# USING ORDERED MODELING TO IDENTIFY THE MOST SIGNIFICANT FACTORS THAT INCREASE THE SEVERITY OF SINGLE-VEHICLE COLLISIONS

**Essam Dabbour, Ph.D., P. Eng.**

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جامعة أبوظبي
ABU DHABI UNIVERSITY

Ryerson University

CARSP • ACPSER

BRITISH COLUMBIA | RoadSafetyBC

# INTRODUCTION

- What is a single-vehicle collision.
- Single-vehicle collisions are significantly more severe than multi-vehicle collisions.
- 59.6% of the fatal collisions that occurred in the United States in 2014 were single-vehicle collisions.
- Why several research studies focus on single-vehicle collisions.
- Most research studies that investigated single-vehicle collisions were based on compiling data from different years into one dataset that was used for analysis.
- The risk factors identified in those studies might be temporally unstable.
- Understanding the temporal stability trends of those factors would help researchers assessing the effectiveness of implementing different safety treatments.

# DATA COLLECTION

- Collision records were obtained from the Highway Safety Information System (HSIS).
- All light-duty single-vehicle injury collisions that occurred in North Carolina between 2007 and 2013.
- Collision records were classified into four injury levels:
  a) *Level 1*: possible injury;
  b) *Level 2*: evident non-disabling injury;
  c) *Level 3*: disabling injury; and
  d) *Level 4*: fatal injury (that resulted in death within 30 days of the collision).

# DATA ANALYSIS

- Ordered probit modeling was used to estimate the latent injury risk propensity for collisions:

$$z_i = \beta X_i + \varepsilon_i$$

- The injury severity level is then estimated:

$$Y_{ij} = \begin{Bmatrix} 1 \text{ if } z_i < k_1 \\ 2 \text{ if } k_1 \leq z_i < k_2 \\ 3 \text{ if } k_2 \leq z_i < k_3 \\ 4 \text{ if } k_3 \leq z_i \end{Bmatrix}$$

- $k_1$; $k_2$; and $k_3$ are thresholds for severity level $j$, which are estimated by the model.

# PROBABILITY OF INJURY LEVEL

The probability that a certain driver, *i*, has different levels of injury severity, *j*, was then estimated:

- $P(Y_{ij} = 1) = P(z_i < k_1) = P((\beta X_i + \varepsilon_i) < k_1) = P(\varepsilon_i < (k_1 - \beta X_i))$
- $P(Y_j = 2) = P(k_1 \leq z_i < k_2) = P(\varepsilon_i < (k_2 - \beta X_i)) - P(\varepsilon_i < (k_1 - \beta X_i))$
- $P(Y_j = 3) = P(k_2 \leq z_i < k_3) = P(\varepsilon_i < (k_3 - \beta X_i)) - P(\varepsilon_i < (k_2 - \beta X_i))$
- $P(Y_j = 4) = P(k_3 \leq z_i) = 1 - P(\varepsilon_i < (k_3 - \beta X_i))$

# RELEVANT RISK FACTORS

The following factors were investigated:

a) **Roadway-related factors:** including the presence of a physical median, the speed limit on the roadway, whether the roadway has a straight or curved alignment, and whether the roadway is in an urban or a rural area;
b) **Vehicle-related factors:** including travel speed and the type of the light-duty vehicle;
c) **Driver-related factors:** including age, gender, being influenced by alcohol, and the use of seatbelt;
d) **Lighting condition factor:** whether the collision occurred during daylight, during nighttime on an illuminated roadway; or during nighttime on an unilluminated roadway and
e) **Environmental-related factors:** including weather and road surface conditions.

