Using Naturalistic Driving Data to Examine Age and Gender Differences on Seat Belt Use

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**Background**

- Seat-belt usage is a proven safety measure for preventing injuries and fatalities among motor vehicle drivers and passengers:
  - Nearly 48% of the 21,000 road fatality victims in the U.S. were unrestrained by seat belts at the time of the accident (NHTSA, 2012).
  - It has been estimated that front seatbelt use reduces the fatal injury risk for occupants by 45%, and the moderate to-critical injury risk by 50% (NHTSA, 2012).
- The seat-belt use rate in the U.S. has been steadily grown over the past few decades.

![Seat belt use rate trend](image)

NHTSA, National Occupant Protection Use Survey
Research Gap

- Studies have identified both individual and environmental factors that affect seatbelt use:
  - Young driver group had significantly lower seatbelt use rates than other age groups (Eby, Molnar, & Olk, 2000; Womack, Trout, & Davies, 1997).
  - Male drivers were less likely to wear seat belts than female drivers.
  - Different seatbelt use rates have also been observed under various travel conditions, such as time of day (Miller, Spiner, & Lestina, 1998).

- Most of the previous studies on seatbelt use based on information mainly from self-report or crash data. Self-report data usually overestimates actual use, while crash data permits no inference on general behavior and intention of the drivers.
Research Gap

- Naturalistic driving studies have provided a unique opportunity to collect objective data to study drivers’ seat belt use behavior at the individual level and trip level.
- One recent study has used naturalistic driving data to evaluate factors that associated with part-time and full-time seat belt users (Reagan, McClafferty, Berlin, & Hankey, 2013). However, no studies has examined teen drivers’ on seat belt use while driving on the real roads.
Datasets: IVBSS and Teen IVBSS

- Integrated vehicle based safety system (IVBSS) program
  - 5-year long program
  - Integrated four types of warnings FCW, LDW, LCM, and CSW
  - 16 instrumented research vehicles (2006 Honda Accord)
  - 108 drivers (6 weeks of driving for each)
    - Younger drivers (M=25.2; SD=2.9)
    - Middle-aged drivers (M=46.0; SD=3.0)
    - Older drivers (M=64.6; SD=2.8)

- Teen-IVBSS program
  - Same research vehicles and safety system as in the IVBSS program
  - 40 teen drivers (16 years old with Michigan Level 2 Intermediate driving license) for a 14-week period
    - equal number of male and female drivers
    - 20 baseline group: no warning present to them at all
    - 20 treatment group drivers: 3 weeks of baseline, 8 weeks of treatment and 3 weeks of post treatment period
IVBSS Instrumented Vehicles

- 16 vehicles each with four prototype crash warning systems
- 7 radars, 5 video streams, GPS, >500 other signals at 10 to 50 Hz
<table>
<thead>
<tr>
<th>Trip</th>
<th>Start Time</th>
<th>End Time</th>
<th>Researcher</th>
<th>Event Type</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16:42</td>
<td>17:30</td>
<td>A</td>
<td>LDW</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>21:23</td>
<td>22:09</td>
<td>B</td>
<td>FCW</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>23:54</td>
<td>00:37</td>
<td>C</td>
<td>Bump</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>19:01</td>
<td>19:50</td>
<td>D</td>
<td>LDW</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>00:19</td>
<td>01:06</td>
<td>E</td>
<td>SV</td>
<td></td>
</tr>
</tbody>
</table>
Data sources:

- CAN buses – IVBSS, OEM
- 5 cameras with video capture & compression
- 6 or 7 radars
- Onboard map match
- Two CPU system
- Automotive-grade hard disks
- Second GPS
- Vehicle motion IMU
- Microphone........ETC!
- GPRS/Edge cellular modem
- DAS power management system
Data Analysis

