# Expert Perspectives on Time Sensitivity and a Related Metric for Children Involved in Motor Vehicle Crashes

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## ABSTRACT

***OBJECTIVE:*** Advanced Automatic Crash Notification (AACN) uses vehicle telemetry data to predict risk of serious injury among motor vehicle crash occupants and can thus improve the accuracy with which injured children are triaged by first responders. To better define serious injury for AACN systems (which typically use Abbreviated Injury Scale [AIS] metrics), an age-specific approach evaluating severity, time sensitivity (TS), and predictability of injury has been developed. This study outlines the development of the TS score.

***METHODS:*** The 95% most frequent AIS 2+ injuries in a national motor vehicle crash data set spanning 2000 to 2011 were determined for the following age groups: 0 to 4, 5 to 9, 10 to 14, and 15 to 18 years. For each age-specific injury, clinicians with pediatric trauma expertise were asked if treatment at a trauma center was required and were asked about the urgency of treatment. A TS score (range 0–1) was calculated by combining the mean trauma center decision and urgency scores.

***RESULTS:*** A total of 30 to 32 responses were obtained for each age-specific injury. The most frequent motor vehicle crash–induced injuries in the younger groups received significantly higher scores than those in the older groups (median TS score 0 to 4 years: 0.89, 5–9 years: 0.87, 10–14 years: 0.82, 15–18 years: 0.72, $P < .001$). Large variations in TS existed within each AIS severity level; for example, scores among AIS 2 injuries in 0- to 4-year-olds ranged from 0.12 to 0.98.

***CONCLUSIONS:*** The TS of common pediatric injuries varies on the basis of age and may not be accurately reflected by AIS metrics. AIS may not capture all aspects of injury that should be considered by AACN systems.

**KEYWORDS:** Advanced Automatic Crash Notification (AACN); injury; pediatric trauma; time sensitivity; triage

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## WHAT'S NEW

Injury severity alone is a poor indicator of the time sensitivity of injuries. The time sensitivity of common pediatric injuries varies on the basis of age and may not be accurately reflected by Abbreviated Injury Scale metrics.

ADVANCED AUTOMATIC CRASH Notification (AACN) systems can improve the speed and accuracy of field triage decisions by alerting control centers that a crash has occurred and utilizing vehicle, occupant, or crash data to predict which occupants are likely to have serious injuries.[1–4] Although several research groups have developed AACN algorithms for adults, none have yet been developed for children.[5,6]

AACN algorithms require an objective measure for defining seriously injured patients. Existing AACN algorithms, such as OnStar AACN and URGENCY, use metrics based on the Abbreviated Injury Scale (AIS), such as a maximum AIS of 3+ or an Injury Severity Score of 15+, to define such seriously injured patients.[7,8] Other methods of injury scoring have been devised and disputes remain about which severity scoring system best discriminates seriously injured patients from nonseriously injured patients.[9–12] The AIS-based metrics remain the most commonly used and were originally created for use in adults. Although a small number of studies have demonstrated the validity of certain AIS-based metrics in children,[13] the true severity of these injuries may not be appropriately defined by these metrics. A recent study has demonstrated that the mortality risk

of similar motor vehicle crash–induced injuries varies on the basis of the developmental stage of a child, which is not reflected in AIS.[14]

To improve on trauma severity scoring systems used by AACN algorithms and thus better evaluate an occupant's need for treatment at a trauma center (TC) after a motor vehicle crash, an injury-based approach using 3 facets of injury (severity, time sensitivity [TS], and predictability) was developed in adults.[15–18] These facets of injury were included into a recently developed AACN algorithm designed for occupants 16 years and older.[19] Given the differences between adults and children, this approach is now being applied to the pediatric cohort for future inclusion into a pediatric-specific AACN algorithm. To do so, 4 key pediatric developmental groups have been identified,[20] and the 3 facets of injury are being quantified for the most frequent motor vehicle crash–induced injuries in each group. These facets of injury will be used to generate a list of injuries indicating a patient's need for treatment at a TC for each age group. These developmentally appropriate lists will then be incorporated into an AACN algorithm. The goal of the AACN is to predict which children are likely to have an injury on these lists after a crash and to recommend a triage decision.

