An evolution of trauma care evaluation: A thesis on trauma registry and outcome prediction models
Joosse, Pieter
Chapter 4

M STUDY; ARGUMENTS FOR REGIONAL TRAUMA DATABASES

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ABSTRACT

Background
The Trauma and Injury Severity Score (TRISS) methodology, in combination with coefficients derived from the Major Trauma Outcome Study (MTOS), is the most widely used outcome prediction model for the care of trauma patients. Utilizing the M statistic, different populations of trauma patients can be compared with the population originally enrolled in the MTOS.

Purpose
We hypothesized that databases outside of North-America would not be well matched to the MTOS study and thus the TRISS methodology would not accurately predict outcome in these different populations.

Methods
All trauma studies utilizing TRISS methodology that were published between 1990-2003 were reviewed and M statistics calculated based on the population described in the study. The populations were grouped by the following geographic locations: Europe, Asia/Africa and North-America.

Results
The median M statistic for Europe was 0.65, compared with 0.88 for Asian/African databases, and 0.90 for North-American studies. There was a significant difference between European and North-American studies ($p < 0.05$).

Conclusion
The trauma populations described in European studies differ significantly from the MTOS with respect to injury severity match, indicating the need for the development of regional trauma databases and modified TRISS coefficients based on the geographic location of the injured population included.
INTRODUCTION

In 1987 Boyd et al.,1 published an article in order to widen the understanding of the Trauma and Injury Severity Score (TRISS) methodology for those interested in developing or improving trauma care evaluation. In their introduction they put TRISS methodology between quotation marks, indicating the relative obscurity of TRISS at that time. It was 6 years after Champion et al., described one of the cornerstones of the TRISS methodology, the Trauma Score.2 The other cornerstone, the Injury Severity Score, was first described by Baker.3 In 1989 the Trauma Score was replaced by the Revised Trauma Score.4 The revision included Glasgow Coma Scale (GCS), systolic blood pressure (SBP), and respiratory rate (RR) and excluded capillary refill and respiratory expansion, which were difficult to assess in the field. The status of TRISS as the most commonly accepted prediction model for outcome of trauma care was made definitive with the publication of the Major Trauma Outcome Study.5

Since the introduction of the TRISS methodology other prediction models have been developed and their validity has been studied in comparison with TRISS. ASCOT (A Severity Characterisation of Trauma) provides a more precise description of patient physiologic status and injury number, location and severity than TRISS. ASCOT performance exceeded TRISS’s for penetrating-injured patients.6 Furthermore, ASCOT was found to have a significantly lower number of misclassifications among patients dying of blunt injuries.7 ICISS (International Classification of Diseases, Ninth Revision-based Injury Severity Score) outperformed TRISS in predicting survival.8 Despite it’s limitations however, TRISS continues to be the most practical and widely used prediction model.

Several attempts have been made to determine the performance of TRISS in an independent data set. By regression analysis TRISS coefficients are developed that are specific to external databases in order to improve calibration. The New York State Trauma Registry9 and the Ontario Trauma Registry10-12 are examples of large study populations that make use of TRISS coefficients that are specific to the province. In Europe multi-center studies like the UK MTOS13 and the trauma registry of the DGU (Deutsch Gesellschaft für Unfallchirurgie), however, have not yet resulted in the development of regional TRISS coefficients. Yet patient characteristics, mechanisms of injury and case mix of injury severity may be significantly different as compared with the MTOS.

The TRISS method can be used for quality control in a single centre over time. Examples in the literature of individual institutions assessing their level of trauma care by means of the TRISS method are multiple (see references listed in the table). The MTOS was introduced in 1990 as a method for trauma centers in North-America to measure quality. However, the original TRISS coefficients, based on the original population included in the MTOS, have never been updated.

The TRISS methodology provides a method, the M statistic, to examine the similarity in the mix of injury severities in the observed data, compared with the MTOS baseline population. The value of M is between 0 and 1, with values close to 1 indicating a very similar mix of injury severities. A value of less than 0.88 is regarded as unacceptable to adequately compare the actual and predicted survival rates.1

We hypothesised that the M statistic would be a valuable tool to study the relation between geographical setting, injury severity mix as compared with the MTOS, and TRISS validity. We expected M values to be closer to 1 in studies performed in North-America, as this population
is similar to the MTOS population. Consequently, we expected to find less favourable M values in other regions. As a result of these hypotheses we assumed to collect arguments for national or regional reference databases.

