
Development of a Time Sensitivity Score for Frequently Occurring Motor Vehicle Crash Injuries



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- BACKGROUND:** Injury severity alone is a poor indicator of the time sensitivity of injuries. The purpose of the study was to quantify the urgency with which the most frequent motor vehicle crash injuries require treatment, according to expert physicians.
- STUDY DESIGN:** The time sensitivity was quantified for the top 95% most frequently occurring Abbreviated Injury Scale (AIS) 2+ injuries in the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) 2000–2011. A Time Sensitivity Score was developed using expert physician survey data in which physicians were asked to determine whether a particular injury should go to a Level I/II trauma center and the urgency with which that injury required treatment.
- RESULTS:** When stratifying by AIS severity, the mean Time Sensitivity Score increased with increasing AIS severity. The mean Time Sensitivity Scores by AIS severity were as follows: 0.50 (AIS 2); 0.78 (AIS 3); 0.92 (AIS 4); 0.97 (AIS 5); and 0.97 (AIS 6). When stratifying by anatomical region, the head, thorax, and abdomen were the most time sensitive.
- CONCLUSIONS:** Appropriate triage depends on multiple factors, including the severity of an injury, the urgency with which it requires treatment, and the propensity of a significant injury to be missed. The Time Sensitivity Score did not correlate highly with the widely used AIS severity scores, which highlights the inability of AIS scores to capture all aspects of injury severity. The Time Sensitivity Score can be useful in Advanced Automatic Crash Notification systems for identifying highly time sensitive injuries in motor vehicle crashes requiring prompt treatment at a trauma center. (J Am Coll Surg 2015;220:305–312. © 2015 by the American College of Surgeons)
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Motor vehicle crashes (MVCs) are a serious public health concern that resulted in >2,000,000 injured occupants and >33,000 fatalities in 2012.¹ Although the advent of safety standards (eg, seat belts and airbags) has lowered the incidence of morbidity and mortality in MVC victims, there are considerable barriers to additional improvements. Most experts believe that an important future avenue for progress is to improve the trauma triage

process, that is, the process by which patients are given the “right care” at the “right place” at the “right time.”

The “golden hour” of trauma care is defined as the hour after traumatic injury in which definitive treatment for the patient is crucial.² As such, the importance of prompt and appropriate field triage in trauma has been demonstrated in several studies. A Massachusetts MVC study reported a 62% fatality rate for occupants that qualified for immediate care at a trauma center (TC) that went elsewhere.³ Garwe and colleagues^{4,5} used propensity score analysis to adjust for confounding variables among trauma patients sent directly to a Level I TC and those who made an initial stop at a non-TC, and demonstrated a substantial increase in 2-week mortality among those patients who first stopped at a non-TC.

Despite its importance, accurate and appropriate triage remains difficult, as the process of determining which MVC occupants are seriously injured based on the limited physical examination possible at the scene of the trauma is

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Abbreviations and Acronyms

AACN	= Advanced Automatic Crash Notification
AIS	= Abbreviated Injury Scale
MVC	= motor vehicle crash
NASS-CDS	= National Automotive Sampling System—Crashworthiness Data System
TC	= trauma center

challenging. Advanced Automatic Crash Notification (AACN) has shown promise in improving trauma triage by predicting occupant injury severity using vehicle telemetry data to recommend a transportation decision.^{2,6-13} This requires an objective mechanism for determining a severely injured patient requiring care at a TC, and methods of injury severity scoring become very important. Current algorithms, such as OnStar and BMW (URGENCY) incorporate model variables, such as crash direction, delta-v, multiple impacts, belt use, vehicle type, age, and sex, and define severely injured patients using Abbreviated Injury Scale (AIS) metrics. Although AIS-based metrics (such as maximum AIS (MAIS) 3+) remain the most commonly used, multiple other methods of injury scoring have been devised and dispute remains about which severity scoring system best discriminates seriously injured patients.¹⁴⁻¹⁷

To improve on severity scoring systems and better evaluate an occupant's risk of injury, an injury-based approach examining 3 facets of injury (ie, severity, time sensitivity, and predictability) was developed.^{14,18,19} A list of injuries necessitating treatment at a Level I/II TC was determined by quantifying the 3 facets for each injury using expert physician opinion and database analyses of the National Automotive Sampling System—Crashworthiness Data System (NASS-CDS), National Trauma Data Bank, and National Inpatient Sample. This list of injuries is incorporated into an AACN algorithm that predicts an occupant's risk of sustaining any injury on the list using vehicle telemetry data.

Time sensitivity, the focus of this article, refers to the urgency with which a particular injury requires treatment. Time sensitivity can inform systems for getting the patient treatment in a timely manner, getting the patient to the correct treatment facility, and having the correct physicians on staff to treat the injury. Injuries have varying levels of time sensitivity in terms of the degree of immediacy or the urgency associated with each injury.²⁰⁻²² Despite its importance, the time sensitivity of specific injuries has not been systematically studied and quantified. The objective of the study was to develop a metric for quantifying the time sensitivity of frequent MVC-induced injuries for incorporation into a more

comprehensive injury severity scoring system that will ultimately inform triage decisions through an AACN algorithm.

METHODS**Top 95% Abbreviated Injury Scale 2+ National Automotive Sampling System—Crashworthiness data system injuries**

The NASS-CDS was used to identify the top 95% most frequently occurring AIS 2+ injuries in MVCs for the years 2000 to 2011 using the AIS 98 coding lexicon.^{23,24} The NASS-CDS provides detailed data on a representative, random sample of thousands of minor to fatal tow-away crashes in the United States. The representative population of MVCs in the United States is determined by applying weighting factors to the data.

The list of the top 95% most frequently occurring AIS 2+ injuries in NASS-CDS 2000–2011 (ie, Top 95% List) contained 240 injuries located in the head, face, thorax, abdomen, upper extremity, spine, and lower-extremity body regions. Inclusion of 100% of the AIS 2+ injuries listed in NASS-CDS 2000–2011 results in 848 unique AIS codes. The approach taken in this study simplifies the analysis to 240 unique AIS codes by focusing on the top 95% most frequent AIS 2+ injuries.

Time sensitivity survey

The time sensitivity of an injury is difficult to glean from data available in source databases due to the retrospective nature of the data and competing risks associated with time sensitivity, such as patient age, co-injuries, pre-existing comorbidities, and physiologic status, which can play a role in patient outcomes. Therefore, we decided to poll expert orthopaedic surgeons, trauma surgeons, and emergency medicine physicians from 22 different medical centers using a “time sensitivity survey” to build a database of time sensitivity data. Institutional Review Board approval was obtained by Wake Forest University to administer the survey. Orthopaedic surgeons, trauma surgeons, and emergency medicine physicians were recruited by email from Wake Forest Baptist Health and from external institutions to take the survey online. For each survey participant, their institution, specialty, level of expertise (resident, fellow, attending), and years of experience at their current level of expertise was collected.

Each survey question presented a single injury and the participant was asked to recommend a treatment location and rank the urgency of the injury presented (Fig. 1). It was assumed that the patient could have additional injuries, however, the injury of interest was considered the most remarkable. For each of the 240 injuries on the Top 95% List, the survey asked:

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