# RESULTS (2007 – 2010)

| Parameter | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|
| **Threshold $k_1$** | 0.790 (0.034) | 0.733 (0.035) | 0.940 (0.038) | 1.067 (0.041) |
| **Threshold $k_2$** | 2.193 (0.038) | 2.158 (0.039) | 2.381 (0.043) | 2.547 (0.046) |
| **Threshold $k_3$** | 2.713 (0.042) | 2.654 (0.043) | 2.846 (0.047) | 3.028 (0.050) |
| **Darkness** | NS[(a)] | NS[(a)] | 0.042 (0.022) | NS[(a)] |
| **Over speed limit** | 0.290 (0.023) | 0.283 (0.024) | 0.312 (0.024) | 0.278 (0.025) |
| **Favor. env. cond.[(b)]** | 0.145 (0.027) | 0.123 (0.025) | 0.135 (0.024) | 0.190 (0.026) |
| **Spring season** | 0.050 (0.025) | NS[(a)] | NS[(a)] | 0.086 (0.026) |
| **Rural highway** | 0.070 (0.023) | 0.067 (0.024) | 0.096 (0.024) | 0.074 (0.024) |
| **Undivided highway** | NS[(a)] | 0.076 (0.031) | NS[(a)] | NS[(a)] |
| **Highway curve** | 0.110 (0.022) | 0.109 (0.023) | 0.119 (0.023) | 0.121 (0.023) |
| **Vehicle type[(c)]** | 0.116 (0.022) | 0.069 (0.023) | 0.098 (0.023) | 0.138 (0.023) |
| **Young driver[(d)]** | -0.554 (0.024) | -0.069 (0.027) | NS[(a)] | NS[(a)] |
| **Senior driver[(e)]** | 0.300 (0.052) | 0.316 (0.048) | NS[(a)] | NS[(a)] |
| **Male driver** | 0.111 (0.023) | 0.143 (0.024) | 0.127 (0.023) | 0.153 (0.023) |
| **Influenced driver** | 0.253 (0.028) | 0.268 (0.029) | 0.276 (0.030) | 0.305 (0.029) |
| **Seatbelt not properly used** | 0.786 (0.029) | 0.752 (0.030) | 0.718 (0.030) | 0.740 (0.031) |

# RESULTS (2011 – 2013)

| Parameter | 2011 | 2012 | 2013 | Overall |
|---|---|---|---|---|
| **Threshold $k_1$** | 0.960 (0.039) | 0.999 (0.045) | 1.045 (0.041) | 0.823 (0.014) |
| **Threshold $k_2$** | 2.438 (0.044) | 2.439 (0.049) | 2.485 (0.046) | 2.260 (0.016) |
| **Threshold $k_3$** | 2.948 (0.049) | 2.914 (0.053) | 2.919 (0.050) | 2.741 (0.017) |
| **Darkness** | 0.071 (0.018) | NS[a] | NS[a] | 0.024 (0.009) |
| **Over speed limit** | 0.289 (0.025) | 0.242 (0.025) | 0.333 (0.026) | 0.284 (0.009) |
| **Favor. env. cond.[b]** | 0.135 (0.028) | 0.103 (0.027) | 0.134 (0.026) | 0.140 (0.010) |
| **Spring season** | NS[a] | NS[a] | NS[a] | 0.038 (0.010) |
| **Rural highway** | NS[a] | 0.116 (0.026) | 0.098 (0.024) | 0.078 (0.010) |
| **Undivided highway** | NS[a] | 0.086 (0.032) | NS[a] | 0.050 (0.012) |
| **Highway curve** | 0.396 (0.024) | 0.195 (0.024) | 0.123 (0.024) | 0.149 (0.009) |
| **Vehicle type[c]** | NS[a] | 0.081 (0.024) | 0.121 (0.024) | 0.105 (0.009) |
| **Young driver[d]** | NS[a] | NS[a] | NS[a] | -0.036 (0.010) |
| **Senior driver[e]** | NS[a] | NS[a] | NS[a] | 0.259 (0.018) |
| **Male driver** | 0.124 (0.024) | 0.167 (0.024) | 0.115 (0.024) | 0.136 (0.009) |
| **Influenced driver** | 0.256 (0.030) | 0.338 (0.030) | 0.238 (0.031) | 0.289 (0.012) |
| **Seatbelt not properly used** | 0.616 (0.033) | 0.727 (0.032) | 0.713 (0.032) | 0.732 (0.012) |

# CONCLUSIONS

- Six risk factors were found to be temporally stable, including:
  a) *driving over the speed limit,*
  b) *failing to properly use seatbelt,*
  c) *driving in favorable environmental conditions,*
  d) *driving on a highway curve,*
  e) *being a male driver, and*
  f) *being influenced by alcohol.*
- Four factors were found to be temporally unstable, including:
  a) *driving on an undivided highway,*
  b) *darkness conditions,*
  c) *spring season, and*
  d) *being a senior driver (above 65 years).*

# THANK YOU