Injury, Int. J. Care Injured 42 (2011) 83–89

Contents lists available at ScienceDirect

Injury

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

# Trauma and Injury Severity Score (TRISS): Is it time for variable re-categorisations and re-characterisations?

Philip J. Schluter [a,b,*]

[a] AUT University, School of Public Health and Psychosocial Studies, Auckland, New Zealand
[b] The University of Queensland, School of Nursing and Midwifery, Brisbane, QLD 4072, Australia

ARTICLE INFO

*Article history:*
Accepted 25 August 2010

*Keywords:*
Trauma and Injury Severity Score
TRISS
Traumatic injury
Survival
Revision

ABSTRACT

*Background:* Despite its limitations, the Trauma and Injury Severity Score (TRISS) continues to be the most commonly used tool for benchmarking trauma outcome. Since its inception, considerable energy has been devoted to improving TRISS. However, there has been no investigation into the classification or characterisation of the TRISS variables. Using a major nationally representative database, this study aims to explore the adequacy of the existing TRISS model by investigating variable re-categorisations and alternative characterisations in a logistic model used to predict survival in adults after traumatic injury.
*Materials and methods:* Data were obtained from the National Trauma Data Bank National Sample Project (NSP). Each variable in the TRISS model was related to discharge status and various categorisations considered using weighted logistic regression. Categorisations were treated nominally, using a series of indicator variables. For each variable and classification level, the best category combination was ascertained using the Bayesian Information Criterion (BIC). All best 5-category classified TRISS variables were combined, as were all best 10-category classified TRISS variables, and their predictive performance assessed against two conventionally defined TRISS models on the unweighted NSP sample using area under the Receiver Operating Characteristic curve (AUC) and BIC statistics.
*Results:* Overall, the weighted sample included 1,124,001 adults with injury events and known discharge status, of whom 1,061,709 (94.5%) were alive at discharge. When separately related to discharge status, each re-classified TRISS variable yielded a superior BIC statistic to its original specification. When investigating predictive performance, complete information was available for 167,239 (79.9%) adults with blunt and 20,643 (82.3%) adults with penetrating injury mechanisms. AUC and BIC estimates for the re-classified TRISS models were superior to the conventionally defined TRISS models. While having better predictive precision, the complexity associated with the best 10-category model resulted in the best 5-category model being preferred for penetrating mechanism injuries and being negligibly inferior for blunt mechanism injuries.
*Discussion:* Substantial improvements in the predictive power of TRISS were demonstrated by re-classifying the component variables and treating the variable categories nominally. However, before a new TRISS model with updated coefficients can be published, variable interactions and the effect of missing data needs thorough statistical evaluation.



## Introduction

Injury remains a public health problem of vast proportions, leading to a massive loss of health and life,[20] and is estimated to cause 12–13% of the entire global burden of disease.[19] While reducing preventable injury is a health priority for most agencies worldwide,[17] it remains relatively under-funded and many avoidable traumatic injuries occur.[19,26] Governments, health departments, health administrators and clinicians constantly seek to improve the delivery of medical health care to reduce the mortality and morbidity associated with injuries, once sustained.[27] Trauma scoring systems provide one vehicle for the benchmarking and monitoring of trauma system performance over time, between hospitals and over jurisdictions.[25,27,31]

Trauma scoring systems have traditionally focused on reducing preventable deaths,[3,25] and performance monitoring has primarily involved comparing observed survival outcomes with expected norms.[4] Multiple scoring systems exist.[25,30] However,

* Correspondence author: School of Public Health and Psychosocial Studies, AUT University, Private Bag 92006, Auckland 1142, New Zealand. Tel.: +64 9 921 9999; fax: +64 9 921 9877.
*E-mail address:* philip.schluter@aut.ac.nz.

0020–1383/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.injury.2010.08.036

despite its extensively documented limitations,[6,12,14,15] the Trauma and Injury Severity Score (TRISS) continues to be the most commonly used tool for benchmarking trauma outcome.[12,13] Originally proposed in 1983 to predict a patient's probability of survival,[7] TRISS is a weighted combination of patient age (AGE), Injury Severity Score (ISS) and Revised Trauma Score (RTS). The TRISS coefficients (which give the variable weights) were estimated from ordinary logistic regression models in 1987,[3] and then revised in 1995,[6] using the American College of Surgeons Committee on Trauma coordinated Major Trauma Outcome Study (MTOS) database. More recently, in 2010, these TRISS coefficients have been further revised using data obtained from the American College of Surgeons Committee on Trauma National Trauma Data Bank (NTDB) and the NTDB National Sample Project (NSP).[24]