**METHODS**

A review of the literature of the period 1990-2003 was performed using the medical databases Embase/Ovid and Pubmed. We searched for studies that performed trauma outcome analysis of an individual institution using the TRISS method. The coefficients used should be those as set by the Major Trauma Outcome Study (Champion, 1990). We excluded articles that used modified TRISS coefficients. The M statistic was either cited in the text or could be calculated from the data given in the article. Retrospective and prospective studies, as well as Anglo-Saxon language and non-Anglo-Saxon articles, were included.

After our initial search, the search was repeated by two clinical librarians in two different hospitals. The initial search revealed 19 articles meeting the requirements above. This result was confirmed by the first clinical librarian. The second search was performed six months later by another clinical librarian using Pubmed. It resulted in 8 new articles, bringing the total on 27. Some of these articles were released recently others were newly discovered due to the differences in both databases. We also looked for relevant articles in the reference lists of the articles we found. MeSH headings used were TRISS (or Trauma Injury Severity Score) and MTOS (or Major Trauma Outcome Study). Since the word ‘M statistic’ is not a MeSH heading, nor is it a useful free text term (in the literature the M statistic is also known as M value or M-statistic), it was not used to search directly.

**RESULTS**

A total of 27 articles were identified in the literature published between 1990-2003. These articles were analysed on M values, size of the population or sub-population, RTS and ISS, mechanism of injury and geographic region. Three regions were identified: Europe, Asia and Africa, and North-America. Most studies (12 articles) were performed in North-American institutions, nine studies in European hospitals and six in the Asia/Africa region. The mean sample size of the North-American studies was 670, European 425 and Asian/African 177. Vles et al.\textsuperscript{14} analysed 2849 Dutch trauma patients, the second biggest population under study of this review. If this study was not included, the mean sample size of the European studies would be 183. Table 1 lists the articles that were included for this article.\textsuperscript{14-32, 36-43}

The median M statistic of the European studies was 0.65. For the Asia/Africa region the median M statistic was 0.88 and for the North-American studies it was 0.90 (Figure 1). Statistical analysis comparing the median of the European data with the North-American data using the Mann-Whitney-U test revealed a statistical significance of $p < 0.05$.\textsuperscript{14-32, 36-43}
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Table 1 | Review of the literature: outcome analysis using the TRISS method in individual institutions.
Four publications described more than one population. Maimaris et al., performed outcome analyses of a large (3315 patients) and a small (331 patients) center. Hartmann et al., compared survival outcomes for patients resuscitated by either emergency medicine or surgical house staff assigned to the trauma service. Trauma care in a designated paediatric trauma centre is described by Hall et al. In their article they cited the M values for blunt and penetrating injuries separately. Bensard et al., described 410 injured children (age £ 15 years) and 188 young adults (age 16 to 18 years). Of three urban trauma centers in Teheran described by Moini et al., only the M value that matched best with the MTOS was given.

**Figure 1** | A comparison of the median M statistics.

**DISCUSSION**

**TRISS Methodology**

TRISS is designed to accurately assess injury severity and predict expected outcomes. It can either be used to evaluate outcome performance in quality-improvement programs or to compare the quality of care with the baseline population. TRISS was first introduced and developed in North-America. In this study we reviewed the literature for TRISS analyses in individual institutions around the world and found that there is a significant difference in M statistic in relation to geographic region. As expected, the median M statistic of the North-American studies (M = 0.90) fell within range of what is acceptable to adequately compare the actual and predicted survival rates (M equal to or greater than 0.88). The median M statistic of the European and Asian/African studies did not fell in this range. The M statistic is useful for revealing gross differences in injury severity mix, however it does not measure the direction of the injury severity mismatch, only its size. For example, two populations under study can both have a M value of 0.76, one containing more severely injured patients than the baseline population, and the other less severely injured patients. To overcome this problem, Hollis et al., introduced a new statistic, Ws, which is standardized with respect to injury severity mix. Therefore it produces more accurate comparisons between different institutions. Despite its clear advantages the Ws statistic is rarely used in the literature and thus less suitable for our study.
Search Strategy
We searched the literature for articles that analysed trauma care in an individual institution using the TRISS method with MTOS coefficients. To have a complete search we asked two librarians at two different times to search the literature in Pubmed, and we extended our search by use of the reference lists. However, articles that are published in journals not subscribed in Pubmed fell out of the scope of this study.

Statistical Analysis
Analysis of the M values showed a non-normal distribution, consequently the Mann-Whitney-U test was used for statistical analysis. Given the variation in sample size a weighted statistical analysis would have been more precise. This means that our results do not reflect the influence of the studies with large populations properly. We did not find a suitable statistical solution for this problem.

