Objective: Identify studies that made adjustments to the equation of Trauma and Injury Severity Score (TRISS) and compared the discriminatory ability of both modified and original equations. **Method:** An integrative review of studies published between 1990 and 2014 using the following databases: LILACS, MEDLINE, PubMed and SciELO, based on searches using the term "TRISS". **Results:** 32 studies were included in this review. Of 67 adjustments to TRISS equations identified, 35 (52.2%) resulted in improved accuracy of this index in the prediction of survival probability for trauma patients. Adjustments of TRISS coefficients to study population were frequent, but did not always improve the predictive ability of the analyzed models. Replacement of physiological variables of the Revised Trauma Score (RTS) and changes in the Injury Severity Score (ISS) in the original equation presented varied performance. An alteration to the method of age inclusion in the equation, and the insertion of gender, comorbidities and trauma mechanism, presented a tendency towards improved performance of the TRISS. **Conclusion:** Different proposals of adjustments to the TRISS were identified in this review and indicated, in particular, RTS fragilities in the original model and the need to change the method of age inclusion in the equation to improve the predictive ability of this index.

DESCRIPTORS

Trauma Severity Indices; Wounds and Injuries; Outcome Assessment; Quality of Health Care; Review.

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INTRODUCTION

Trauma is a pandemic public health problem, accounting for 5 million deaths a year worldwide[1-2]. In Brazil, according to data from the Ministry of Health, in 2012, 152,013 people died due to injuries from external causes[3]. Improvements in the prevention of trauma and quality control of care systems to trauma patients have shown measurable and predictable effects in terms of saved lives and improved results[4]. The most effective methods to control the results of care systems for trauma patients are through Quality Improvement Programs, whose databases have trauma records with the utilization of severity scores[5].

Severity scores in trauma are screening or prognostic evaluation systems based on physiological alterations and/or anatomical injury to the patient. An evaluation of these scores allows for the estimation and analysis of the survival probability (Ps) of the patient and for the comparison of results in a care service or between different care services, when analyzing the quality of service provided[6].

Currently, the most common trauma severity scores, obtained from information provided by the patient, are grouped into three categories: anatomical scores, for example, the Abbreviated Injury Scale (AIS)[7] and the Injury Severity Score (ISS)[8]; physiological scores, for example, the Revised Trauma Score (RTS)[9]; and mixed scores, which use both anatomical and physiological scores, such as the Trauma and Injury Severity Score (TRISS) [10].

The TRISS was developed by the American College of Surgeons, based on a study started in 1982 and published in 1990, titled Major Outcome Study (MTOS), to provide a mathematical method of Ps calculation for a patient or a population after a serious trauma and also to allow the comparison of patient mortality from different hospital centers and service systems, classifying trauma patients according to differences in trauma severity [10-12].

The TRISS calculation uses RTS and ISS and considers the patient age and type of trauma – blunt or penetrating[9-10]. The RTS, a physiological score, considers information from the following values: the Glasgow Coma Scale (GCS), systolic blood pressure (SBP) and respiratory rate (RR) at patient admission. This index is calculated by adding up the results of the values from these three components and multiplying them by their respective weights[9-10].

The ISS is an anatomical index that calculates trauma severity; it is based on the AIS [7]. To obtain the AIS values, one manual of anatomical descriptors of injury is used, which determines, in a scale of one (minor injury) to six (maximal, usually fatal, injury), the severity of a traumatic injury, according to the body region. The ISS considers six body regions (head and neck, face, thorax, abdomen or pelvic content, extremities or pelvic girdle, external surface) and the sum of the squared value of the highest AIS values from three distinct regions defines the final score of the ISS[8].

The Ps value from the TRISS is calculated by using the equation: $Ps=1/(1+e^{-b})$, where "e" is the Neperian logarithm base and "b" is taken from the formula that considers the values of RTS, ISS, age (<55 or ≥55 years) and distinct coefficients according to the type of trauma (blunt or penetrating)[10].

