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On scene injury severity prediction (OSISP) algorithm for car occupants

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ABSTRACT

Many victims in traffic accidents do not receive optimal care due to the fact that the severity of their injuries is not realized early on. Triage protocols are based on physiological and anatomical criteria and subsequently on mechanisms of injury in order to reduce undertriage. In this study the value of accident characteristics for field triage is evaluated by developing an on scene injury severity prediction (OSISP) algorithm using only accident characteristics that are feasible to assess at the scene of accident. A multivariate logistic regression model is constructed to assess the probability of a car occupant being severely injured following a crash, based on the Swedish Traffic Accident Data Acquisition (STRADA) database. Accidents involving adult occupants for calendar years 2003–2013 included in both police and hospital records, with no missing data for any of the model variables, were included. The total number of subjects was 29 128, who were involved in 22 607 accidents. Partition between severe and non-severe injury was done using the Injury Severity Score (ISS) with two thresholds: ISS > 8 and ISS > 15. The model variables are: belt use, airbag deployment, posted speed limit, type of accident, location of accident, elderly occupant (>55 years old), sex and occupant seat position. The area under the receiver operator characteristic curve (AUC) is 0.78 and 0.83 for ISS > 8 and ISS > 15, respectively, as estimated by 10-fold cross-validation. Belt use is the strongest predictor followed by type of accident. Posted speed limit, age and accident location contribute substantially to increase model accuracy, whereas sex and airbag deployment contribute to a smaller extent and seat position is of limited value. These findings can be used to refine triage protocols used in Sweden and possibly other countries with similar traffic environments.

1. Introduction

The Swedish parliament enforced "Vision Zero" in 1997 stating the long-term goal that no loss of life or severe injuries shall occur due to road traffic accidents. Although the mortality has been successfully decreased, there are still around 300 people killed and 3000 severely injured yearly (Saxton, 2013). Much effort has been devoted to improving crashworthiness and developing active safety of vehicles with good results; however, improving the prehospital care process has received less attention, even though it is fundamental for decreasing mortality and mitigate injury (Murad et al., 2012; MacKenzie et al., 2006).

Minimizing the delay to definitive treatment has been shown to decrease mortality substantially (Haas et al., 2010). A key to achieve this is taking the correct decision on optimal treatment and where to transport the patient; severely injured should be taken to a trauma center, having the expertise to treat major injury (Haas et al., 2010; MacKenzie et al., 2006). The prehospital personnel's, i.e. typically the crew in road and air ambulances, most important decision support is the triage protocol. It facilitates identifying patients with severe injury, while using health care resources efficiently by recognizing patients not likely to be in need of urgent and specialized care. In Sweden the Rapid Emergency Trauma and Triage System (RETTS) (Widgren and Jourak, 2011) is the most widespread protocol.

Developing and maintaining a highly accurate triage protocol requires detailed and updated knowledge about what type of

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traffic accidents that are most dangerous. Statistics about mortality are rather well established, but there are few publications studying how injury severity is linked to Mechanisms of Injury (MOI)/Accident Characteristics (AC). MOI is commonly used in trauma care to refer to the cause of injury (Brown et al., 2011). In this paper, the broader term AC is used to refer to characteristics of the accident such as type of collision, posted speed limit, and characteristics of the vehicles involved and their occupants. The importance of AC lie in their potential to predict occult injuries and thereby reducing undertriage. A retrospective study including data of around a million trauma patients concluded that using physiologic and anatomic criteria alone lead to undertriage, and strongly supported the use of MOI in trauma and triage systems (Brown et al., 2011).

The aim of this study is to develop an on scene injury severity prediction (OSISP) algorithm using only AC that are feasible to assess at the scene of accident.

The purpose of developing the model is to identify important factors for improving triage protocols used in Sweden and possibly in other countries with similar traffic environments. Furthermore, that knowledge may help to guide future traffic safety efforts. The long-term goal is to incorporate an OSISP algorithm into the triage/decision support system used by the prehospital personnel, to increase triage accuracy and minimize delay to definitive treatment by e.g. bypassing the closest medical facility in favor of a trauma center when appropriate. The system is aimed primarily at ambulance personnel. In Sweden, traffic accidents are usually first handled by the public-safety answering point reached at the common emergency telephone number 112, whose operators are in direct contact with dispatch management for ambulance, fire brigade and police. A road ambulance is usually the first or one of the first resources to reach the scene of accident, and its crew has the medical responsibility. The system could be implemented on e.g. a tablet computer to make it easy-to-use in the field for ambulance crew.

