METHODOLOGIC ISSUES

An overview of the injury severity score and the new injury severity score

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Abstract

Objective—The research was undertaken to describe the injury severity score (ISS) and the new injury severity score (NISS) and to illustrate their statistical properties.

Design—Descriptive analysis and assessment of the distribution of these scales.

Methods—Three data sources—the National Pediatric Trauma Registry; the Massachusetts Uniform Hospital Discharge Data Set; and a trauma registry from an urban level I trauma center in Massachusetts—were used to describe the distribution of the ISS and NISS among injured patients.

Results—The ISS/NISS was found to have a positively skewed distribution and transformation did not improve their skewness.

Conclusion—The findings suggest that for statistical or analytical purposes the ISS/NISS should not be considered a continuous variable, particularly if ISS/NISS is treated as a continuous variable for correlation with an outcome measure.

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Keywords: injury severity score; new injury severity score; trauma

Injury classification by type and severity is fundamental to the study of its magnitude, distribution, and determinants. Since the late 1960s a number of scales assessing injury severity have been proposed. Introduced in 1971 by a joint committee comprising members of the American Medical Association, the Society of Automotive Engineers, and the American Association for Automotive Medicine (now named Association for the Advancement of Automotive Medicine), the abbreviated injury scale (AIS) was one of the first such scales. It is now the most widely reported severity scale, used throughout North America, Europe, Japan, Australia, and New Zealand as a consensus derived anatomically based scale for rating the severity of injuries. The AIS was first published in 1976. Three revisions of the AIS have been published since then (1980, 1985, and 1990).

The AIS and MAIS

AIS-90 classifies more than 2000 injury descriptors into nine body regions (head, face, neck, thorax, abdomen, spine, upper extremities, lower extremities, and external). Each injury is assigned an AIS score on an ordinal scale ranging from 1 (minor injury) to 6 (maximum injury, possibly lethal). In multiple injured patients, the highest AIS is known as the maximum AIS (MAIS). Although MAIS has been used to describe overall severity, evaluations indicated that MAIS was not linearly correlated with the probability of death. To address these limitations, a derivative of the AIS was developed by Baker et al, the injury severity score (ISS).

The ISS

The ISS is also an anatomically based ordinal scale, with a range from 1 to 75. To compute the ISS the nine AIS body regions are grouped into six: head or neck, face, chest, abdominal or pelvic contents, extremities or pelvic girdle, and external. The ISS is then calculated as the sum of the squares of the highest AIS scores for the three most severely injured body regions. For example, if a person sustained multiple injuries to the head, thorax and extremities, and if the most severe injuries in each body region were a closed non-depressed vault skull fracture (AIS = 2), one rib fracture (AIS = 1), and an open tibial fracture (AIS = 3), the ISS would be calculated as the sum of squares of each of these values. An exception to this algorithm happens when any single body region has an AIS of 6, when an ISS of 75 is then assigned. Also, if the severity of an injury cannot be determined an AIS of 9 is assigned. An ISS cannot then be calculated and a score of 99 is given.

The NISS

Recently, researchers have proposed a new injury severity score (NISS) which, unlike the ISS, considers the three most severe injuries, regardless of body region. The NISS is computed as the simple sum of squares of the three most severe AIS (1990 revision) injuries. To date, two studies have reported that the NISS is more predictive of survival and performs better, statistically, than the ISS.

Uses of the ISS

Although the ISS was developed to predict mortality, numerous other applications of the
ISS/NISS have been reported in the medical literature over the past two decades. For example, researchers have used the ISS to control for patient case mix when evaluating the quality of care of hospital patients admitted with trauma and to predict the time it takes for individuals to return to pre-injury levels of functioning. Among the studies reviewed for this paper, most treated ISS as a continuous, normally distributed variable. Others used categorical classifications (for example, binary or higher order) in studies where the ISS was categorized, there was a lack of consistency in the number of categories and the cut-off points selected. Further, researchers concerned with the ISS is not continuous often try to “normalize” the data by logarithmic transformations.

The purpose of this paper is to describe the ISS and NISS distributions among several injured populations and to illustrate their statistical properties. Although the former is well discussed, few papers have described their statistical properties using various datasets. Recommendations are made to improve the use of these scales.

**Methods**

To illustrate the distribution of the ISS and NISS, two steps were taken. First, an algorithm was used to identify all possible ISS/NISS values following the usual rules for its calculation. A total of 1975 cases with ISS values between 1 and 75 were used in our analysis.
Comparison with NISS

Table 2: Distribution of patients by injury severity (ISS) in three data sources and the Trauma Registry.