The development of TRISS and the MTOS represented an important improvement in the quality assessment of the care service provided to trauma patients, making this score a gold standard in the assessment of results from service provided to trauma patients[10-13]. Yet, limitations are identified in TRISS, particularly involving its components and coefficient calculation. Considering this fact, investigators have proposed alterations to this index in an attempt to improve its accuracy in Ps calculation[14-17].

Considering the importance of TRISS as an instrument to improve the quality of care provided to trauma patients and the variations proposed in the scientific literature to this score in an attempt to improve its accuracy, an integrative review was conducted to identify and analyze studies that have made adjustments to the original equation of TRISS and compared the discriminatory ability of both the modified and original equation in survival prediction.

METHOD

This was an integrative review of the literature, whose data search was conducted in the following databases: Latin-American and Caribbean Center of Information on Health Sciences (LILACS), Medical Literature Analysis and Retrieval System Online (MEDLINE), PubMed and Scientific Electronic Library Online (SciELO), using the term "TRISS".

The inclusion criteria for studies in this review were: studies related to TRISS, published in full between 1990 (year of TRISS publication) and 2014, in English, Portuguese or Spanish. This review excluded book chapters, doctoral and master's degree theses, articles of literature review and updates.

First, a search was conducted in the databases and duplicate studies were eliminated. After this phase, the titles, abstracts and full publications were read by two reviewers, independently, and a third reviewer was consulted in case of any disagreement in study selection. In the abstract analysis phase, when the information was not sufficient for a decision, the study was kept for full article reading.

Studies were excluded which, after reading the titles, abstracts and full articles, had the following classification: application of original TRISS as survival predictor, comparison of TRISS performance to that of other scores and proposals of TRISS variations without any comparison to the original equation from the MTOS[10,12].

The following information was collected from the studies selected for the final sample: year, country and idiom of publication, site where the study was conducted, design (retrospective and/or prospective) and coverage (national, international or institutional multi-center), data coverage period, data source (database, hospital and/or pre-hospital records), type of trauma in the analyzed casuistry (blunt, penetrating or both), target population (adult, pediatric or both) and sample size. In addition, adjustments to TRISS and results from comparisons were identified and classified as better, equivalent or worse, in relation to the original equation, according to the conclusion of each study.

Data were inserted in a Microsoft Excel® 2010 spreadsheet, submitted to descriptive analysis and the synthesis of results is presented in tables and a box, and in the form of a narrative. It was not possible to conduct a meta-analysis due to heterogeneity of TRISS equation adjustments found in the literature.

RESULTS

Based on searches in databases and application of eligibility criteria, 32 studies were included in the present review. Figure 1 presents the flowchart of study selection.

