Advanced Automatic Crash Notification for Children - Year 3

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Project Goals

• **Advanced Automatic Crash Notification (AACN):** Technology that uses Event Data Recorder (EDR) data to predict risk of serious injury among occupants  
• **Project Goal:** Create an AACN Algorithm to predict serious injury among pediatric occupants

### Variables

- Age
- Crash Type
- Delta V
- Airbag Deployment
- Multiple Impacts
- Belted Status
- Risk of Serious Injury
Algorithm Schema

Target Injuries (Serious Injuries)

Crash Characteristics

AACN Algorithm computes risk of Target Injury

Makes occupant triage recommendation

Project Outline

Year 1

Determine which developmental metric (age, height or weight) should be used as a covariate of injury risk in a pediatric AACN algorithm

Year 2

Define Target Injuries among Pediatric Occupants in 4 age groups

Apply AACN algorithm created for adults to pediatrics using pediatric-specific Target Injury Scores

Year 3

Time-Sensitivity

Predictability

Severity

AACN Algorithm computes risk of Target Injury

Makes occupant triage recommendation
Year 1 Goals

Target Injuries (Serious Injuries)

Determine which developmental metric (age, height or weight) should be used as a covariate of injury risk in a pediatric AACN algorithm.

Crash Characteristics

AACN Algorithm computes risk of Target Injury

Makes occupant triage recommendation

Year 1 Results

✓ Age is the best predictor for our purposes
  ✓ Greater clinically relevant differences seen in 0-4, 5-9, 10-14 & 15-18 year group
  ✓ NIH guidelines support this
  ✓ Can be programmed into vehicle’s AACN software via birthdate
Year 2 Goals

Define Target Injuries among Pediatric Occupants in 4 age groups

Crash Characteristics

AIS 3 Cerebral Contusion Ages 0-18 Years

Year 2 Results: Severity Score

Mortality Risk: 2.8%
Disability Risk: 32.3%
2.8% Died
97.2% Survived
32.3% Disabled
67.7% Non-Disabled
Year 2 Results: Time Sensitivity Score

Survey of Expert Opinion

✓ Experts included pediatric & orthopedic surgeons and emergency medicine physicians

✓ For each injury, experts asked:
1. Does this injury require treatment at a TC?
2. How urgently does the injury require treatment from a scale of 1 (not urgently) to 5 (urgently)?

Year 2 Results: Occult Score

Survey of Expert Opinion

✓ Experts included pediatric & orthopedic surgeons and emergency medicine physicians

✓ For each injury, experts asked to assess the likelihood that an injury might be missed on initial assessment on a scale of 1 (not likely, less occult) to 5 (very likely, more occult)
Year 2 Results:
Transfer Score

Quantitative metric indicating likelihood that an injury requires patient transfer from a non-TC to a Level I/II TC

Transfer Score

No Transfer
Transfer Score=0
High Predictability

Transfer
Transfer Score=1
Low Predictability

Ulna fracture (AIS 3)
3% transferred (not frequently transferred)
More predictable

Cerebrum contusion (AIS 3)
11% transferred (frequently transferred)
Less predictable

Year 2 Results:
Target Injuries

Severity
NTDB MRs & DRs Mortality/Disability

Time Sensitivity
Physician Survey

Predictability
Occult Injuries & Trauma Transfers

Doud, AAAM/TIP 2015
Year 2 Results: Target Injury List (TIL)

Target Injury Score (TIS) = \( M_S S + M_{TS} TS + M_P P \)

(variable coeff. \( M_S, M_{TS}, M_P \))

- Severity Score
- Time Sensitivity
- Predictability

*Each score ranges from 0-1

Injuries that fall to the right of the variable threshold are included on the Target Injury List.