Injury Severity
The validity of a trauma scoring system is most accurately assessed by its impact on the mortality of severely injured patients. Moderate to severe injury was defined as an ISS$\geq$12. The mean ISS in the MTOS is 12.8. Most studies in this review included all trauma patients regardless of their RTS or ISS, although some made subdivisions by ISS. In 18 out 27 studies we reviewed either RTS, ISS or both (Table 1). From these studies, three (Moini, Hall and Bensard) showed a higher RTS and/or a lower ISS as compared with the MTOS. Supposing the unlikely situation that all 9 studies with no data on RTS and ISS are less severely injured compared with the MTOS, still 15 out of 27 studies are more severely injured. This suggests that patients in our study are more severely injured than in the MTOS population. This should be taken in consideration because it indirectly influences the M statistic since the M statistic is calculated by means of the probability of survival, which depends on RTS, ISS, patient age and mechanism of injury.

Mechanism of Injury
The percentage of blunt trauma in the MTOS is approximately 79%. It is suggested that the incidence of penetrating injury is relatively high in the United States. Although this was not the aim of our study (and data on this parameter are incomplete) we looked whether this suggestion is supported by our data. For the European data the incidence of blunt injury ranges from 89% to 99%. Studies performed in North-America showed blunt injury incidence ranging from 65% to 96%. It could well be that this difference in mechanism of injury between MTOS and study populations leads to less accurate outcome predictions.

Paediatric TRISS
We included studies concerning adults as well as children. Several studies show that MTOS TRISS norms predict the outcome of paediatric trauma equally well as specially developed paediatric norms. Hall et al. documented that the outcome for children with blunt trauma was best at a paediatric trauma centre. Apart from Hall’s study there was a study by Orliaguet et al. that also included paediatric trauma. Their effort to assess validity of TRISS analysis to paediatric blunt trauma patients was set in a paediatric trauma center. They found both adult and paediatric norms were equally good predictors of the probability of survival for injured children. Two other studies$^{11,17}$ point out that the quality of care for paediatric trauma patients admitted to (non-paediatric) trauma centers compares favourably with MTOS standards.
Therefore, we did not differentiate between adult and paediatric TRISS data in this study and/or paediatric trauma cared for in a paediatric trauma center versus non-paediatric trauma center.

**Socio-economic Factors**

Several factors influence the quality of trauma care. We looked at performances of individual institutions in developed and developing countries. Validation of the TRISS methodology is limited in developing countries. To create regions that have similar socio-economic characteristics we regard Asia and Africa as one region. We found a small number of studies in this region, of which two were set in circumstances that can be considered as developed rather than developing, i.e. South Africa and Hong Kong. Supposedly, the gross national product correlates better as an indicator for the organisation and the level of trauma care. In our study we focussed mainly on North-American and European studies and therefore we judged the geographical setting to be practical and logical.

Another factor that has to be considered is the quality of pre-hospital care and transport times from accident to the hospital. Within a country there can be a difference between rural and urban areas for these factors. In Europe and North-America we assumed a comparable level of prehospital care. From a predominantly rural-population-based trauma center, Norwood et al., reported a mean prehospital transportation time of 25 minutes. This does not differ much from, for example, a study in the Netherlands where the access time for ambulance services from emergency call to arrival at the accident rarely exceeded the legal demand of 15 minutes.

Glance et al., critically commented on validation of TRISS in external data sets. The question why model calibration almost always deteriorates when a model is evaluated in a data set not used to develop the model is partly answered. It is either because of problems with the model itself, or because of differences in quality of care between the reference system (i.e. MTOS) and the external data set. As another factor, we think we should add the difference in patient characteristics and injury patterns between the reference and the external data set. Therefore, we studied the M statistic, a tool to describe case mix variety, and found a significant difference between North-America and Europe. First of all, a TRISS validation study of a considerable sample size of the European trauma population is needed to determine these differences. Glance et al., also state that the time has come for a national-based trauma registry to be able to accurately adjust for case mix and predict outcome. The MTOS, using references which are at least 15 years old, is no longer a contemporary reference point. In the United States the need for more up-to-date calculated coefficients prompted the development of the National Trauma Data Bank. A comparable initiative for the European situation should be the second step to be able to accurately predict trauma outcome. This conclusion is supported by the results of this study that suggest a difference in patient characteristics and injury patterns of European trauma patients as compared to the MTOS, indicating the need for the modification of TRISS coefficients for a European trauma registry.
REFERENCES


M study; arguments for regional trauma databases