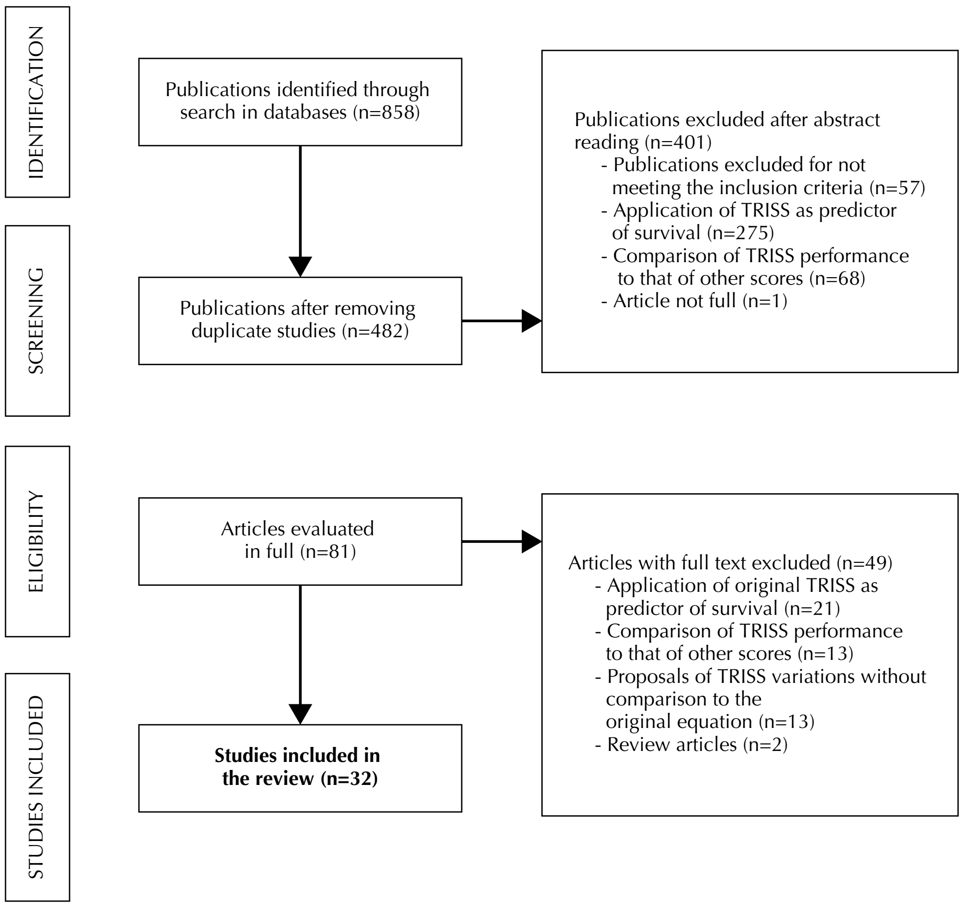

Figure 1 - Flowchart of study selection according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

In the 5-year distribution of articles for this review, a homogeneous number of publications was seen in the analyzed periods, except for the period between 2006 and 2010, when an increase was seen in the number of publications with proposed alterations to TRISS. Most studies were conducted and published in the United States[14,21,23,25,27-29,31-32,34-39,42-45]; so English was the most frequent language of the publications[14-16,18-45].

The descriptive analysis of all 32 articles included in this review is presented in the following tables and box[14-45].

Table 1 - Distribution of studies (n=32), according to the method characteristics, databases: LILACS, MEDLINE, PubMed and SciELO, 1990-2014.

Method characteristics	N	%
Study design		
Retrospective	28	87.5
Prospective	3	9.4
Prospective / Retrospective	1	3.1
Data source		
Database	26	81.3
Database and hospital records	1	3.1
Hospital records	4	12.5
Pre-hospital and hospital records	1	3.1

Method characteristics	N	%
Study coverage		
Institutional	9	28.1
International multi-center	3	9.4
National multi-center	20	62.5
Data coverage period		
≤5 years	22	62.8
>5 and ≤10 years	7	21.9
>10 and ≤15 years	1	3.1
>15 years	1	3.1
Not informed	1	3.1

Table 1 shows predominance of retrospective (87.5%)[(14-16,19-32,35-45)] national multi-center studies (62,5%)[(18-20,22-23,25-33,35,38,41-42,44-45)], using databases as sources (81.3%)[(19-33,35-45)] and covering up to 5 years (62.8%)[(14-16,18,20-21,25-28,30-36,40-43,45)].

Most studies (56.3%) included blunt and penetrating trauma patients[(15,17-20,23,26-28,31,34,36-38,42-45)], followed by patients with blunt trauma only (40.6%)[(14,21-22,24-25,29-30,32-33,35,39-41)]. No study addressed penetrating trauma only. The most common population was of adult patients (n=18; 56.3%)[(14-18,20,22,24-25,29-30,32,35-36,38-39,42-43)], followed by mixed adult and pediatric patients (n=6; 18.8%)[(23,26-28,31,37)]. The sample size of studies ranged from 34 to 2,350,596 individuals; the most frequent samples had over 10,000 patients (40.6%)[(22-23, 27-29, 32, 39-45)].

