A Systemic Framework for Studying Traffic Crash Sequence Using Naturalistic Driving Study Data

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What are Crash Sequences?

- Normal Driving
- Safety-Related Events
- Crash Surrogate
- Crash
- Near Crash

Diagram showing the flow from Normal Driving to Safety-Related Events leading to a Crash Surrogate, which then splits into Crash and Near Crash. The diagram includes a visual representation of recoverable and unrecoverable scenarios.
Explore Paradigms from Epidemiology and Transposing Their Methods to the Study of Road Crashes

Start of Etiology Process → Disease Begins → Clinical Symptoms → Outcome of Disease

Induction → Promotion → Expression

Safety-related Event → Crash Symptom

Crash Symptom → Crash

Crash Symptom → Near Crash
The Hospital for Sick Children Project (IBM)

Absolute Time

10:00AM

1:30PM

Baby 1

Sensor 1
Sensor 2
Sensor 3

Onset Detection

Symptom

Baby 2

Sensor 1
Sensor 2
Sensor 3

Onset Detection

Symptom

Baby i

Sensor 1
Sensor 2
Sensor 3

Onset Detection

Symptom
ANALYSIS DATASET

- VTTI 100-Car Data
- Single-vehicle run-off-road crashes
  - 63 identified events
    - 21 Crashes
    - 42 Near crashes
- Apply the structural framework to the dataset to identify “crash symptoms”
RECEIVER OPERATOR CHARACTERISTIC (ROC) CURVE

Excellent Discrimination
Fair Discrimination
Poor Discrimination

Risk Index A
Risk Index B
Risk Index C

Area under the curve: 0.9 - 1
Area under the curve: 0.7 - 0.9
Area under the curve: 0.5 - 0.7
Raw Naturalistic Driving Data

First Screening
Safety-related Event/Event of Interest

Classification
Events Without Structural Difference

YAW30D > 4 deg/sec

Second Screening
Candidate Surrogate Events

Non-Intersection (51)

Validate Surrogate Events
Well-Defined Surrogate Events

Lat10D > 0.6g nighttime
Lat10D > 0.9g daytime

23 Events Identified

Estimate Conversion Factor, \( \pi \)
Conditional Crash Probability
The Quantification of Crash Symptoms for All the Six Screening Measures

<table>
<thead>
<tr>
<th>Crash Symptoms (Screening Measure at First Screening)</th>
<th>Conditions</th>
<th>Number of Quantification In terms of the 51 Events</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symptom A (Start with Lat10D)</strong></td>
<td>• Lat10D &gt; 0.4g during event; Non-intersection related</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>• Lat30D &gt; 0.7g if during nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lat30D &gt; 0.9g if during daytime</td>
<td></td>
</tr>
<tr>
<td><strong>Symptom B (Start with Lat30D)</strong></td>
<td>• Lat30D &gt; 0.4g during event; Non-intersection related</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>• Lat30D &gt; 0.8g if during nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lat30D &gt; 0.9g if during daytime</td>
<td></td>
</tr>
<tr>
<td><strong>Symptom C (Start with Lat01M)</strong></td>
<td>No statistical relationship between crash symptoms and crash risk can be established.</td>
<td>NA</td>
</tr>
<tr>
<td><strong>Symptom D (Start with Lat10M)</strong></td>
<td>• Lat10M &gt; 0.3g during event; Non-intersection related</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>• Lat30D &gt; 0.8g if during nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lat30D &lt; 0.9g &amp; if during daytime</td>
<td></td>
</tr>
<tr>
<td><strong>Symptom E (Start with Lat30M)</strong></td>
<td>• Lat30M &gt; 0.3g during event; Non-intersection related</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>• Lat10D &gt; 0.7g if during nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lat10D &gt; 0.9g if during daytime</td>
<td></td>
</tr>
<tr>
<td><strong>Symptom F (Start with Yaw30D)</strong></td>
<td>• Yaw30D &gt; 4 degree/sec during event; Non-intersection related</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>• Lat10D &gt; 0.6g if during nighttime</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lat10D &gt; 0.9g if during daytime</td>
<td></td>
</tr>
</tbody>
</table>
In Traffic Safety Field, NDS Data Provides a Similar Opportunity to Study the Progression of a Crash.
Summary

• NDS data provides an excellent opportunity to better understand the crash process.
• This study explores paradigms from other disciplines and transposes their methods to the study of road crashes.
• The results based on the algorithm developed are consistent with researchers’ video review of event initiation and duration.
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THANK YOU