Considerable energy has been devoted to improving or refining TRISS; for example, through recalibration of the coefficients,[6,24] careful consideration of the effect of missing data,[16,24] or through specification of new or modified variables, such as the New Injury Severity Score (NISS)[22]. These investigations are often[18,21] but not always[1,28] fruitful, usually yielding models with incrementally superior predictive performance. However, what has not been challenged in the literature is the classification of the TRISS variables themselves or the way in which they are characterised within the ordinary logistic regression models. In the TRISS model, patient age is treated as a binary variable, ISS and RTS are both treated as continuous variables, each assumed to have a linear relationship with survival over their value range, and the RTS is a weighted linear combination of three variables (respiratory rate [RR], systolic blood pressure [SBP], Glasgow Coma Score [GCS]), each categorised into 5 groups, assigned a value from 0 to 4, and then treated as a linear continuous variable. The rationale for the age and RTS component variable categorisations in predicting survival does not appear to have been tested in the literature nor have the relatively strong linear assumptions. Since the derivation of TRISS over 30 years ago, major contemporary datasets have been established, more sophisticated statistical techniques developed, and computational capacity and power have dramatically increased. Revisiting and improving the existing TRISS variable specifications and relaxing the regression model assumptions may improve the predictive power of the TRISS model; perhaps substantially.

Using a major nationally representative database, this study aims to explore the adequacy of the existing TRISS variable categorisations and assumptions by investigating variable reclassifications and alternative variable characterisations in the logistic model used to predict survival after traumatic injury. Predictive performances of two conventionally defined TRISS models and the newly specified TRISS models will be presented and assessed.

## Materials and methods

### *Data sources: the National Trauma Data Bank (NTDB) National Sample Project (NSP)*

The American College of Surgeons Committee on Trauma established the NTDB in 1997.[30] Currently, the NTDB contains detailed data on over 3 million cases from over 900 United States trauma centres.[30] However, like the MTOS database, the NTDB is not population based and consists solely of data submitted by participating trauma centres. It includes a disproportionate number of larger hospitals with younger and more severely injured patients,[30] which may, in turn, affect the generalisability of pursuant statistical findings.[8] In response, the NTDB National Sample Project (NSP) has been created.[29] Based on the NTDB, the NSP is a nationally representative sample data of traumatic injuries treated at level I and II trauma centres in the United States (US). The NSP consists of a stratified sample of 100 hospitals (90 hospitals that have contributed data to the NTDB and 10 that have not contributed data to the NTDB before 2003).[29] Strata used for sampling were: (i) NTDB participation (NTDB, non-NTDB); (ii) trauma level (I or II); and (iii) US region (Northeast, Midwest, West, South).

### *Study sample*

The NSP sample used in this study included all traumatic injuries from a stratified sample of 100 hospitals with admission year 2003 to 2006. Traumatic injuries were defined as all admitted patients with ICD-9-CM discharge diagnosis 800.0–959.9, except those with (i) 905–909 (late effects of injury); (ii) 910–924 (blisters, contusions, abrasions, and insect bites); (iii) 930–939 (foreign bodies). Patients who died before receiving any evaluation or treatment or who were dead on arrival were excluded.[29,30] Cases where the mechanism of injury was burns or unknown were also excluded.

### *The TRISS model*

The TRISS model has two separate specifications for adults, defined as being $\geq$15 years of age: (i) for injuries sustained from a blunt mechanism, and (ii) for injuries sustained from a penetrating mechanism. TRISS coefficients give the probability of survival ($P_S$) rather than the probability of death ($P_D$); naturally $P_D = 1 - P_S$. The probability of survival for any one patient can be estimated from:

$$P_S = \frac{1}{1 + e^{-b}},$$

where

$$b = \alpha_i + \beta_{AGE,i} \times AGE + \beta_{RTS,i} \times RTS + \beta_{ISS,i} \times ISS$$

with $i = 1$ (blunt mechanism) or 2 (penetrating mechanism), $\alpha_i$ is a constant for mechanism $i$, $\beta_{AGE,i}$ is the coefficient associated with AGE and mechanism $i$, $\beta_{RTS,i}$ is the coefficient associated with RTS and mechanism $i$, and $\beta_{ISS,i}$ is the coefficient associated with ISS and mechanism $i$. RTS is given by

$$RTS = \beta_{RR} \times RR + \beta_{SBP} \times SBP + \beta_{GCS} \times GCS$$

where $\beta_{RR}$ is the coefficient associated with RR, $\beta_{SBP}$ is the coefficient associated with SBP, and $\beta_{GCS}$ is the coefficient associated with GCS. However, it is convenient to combine the above equations, so that

$$b = \alpha_i + \beta_{AGE,i} \times AGE + \beta_{RR,i} \times RR + \beta_{SBP,i} \times SBP + \beta_{GCS,i} \times GCS + \beta_{ISS,i} \times ISS$$

where $\beta_{RR,i}$ is the coefficient associated with RR and mechanism $i$, $\beta_{SBP,i}$ is the coefficient associated with SBP and mechanism $i$, $\beta_{GCS,i}$ is the coefficient associated with GCS and mechanism $i$, and $\beta_{AGE,i}$ and $\beta_{ISS,i}$ are defined as above. The TRISS variable classifications, assigned values and coefficients derived from the MTOS in 1995[6] and the NTDB in 2010[24] appear in Table 1.

### *Statistical analyses*

Once approval was obtained, NSP data were downloaded and imported into SAS version 9.2 (SAS Institute Inc., Cary, US) for all