According to the alterations proposed in the original equation of TRISS, the studies presented one to ten new equations. However, predominance was observed of studies proposing only one modified equation (43.8%)[(14-17, 22, 25-26, 29, 31, 34-35, 37-38, 43)].

In the analysis of 83 adjustments of equations, 16 of them were elaborated for specific patient groups, such as patients with abdominal trauma, head trauma and intubated patients. These equations[(23, 27-28, 31-34, 36, 38, 45)] were not included in the analyses of this study due their specificity. Of total equations analyzed (n=67), 52 (77.6%) replaced the original equation coefficients[(14,19-26,32,35-37,39-41,43-45)], 42 (62.7%) changed the physiological variable[(14,18-20,22-23,25,29,36-37,39-43,45)] and 31 (46,3%) changed the anatomical variable[(15-17,22-25,32,36-37,39,41-44)]. New variables were included in 10 (14.9%) equations[(21-24,30,37,39-40,42-43)] and new proposals of age insertion was observed in 26 (38.8%)[(19,21-25,30,39-40,42-43)].

Table 2 shows the performance of these 67 equations according to the alterations made. A better performance in relation to the original TRISS was observed in 35 equations (52.2%), an equivalent performance in 29 (43.3%) and a worse performance in three (4.5%).

Table 2 - TRISS variations (n=67) according to adjustments in the equation and performance in relation to the original equation, databases: LILACS, MEDLINE, PubMed, SciELO, 1990-2014.

Adjustments to the equation	Performance in relation to the original equation*			Total
	Better	Equivalent	Worse	
Coefficients	3 (30.0%)	6 (60.0%)	1 (10.0%)	10
Coefficients+inclusion of variables	1 (100.0%)	-	-	1
Coefficients+physiological variable	3 (50.0%)	3 (50.0%)	-	6
Coefficients+anatomical variable	-	3 (100.0%)	-	3
Coefficients+age	2 (100.0%)	-	-	2
Coefficients+age+inclusion of variables	1 (100.0%)	-	-	1
Coefficients+physiological variable+anatomical variable	2 (25.0%)	5 (62.5%)	1 (12.5%)	8
Coefficients+physiological variable+anatomical variable+inclusion of variables	1 (50.0%)	-	1 (50.0%)	2
Coefficients+physiological variable+age	4 (80.0%)	1 (20.0%)	-	5
Coefficients+physiological variable+age+inclusion of variables	1 (100.0%)	-	-	1
Coefficients+physiological variable+anatomical variable+age	8 (88.9%)	1 (11.1%)	-	9
Coefficients+physiological variable+anatomical variable+age+inclusion of variables	2 (100.0%)	-	-	2
Coefficients+anatomical variable+age	-	1 (100.0%)	-	1
Coefficients+anatomical variable+age+inclusion of variables	1 (100.0%)	-	-	1
Physiological variable	-	7 (100.0%)	-	7
Physiological variable+anatomical variable+age	2 (100.0%)	-	-	2
Anatomical variable	2 (66.7%)	1 (33.3%)	-	3
Age	1 (100.0%)	-	-	1
Age+inclusion of variables	1 (100.0%)	-	-	1
Inclusion of variables	-	1 (100.0%)	-	1

*Extracted from the conclusions of analyzed publications

Table 2 shows adjustments to coefficients were very frequent in the equations; but these results did not show a clear tendency of improved performance of these models with this type of alteration: with adjustment made in coefficients only, the results showed improved performance in 3 out of 10 equations only; in combined alterations that included adjustment in coefficients, 26 (61.9%) out of 42 equations showed a better performance.

Regarding the adjustments in the physiological variable, isolated changes did not lead to improved performance of the model and combined alterations sometimes generated improvements (23 equations) and sometimes resulted in equivalent or worse performance in relation to TRISS (12 equations). Regarding the anatomical variable, among the three isolated changes proposed, two led to improved performance. All 28 combined alterations resulted in improved performance in 16 proposals (57.1%).