Year 3 Goals

Apply AACN algorithm created for adults to pediatrics using pediatric-specific Target Injury Scores

AACN Algorithm computes risk of Target Injury

Makes occupant triage recommendation
Pediatric AACN Algorithm

- **Inputs**: NASS CDS cases & Target Injury List (TIL)

- **Output**: Recommends triage decision based upon risk of occupant sustaining injury on TIL

NASS Inclusion Criteria

<table>
<thead>
<tr>
<th>Crash Mode</th>
<th># of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal</td>
<td>6,196</td>
</tr>
<tr>
<td>Rear</td>
<td>717</td>
</tr>
<tr>
<td>Far side</td>
<td>1,207</td>
</tr>
<tr>
<td>Near side</td>
<td>1,128</td>
</tr>
<tr>
<td>Rollover</td>
<td>2,384</td>
</tr>
<tr>
<td>Total</td>
<td>11,632</td>
</tr>
</tbody>
</table>
Pediatric AACN Variables

(1) Crash Mode
- Crash mode classified as rollover, frontal, rear, near-side or far-side
- Separate model for each crash mode

(2) Delta V
- Longitudinal Delta V used for frontal & rear crashes
- Lateral Delta V used for near-side & far-side crashes
- # Quarter turns used for rollover

(3) Multiple Impacts
- Single vs. Multiple

(4) Seatbelt Use
- Used AAP recommendations (Optimally, sub-optimally, or unrestrained)
- Grouped optimally and sub-optimally restrained vs unrestrained
- Belt status not used as model parameter

(5) Airbag Deployment
- Front and Side AB

(6) Age Group
- 0-4 YOs, 5-9 YOs, 10-14 YOs, 15-18 YOs
Pediatric AACN Algorithm

**DATA SOURCES**
- NTDB
- Physician Survey
- NIS
- Transfer
- Occult

**INPUTS**
- NASS Cases
  - Occupants
  - Crash Conditions
  - Injuries

**OUTPUT**
- Target Injury List
  - Risk $\geq$ Risk Threshold for any Target Injury: TC Recommended
  - Risk $<$ Risk Threshold for any Target Injury: Non-TC Recommended

**Risk of Target Injury**
$$ e^{x_i} $$
$$ \frac{1}{1 + e^{x_i}} $$

**INPUTS**
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  - Occupants
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**Risk of Target Injury**
$$ e^{x_i} $$
$$ \frac{1}{1 + e^{x_i}} $$
Pediatric AACN Performance Assessment

- Run NASS-CDS cases through decision algorithm comparing Pediatric AACN decision to the “ground truth”

ISS ≥ 16

Over/Under Triage Assessment

**Over triage (OT) rate:**
- Proportion of mildly injured people that went to a TC ACS: <50%

**Under triage (UT) rate:**
- Proportion of seriously injured people that didn’t go to a TC ACS: <5%

110099.1 Scalp Abrasion
410600.1 Chest Laceration
751800.2 Arm Fracture
850826.2 Knee Sprain

ISS= 6
Trauma Center

140602.3 Cerebrum Contusion
544222.2 Spleen Laceration
851800.3 Femur Fracture

ISS= 22
Non-Trauma Center
Pediatric AACN Optimization

- Pediatric AACN optimized with 5 continuous parameters
- Objective function
  - Minimize UT
  - Maintain OT < 50%
- Convergence in 50-100 iterations

Preliminary Pediatric AACN Results

Triage Rate Comparison

1) Belt Status as model parameter (Optimally & Sub-Optimally Restrained vs Unrestrained)
2) No Belt Status

Model parameters included:
- Crash Type
- Δv
- # Quarter Turns
- Multiple Impact
- Airbag
- Age Group

ACS OT/UT Guidelines
Year 3 Deliverables

- Refined Pediatric AACN algorithm
  - Additional variables including gender, vehicle type, and seat position
  - Remove age group from model parameters
  - Optimization of weighting factors for Severity and Predictability scores

- Evaluate OT/UT rates

Conclusions

- Year 1 defined pediatric injury patterns correlated with developmental stage (age)
- Year 2 quantified Severity, Time Sensitivity, & Predictability and defined Target Injuries associated with a patient’s need for TC treatment in 4 pediatric age groups
- Year 3 will continue to refine pediatric AACN algorithm & improve triage rates among pediatric occupants