• **Mixed model**
  • **Between-subject variables:** age (teen, younger, middle-aged or older) and gender (male or female)
  • **Within-subject variables**
    • Time of a day (day or night)
    • Wiper state (on or off), as a surrogate measure of weather condition
    • Average driving speed during each trip (continuous variable)
    • Trip distance (continuous variable)

• **Dependent variables**
  • Seatbelt use was determined via a signal from the vehicle’s Car Area Network (CAN) bus (Yes or No).
  • The second dependent variable is when drivers buckled their seatbelts during a trip:
    • Early-stage (i.e., put on their seatbelts within 5 s of trip start)
    • Late-stage (i.e., after 5 s)
Descriptive Data Analysis

- The combined data set collected represents 313,500 miles, 37,695 valid trips, and about 9,500 hours of driving
  - Of the total 1,284 unbelted trips, teen drivers accounted for about 10.8%, younger drivers accounted for about 59.7%, middle-aged for about 16.9%, and older drivers for 12.5%
  - Male drivers accounted for 72.8% of the unbelted cases
Results: Likelihood of seat belt use

- Logistic regression model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teen vs. Younger</td>
<td>7.84 (3.31, 19.64)</td>
<td>&lt;0.01.</td>
</tr>
<tr>
<td>Teen vs. Middle</td>
<td>3.72 (1.62, 8.51)</td>
<td>&lt;0.05.</td>
</tr>
<tr>
<td>Teen vs. Older</td>
<td>2.58 (1.19, 5.58)</td>
<td>&lt;0.05.</td>
</tr>
<tr>
<td>Middle vs. Young</td>
<td>1.44 (0.73, 2.82)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Older vs. Young</td>
<td>3.03 (1.51, 6.06)</td>
<td>0.05</td>
</tr>
<tr>
<td>Older vs. Middle</td>
<td>2.11 (0.99, 4.48)</td>
<td>&lt;0.01.</td>
</tr>
<tr>
<td><strong>Gender group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female vs. Male</td>
<td>2.38 (1.44, 3.91)</td>
<td>&lt;0.01.</td>
</tr>
</tbody>
</table>
When they buckled their seatbelt?

Timing of Seatbelt Use (in seconds)

Early-stage
85%

Late-stage
Results: Likelihood of Seat Belt Use at Early Stage

- Logistic regression model (only belted trips were used)

**TABLE 2.** Likelihood of seatbelt wearing at the beginning a trip (within 5 seconds)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Odds Ratio (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Young vs. Teen</td>
<td>0.49 (0.34, 0.72)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Middle vs. Teen</td>
<td>0.45 (0.31, 0.64)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Older vs. Teen</td>
<td>0.59 (0.37, 0.94)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Young vs. Middle</td>
<td>1.09 (0.76, 1.57)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Young vs. Older</td>
<td>0.84 (0.51, 1.35)</td>
<td>n.s.</td>
</tr>
<tr>
<td>Middle vs. Older</td>
<td>0.76 (0.48, 1.21)</td>
<td>n.s.</td>
</tr>
<tr>
<td><strong>Gender group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male vs. Female</td>
<td>0.71 (0.52, 0.95)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Wiper state</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On vs. Off</td>
<td>1.94 (1.70, 2.19)</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>
Conclusions

- Significant differences on the likelihood of seatbelt use between teen drivers and each of the three other age groups, with teen drivers being the most likely to use a seatbelt, followed by older, middle-aged, and young drivers.

- It was also found that teen drivers were more likely to fasten their seatbelts at the beginning of a trip when compared to the other three adult groups.

- Female drivers used seatbelts more frequently and more likely to buckle seatbelts at early stage of the trip than male drivers, suggesting female drivers are generally more conservative belt users.

- Even during a belted trip, it can take quite a long time for a driver to buckle up:
  - 7% of belted trips, drivers did not buckle up for over 1 minute;
  - 1% of belted trips, drivers did not buckle up for over 8 minutes.
Acknowledgement

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Questions?

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