Age and the inclusion of new variables in the equations occurred at a lower frequency in the studies; however, they resulted in a better performance of the equations. The proposed change in age inclusion improved the performance of 23 (88.5%) out of 26 equations and the inclusion of new variables led to improvement in 8 (80.0%) out of 10 equations.

Gender was included in one equation, which presented a better performance than the original equation. Comorbidities were added as TRISS components in six adjustments, improving the ability to predict survival in five of these components and keeping the performance in the remaining component. Trauma mechanism was included as a component in three equations, replacing the adjustment to coefficients proposed in the original version of the score - this alteration to TRISS resulted in better performance in two equations and equivalent performance in one of them.

The characteristics of the alterations in 67 equations according to the performance are presented in the box below.

Box 1 - Physiological and anatomical variables and method of age inclusion in modified equations, according to the performance. Databases: LILACS, MEDLINE, PubMed and SciELO, 1990-2014.

	Performance of modified equations*		
Physiological variables	**Better[20,22-23,25,39-43]**	**Equivalent[14,18-20,23,29,36,41]**	**Worse[37,41]**
	-GCS+SBP+RR -GCS+SBP+RR as cubic splines -GCS+SBP+RR stratified in 10 categories -GCS as a continuous variable+SBP+RR -GCS+SBP -GCS only -BMR only	-RTS with scene values -RTS with neutralized RR+RR -RTS with neutralized RR+SpO_2 -GCS+SBP+RR -GCS+SBP+RR/2 -GCS+SBP -SBP of scene+HR of scene -SBP+HR -BMR+SBP -BMR only -Excessive bases	-GCS+SBP+RR -Excessive bases
Anatomical variables	**Better[15,17,23-25,39,41-43]**	**Equivalent[15,23-24,32,36,41,45]**	**Worse[37,41]**
	-ISS submitted to polynomial fraction -ISS as a categorical variable -ISS as a cubic spline -Survival Risk Ratios -AIS -NISS -APS -Optimal Consensus -ICISS -TRAIS	-ISS submitted to polynomial fraction -ISS as a categorical variable -Survival Risk Ratios -NISS -mAP -ICISS -Exclusion of anatomical variable	-Head trauma (presence/ absence) -Exclusion of anatomical variable
Variable age	**Better[21,25,30,39-40,42-43]**	**Equivalent[19,23-24]**	**Worse**
	-Age as a categorical variable (4 or more categories) -Age as a continuous variable -Age as a cubic spline	-Age as a categorical variable (4 categories) -Age as a continuous variable	

*Extracted from the conclusions of analyzed publications
GCS: Glasgow Coma Scale; SBP: Systolic Blood Pressure; RR: Respiratory Rate; BMR: Best Motor Response; RTS: Revised Trauma Score; SpO_2: Saturation of peripheral oxygen; HR: Heart rate; ISS: Injury Severity Score; AIS: Abbreviated Injury Scale; NISS: New Injury Severity Score; APS: Anatomic Profile Score; ICISS: International Classification of Disease Based Injury Severity Score; TRAIS: Trauma Registry Abbreviated Injury Scale Score; mAP: Modified Anatomical Profile

Regarding modifications in physiological variables, Box 1 shows improved performance with the exclusion of RTS from the score, but variables GCS, Better Motor Response (BMR), SBP and RR presented varied performance with RTS replaced with other indexes. Excessive base, heart rate and scene values of physiological parameters did not improve the score performance, and use of saturation of peripheral oxygen (SpO_2) with neutralized RR in RTS did not result in improved performance either.

Regarding the anatomical variables, besides alteration to the method of ISS insertion in TRISS equation, different anatomical scores were proposed to replace the ISS. The results of these alterations were sometimes improved performance of the score, and sometimes not. The proposal of exclusion of the anatomical variables did not favor the TRISS performance (Box 1).

Age was not considered a categorical variable (minimum 4 categories), a continuous variable or a cubic spline. The two first forms showed improved performance of the equation and equivalent accuracy (Box 1).