TS—our focus here—refers to the urgency with which a particular injury requires treatment.[17] Thus, the objective of the study was to develop a TS metric for the most frequently occurring motor vehicle crash–induced injuries in 4 pediatric age cohorts.

## METHODS

### INJURIES

Institutional review board approval was obtained for retrospective review of the National Automotive Sampling–Crashworthiness Data System (NASS-CDS) and for administration of an electronic survey of expert opinion. NASS-CDS data for the years 2000 to 2011 were utilized to determine the most common injuries among children in motor vehicle crashes. NASS-CDS collects data on a representative, random sample of thousands of minor, serious, and fatal tow-away crashes in the United States.[21] Weighting factors are applied to provide a population-based estimate of the incidence of particular injuries associated with motor vehicle crashes in the United States.

Pediatric motor vehicle crash occupants 18 years and younger were analyzed and divided into 4 age classifications on the basis of injury patterns previously studied by this group[20] and coinciding with commonly used US Centers for Disease Control and Prevention groupings.[22] Children were thus grouped into the following age categories: 0 to 4, 5 to 9, 10 to 14, and 15 to 18 years. The most frequently occurring AIS 2+ injuries comprising the top 95% of the cumulative weighted injury count were included in that age group's "Top 95% Injury List."

### TS SURVEY

Expert opinions of the need for treatment at a TC and the urgency associated with such treatment for each injury on each age group's Top 95% Injury List were obtained through use of an electronic survey. The survey was deployed by personal e-mail requests to pediatric surgeons, pediatric orthopaedic surgeons, and pediatric emergency medicine physicians at the Wake Forest Baptist Level 1 Pediatric TC. Additionally, we collected recommendations for pediatric surgeons with special expertise in pediatric trauma to poll outside our institution. The survey was also deployed through the Childress Institute for Pediatric Trauma to medical practitioners with expertise in caring for children with traumatic injuries. This included physicians, nurse practitioners, physician assistants, and experienced emergency department registered nurses (RNs).

A sample question from this survey is shown in Figure 1. Participants were asked to choose whether, for each age group, the injury of note should be treated at a Level I/II TC or if the injury could be treated safely at a non-TC. This response was termed the TC Decision and was assigned a value of 1. Responses in which the participant determined that treatment at a non-TC was acceptable were assigned a value of 0. For each age-specific injury, the mean of the TC Decision responses was calculated and became the *Mean*(*TC Decision*) score for that age-specific injury.

The participant was also asked to determine the urgency associated with the treatment of each age-specific injury with a 5-point Likert scale. A score of 5 indicated a high level of urgency and a score of 1 a low level of urgency. This score, termed the Urgency score, was averaged from the responses for each age-specific injury and became the *Mean*(*Urgency*) score for that age-specific injury.

To create the TS scores, we applied a scoring method developed for the adult population[17] to incorporate and weight both the effects of preferred triage decision and urgency of an injury to generate a quantitative metric on a scale from 0 to 1 for later inclusion into an AACN algorithm. First a TC Decision multiplier was determined for each age-specific injury, as demonstrated in Equation 1:

$$\text{TC Decision Multiplier} = [Mean(Urgency) \times 0.1] - 0.3 \quad (1)$$

This multiplier adjusted the *Mean*(*TC Decision*) by −20% (least urgent; *Mean*(*Urgency*) = 1) to 20% (most urgent; *Mean*(*Urgency*) = 5). This product was added to the original *Mean*(*TC Decision*) score, creating a raw TS score for each age-specific injury (Equation 2):

$$\text{Raw TS Score} = Mean(TC\ Decision) + [\text{TC Decision Multiplier} \times Mean(TC\ Decision)] \quad (2)$$