<table>
<thead>
<tr>
<th>ISS/NISS categories</th>
<th>NPTR* (%)</th>
<th>UHDDS† (%)</th>
<th>Trauma registry‡ (%)</th>
<th>NISS; NPTR* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minor (ISS/NISS 1–3)</td>
<td>8 433 (20)</td>
<td>5 855 (14)</td>
<td>314 (16)</td>
<td>8 621 (20)</td>
</tr>
<tr>
<td>Moderate (ISS/NISS 4–8)</td>
<td>17 668 (43)</td>
<td>18 811 (45)</td>
<td>754 (38)</td>
<td>17 926 (45)</td>
</tr>
<tr>
<td>Severe (ISS/NISS 9–15)</td>
<td>8 926 (22)</td>
<td>14 804 (36)</td>
<td>618 (31)</td>
<td>10 091 (24)</td>
</tr>
<tr>
<td>Very Severe (ISS/NISS 16–24)</td>
<td>3 124 (8)</td>
<td>1 846 (4)</td>
<td>182 (9)</td>
<td>3 384 (8)</td>
</tr>
<tr>
<td>Critical (ISS/NISS 25–75)</td>
<td>2 738 (7)</td>
<td>1 205 (3)</td>
<td>107 (6)</td>
<td>1 557 (5)</td>
</tr>
<tr>
<td>Median</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Mode</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

*NPTR = National Pediatric Trauma Registry (ISS derived from AIS-90, NISS derived from AIS-90).
†UHDDS Massachusetts Uniform Hospital Discharge Data Set (ISS derived from AIS-85).
‡Trauma registry (ISS derived from AIS-90).

Non-valid (that is, non-existing) ISS/NISS values along the interval 1 to 75. The non-valid values are denoted as N/A in table 1.

Discussion

This study showed that the pattern of the ISS distribution was similar among the three databases and between the ISS and NISS both
Injury severity score

regarding its marked skewness as well as the distribution of the scores. The finding that the transformations did little to make the ISS or NISS resemble a normal distribution in the available datasets was not surprising given their excessive skewness and the fact that the ISS/NISS is an ordered categorical variable. There is no simple when ISS was used as a binary or ordered categorical variable. In the ISS/NISS values (from 1 to 75), there are several implications for the choice of analytical methods. Numerous researchers have used the mean ISS as a way of describing and comparing injury severity in populations.11 13–15 26

The shape of the ISS/NISS distribution has several implications for the choice of analytical procedures. Numerous researchers have used the mean ISS as a way of describing and comparing injury severity in populations.11 13–15 26

Since the ISS (or the NISS) is not normally distributed, reporting the mean ISS (the least robust measure of central tendency), may lead to incorrect interpretations. For example, the mean ISS value in the NPTR dataset was 7. Apart from the fact that 7 is not a valid ISS value, almost two thirds (63%) of the sample have an ISS value lower than 7. Use of the mean ISS may also be misleading when comparing values from different populations. As highlighted in table 2, the three data sources for the ISS and the one used for the NISS had similar means and identical medians, although the tails of their distributions were dissimilar. For example, the proportion of severely injured cases (ISS and NISS 16 to 24) in the NPTR and trauma registry databases was two times higher than that of the Massachusetts UHDDS. Differences in the tails of the distribution are important when comparing cost and outcomes among facilities.

Two possible explanations for the observed differences in these datasets may be: differences in the populations, and the fact that the computerized algorithm used to calculate AIS and ISS for the Massachusetts UHDDS data underestimates severity. Despite the explanations for the observed differences, only by presenting ISS as a categorical variable could the differences in the distributions be observed. Since the NISS uses the same scale as the ISS, the same findings apply to the descriptive interpretation of the NISS data. Thus, we suggest that for analytic purposes, neither the ISS and NISS be considered a continuous variable. This is because it is a collection of discrete values (that is, there are not an infinite number of values between any two integers) and that along the range of ISS/NISS values (from 1 to 75), there are several integer values that are not possible.

From a review of the literature it was evident that there was no consistency in the number of categories used or the severity cut off points when ISS was used as a binary or ordered categorical variable.16–21 There is no simple solution to the categorisation of the ISS (or NISS) and the establishment of a committee to develop clinically meaningful dichotomization and transformation of the ISS (or NISS) may do little to rectify this issue. In part, this is due to the fact that the most meaningful categorization may differ from study to study and the “best fit” (in relation to the application of these categories in multivariate modeling) will always depend on the given set of data. However, for comparative purposes, we believe that it would be advisable to agree to a standard categorization scheme that could be reported in addition to any project specific categorization.

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