DISCUSSION

In this literature review, all analyses and comparisons attempted to determine more accurate TRISS variations in Ps prediction for trauma patients and, consequently, contribute to the quality of assessment of service provided to trauma patients by multidisciplinary teams. Based on that, some aspects of the results obtained should be highlighted.

TRISS has been criticized in the scientific literature for being based on trauma patients in the United States and Canada, presenting regression coefficients related to the reality of these countries[14, 19-28, 31-41, 43-45]. These criticisms have led to the development of many studies in which regression coefficients were adjusted to the local reality, considering that, according to some investigators, the predictive value of this score may be maximized when using coefficients adjusted to the studied population[20-27]. Unexpectedly, an analysis of all results from these studies did not show a tendency to improved predictive ability with alterations to the coefficients of the equation and brought some uncertainty about the importance of generating TRISS coefficients adjusted to the local reality.

The TRISS calculation uses the RTS, which considers the variables GCS, SBP and RR at admission, preferably at a trauma center[9].

In the last years, a great challenge in RTS calculation is due to the increased number of endotracheal intubations, sedations and neuromuscular paralysis during pre-hospital care, which does not allow the obtaining of the GCS and spontaneous RR scores at admission [14,46]. These interventions conducted during pre-hospital care influence the intra-hospital initial evaluation and, consequently, the results of RTS and TRISS.

Studies have shown patients submitted to endotracheal intubation, when analyzed separately, have the most severe traumas and a high mortality rate; consequently, the exclusion of these patients generates a bias in the service quality assessment [10, 14, 46]. In addition, resources like assigning score one to MRV for intubated patients or considering scene values have not improved TRISS performance[36].

In the literature, several studies included variables GCS or BMR, SBP, RR and SpO_2 in the models and excluded RTS from the regression equation, as these parameters exclude more serious patients from the analyses of survival probability (intubated patients)[14,47-48]. In the analyses of comparisons between the original TRISS and modified models, improved performance of TRISS was obtained when the RTS was removed from the model and replaced with parameters GCS, BMR, SBP and RR in the equation; however, in several studies, such replacement did not increase the predictive ability of TRISS; this predictive ability remained equivalent to the original TRISS or became worse. Such results show uncertainty regarding the performance of these parameters and indicate that further studies are required to analyze the physiological components in Ps prediction for trauma patients.

To improve the TRISS ability of Ps prediction, some alterations to the anatomical parameter of this score have also been proposed by scientific publications, but the results have not always led to improved performance. The NISS, a new version of ISS, seems to replace the original score with advantages[49]; however, the NISS ability to improve the TRISS performance has not been clearly established in the literature yet. It should be noted that the NISS simplifies the ISS calculation and this fact alone should indicate its use in the equation, considering that the literature so far has shown this replacement does not affect the TRISS performance.

In the publications analyzed, the alteration to the method of age insertion in equations resulted in a better performance in about 90% of the new proposals. These findings indicate age as a parameter that requires revaluation in terms of insertion in the TRISS. The cutoff point of 55 years has to be revised, since progress in medicine and life conditions have had a direct impact on factors related to the physiologic reserves of older people. Age as a dichotomous variable seems to be not really advisable, especially because different responses to the disease have been observed not only among adults and older people, but also among the elderly and very old people (≥80 years) in the population[50].

The addition of variables gender, comorbidities and trauma mechanism in the Ps mode improved the TRISS performance in several studies[21-24, 30, 37, and 39]. Being of female gender has been indicated as a protective factor after a trauma due to hormonal specificities[51-53], which may justify the better performance of the equation when this variable was included.

Studies have shown the presence of comorbidities has been associated with undesirable results, and trauma mechanism, although considered in TRISS coefficients, has also been proposed as one of the equation components.

Despite the benefits of adding these variables to the model, it should be noted that inserting each of these items in the equation requires validation in large populations. In addition, these variables should be parameters immediately obtained, which does not always happen for comorbidities.

