Predicting Performance and Safety Based on Driver Fatigue

Daniel Mollicone, Ph.D.

10th International Conference on Managing Fatigue
March 20–23, San Diego CA
Fatigue Meter: Identify drivers at elevated fatigue risk

<table>
<thead>
<tr>
<th>Date</th>
<th>Legs</th>
<th>People on duty</th>
<th>Avg fatigue</th>
<th>Max fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 24 - January 30, 2016</td>
<td>28</td>
<td>0</td>
<td>7</td>
<td>17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fatigue</th>
<th>Name</th>
<th>Legs</th>
<th>Period Avg</th>
<th>Deviation from historical avg</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
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<tr>
<td>16</td>
<td>White, Jamie</td>
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<td>13</td>
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<td>-2</td>
</tr>
<tr>
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<td>Vecchio, Steve</td>
<td>3</td>
<td>5</td>
<td>-3</td>
</tr>
</tbody>
</table>

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Data collected in naturalistic field study

Study overview:

• 106 US truck drivers
  o 44 local drivers
  o 26 regional drivers
  o 36 long-distance drivers

• Drivers were studied across two duty cycles intervened by a restart break of at least 34h

• Data collected included:
  o HOS logs
  o Wrist actigraphy and sleep diary
  o Continuous measurement of vehicle performance

• Analysis based on 48 drivers
Timing of duty and sleep

Drivers exhibited wide variety of schedule patterns

Day driver

Night driver

Mixed driver

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Analysis of the work day duration and composition

Total hours driving per day → Risk (Exposure)

- **Total Hours Driving Per Day**
  - Average hours of driving: 6.9h

- **Total Hours On-Duty but not Driving**
  - Average hours of on-duty: 2.2h
Analysis of the work day duration and composition

Long duty days → Restricted sleep opportunity → Fatigue

Total Hours Driving & On-duty Per Day

Average hours on-duty/driving: 9.0h

Total Hours Driving & On-duty & Breaks

Average duration of duty day: 10.6h
Analysis of the work day by time of day

Variable start times → Disrupted circadian cycles → Fatigue
Analysis of sleep timing and duration

17.1% of the time drivers had <5 hours of sleep (105/600 driver-days)

![Graph showing total daily sleep duration and distribution of sleep timing.](image)
Analysis of fatigue and performance

Analysis overview:

- Extracted hard braking events from vehicle acceleration data based on threshold of 3mph/s and 5mph/s with initial speed greater than 50mph.
- Estimated fatigue based on HOS data from the ELD using published biomathematical model (McCauley et al., 2009, 2013)
- Estimated effect of fatigue on hard-braking rates based on nonlinear mixed-effects with time-of-day covariates.
Estimated fatigue and hard breaking events

Fatigue was above 12 while driving only 2.8% of the time

Distribution of Fatigue While Driving

Hard Breaking Events by Time of Day

Peak traffic

<table>
<thead>
<tr>
<th>Hours Driven at Fatigue Level</th>
<th>Fatigue</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
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<tr>
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</tr>
<tr>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>16</td>
<td>8</td>
</tr>
</tbody>
</table>

Mean Fatigue: 6.1
Estimated fatigue and hard breaking events

Hard Breaking Events as a Function of Fatigue
(Threshold >3 mph/s)

Hard Breaking Events as a Function of Fatigue
(Threshold >5 mph/s)
Acknowledgments

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(TPOC: Martin Walker, Ph.D.)

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