To gain understanding of how modern triage systems are designed, the *Guidelines for Field Triage of Injured Patients - Recommendations of the National Expert Panel on Field Triage* (Sasser et al., 2012) used in US and RETTS (Widgren and Jourak, 2011) in Sweden can be reviewed. In both systems the first step is based on physiological criteria, such as pulse and breathing rate, and the second step is anatomical criteria of identified injuries, e.g. type of fractures. If any of the criteria in the first two steps is fulfilled, the patient is given the highest priority level (red in RETTS). Next, in step three, MOI are examined. If any of the MOI inclusion criteria are met, the patient is given second highest priority level in RETTS (orange). This differs from the US protocol, where patients that meet MOI criteria should be handled as stated in Sasser et al. (2012): "*Transport to a trauma center, which, depending upon the defined trauma system, need not be the highest level trauma center*".

Focusing on the MOI that apply for motor vehicle crashes, some criteria are shared between both triage systems, but differences are also found. Both systems include death in the same car and occupant being ejected from the vehicle. Rollover accident was previously a criteria in the American system, but it has been removed in the two last versions of the protocol. RETTS includes rollover as a criteria, as well as trapped occupant. There are two other criteria in RETTS that apply to car accidents, estimated speed > 60 km/h and deployment of airbag. These have no direct equivalent criteria in the US system, which recommends to measure intrusion of the occupant compartment to assess the forces having acted upon the occupant(s). Furthermore, the expert panel recommends to utilize vehicle telemetry data (transmitted from vehicle to dispatch center) consistent with high risk of injury when available (Sasser et al., 2012). In the development of the URGENCY algorithm (Augenstein et al., 2003) for identifying severe crashes and a similar algorithm for the OnStar® system (Kononen et al., 2011), seat belt use, direction and location of impact, and delta-V, i.e. the total change in velocity, were recognized as important predictors of severe injury that can be recorded by telemetry systems integrated in vehicles (incorporating sensors such as accelerometers and gyroscopes to measure impact forces). However, the use of telemetry systems is currently limited in Sweden and Europe, thus algorithms that can predict risk of severe injury as a function of AC that can be quickly assessed at the scene of accident would be valuable.

2. Materials and methods

2.1. Data selection

The scope of this study is adult car occupants in traffic accidents registered in the Swedish Traffic Accident Data Acquisition (STRADA) database for calendar years 2003–2013. STRADA is the Swedish Transport Administrations national information system for traffic accidents occurring on the Swedish road network. It contains information reported by the police, and medical data on injured road users treated at emergency hospitals reporting to STRADA. The police visits the scene of accident and reports the circumstances, whereas the hospitals determine the injuries the patient sustains and their degree of severity. By combining data from two sources, the STRADA system can provide more comprehensive information on the circumstances and consequences of road traffic accidents. The hospital reports focus on the individual level, i.e. the patient, as opposed to the police reports that focus on the circumstances of the accident, which may involve multiple casualties. The database is contained in a Microsoft Access® database file. More information about STRADA can be found in Howard and Linder (2014).

There are over 600 000 injured patients registered in the hospital dataset of STRADA from 2003 to 2013. In the database, every accident has a unique accident number, which is the link between the police reported and hospital reported information. Only accidents containing both reports were used in this study. Thereafter, adults of age ≥18 years were selected. The time span considered was from 2003, when the police started to systematically report to STRADA, until and including accidents reported in 2013. Only the entries with no missing data in any of the model variables were selected. After this selection process, 29 128 casualties injured in 22 607 accidents remained.

2.2. Injury severity assessment and dichotomization

In order to classify occupants as severely injured or not, the Injury Severity Score (ISS) (Baker and O'Neill, 1976) was used. ISS is based on the classification of the severity of each injury according to the Abbreviated Injury Scale (AIS) (AAAM, 2005). Two different thresholds were used to define severe injury: ISS > 15 and ISS > 8.

2.3. Variables included in the model

The dependent variable is whether the patient is classified as being severely injured or not. Two sets of models were developed for the two different levels of severity, i.e. ISS > 8 and ISS > 15, respectively. All variables included in the model are detailed in Table 1.

2.4. Data analysis

All statistical calculations were performed with IBM SPSS Version 22. Univariate Chi-squared tests of association were used to compute *p*-values under the null hypothesis of no association between the different explanatory variables and injury severity. Next, multivariate analyses were performed. Logistic regression