Finally, some limitations of this review should be highlighted: the studies presented a high variability of proposed adjustments, not allowing for the conducting of a meta-analysis to define the best modified TRISS equation, and the adjusted equations proposed in the studies have to be validated in different populations.

CONCLUSION

About half of the adjustments made to the original TRISS equation resulted in better accuracy of the score in Ps prediction for trauma patients. Coefficient adjustments to the study population were conducted in most equations, but they did not present a clear tendency of improved predictive ability of the methods, as expected. A better performance of TRISS variations was observed when the adjustments included a change in the method of age insertion in the equation. TRISS variations that used the RTS in the equation did not present improved performance, regardless of the adjustment made in the score. Other physiological parameters that replaced the RTS presented varied performance, as well as the alterations to the ISS. Gender, comorbidities and trauma mechanism were variables that, when used in the equation, presented a tendency of improved performance.

RESUMO

Objetivo: identificar estudos que realizaram ajustes na equação do Trauma and InjurySeverity Score (TRISS) e compararam a capacidade discriminatória da equação modificada com a original. **Método:** Revisão integrativa de pesquisas publicadas entre 1990 e 2014 nas bases de dados LILACS, MEDLINE, PubMed e SciELO utilizando-se a palavra TRISS. **Resultados:** foram incluídos 32 estudos na revisão. Dos 67 ajustes de equações do TRISS identificados, 35 (52,2%) resultaram em melhora na acurácia do índice para predizer a probabilidade de sobrevida de vítimas de trauma. Ajustes dos coeficientes do TRISS à população de estudo foram frequentes, mas nem sempre melhoraram a capacidade preditiva dos modelos analisados. A substituição de variáveis fisiológicas do Revised Trauma Score (RTS) e modificações do Injury Severity Score (ISS) na equação original tiveram desempenho variado. A mudança na forma de inclusão da idade na equação, assim como a inserção do gênero, comorbidades e mecanismo do trauma apresentaram tendência de melhora do desempenho do TRISS. **Conclusão:** Diferentes propostas de ajustes no TRISS foram identificadas nesta revisão e indicaram, principalmente, fragilidades do RTS no modelo original e necessidade de alteração da forma de inclusão da idade na equação para melhora da capacidade preditiva do índice.

DESCRITORES

Índices de Gravidade do Trauma; Ferimentos e Lesões; Avaliação de Resultados; Qualidade da Assistência à Saúde; Revisão.

RESUMEN

Objetivo: Identificar los estudios que se ajuste a La ecuación de Trauma and Injury Severity Score (TRISS) y comparar con la capacidad discriminatoria de la ecuación modificado con el original. **Método:** revisión de estudios publicados entre 1990 y 2014 en las bases de datos LILACS, MEDLINE, PubMed y SciELO utilizando la palabra clave TRISS. **Resultados:** Se incluyeron 32 estudios. De los 67 TRISS ecuaciones ajustes identificados, 35 (52,2%) resulto en una mejora en la precisión del índice para predecir la probabilidad de supervivencia de las víctimas de trauma. Ajustes coeficientes TRISS a la población del estudio eran frecuentes, pero no siempre mejoran la capacidad predictiva de los modelos analizados. La sustitución de variables fisiológicas revisadas Trauma Score (RTS) y modificaciones Del Injury Severity Score (ISS) en La ecuación tenía variada rendimiento. El cambio en la forma de inclusión de la edad, así como La inserción de género, las comorbilidades y mecanismo de la lesión mostro tendencia de mejora del rendimiento TRISS. **Conclusión:** diferentes propuestas de ajustes a la TRISS fueron identificados en esta revisión y señalaron principalmente RTS debilidades en el modelo original y la necesidad de cambiar la forma de inclusión de la edad en la ecuación para mejorar la capacidad predictiva del índice.

DESCRIPTORES

Índices de Gravedad del Trauma; Heridas y Traumatismos; Evaluación de Resultado; Calidad de la Atención de Salud; Revisión.

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