Vulnerability of Motorcycle Users to Injury Crashes: A Heterogeneity Based Case-Control Analysis

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Data Linkage and Assembly

<table>
<thead>
<tr>
<th>Type of helmet coverage</th>
<th>Dependent variable: Injury crash (1/0)</th>
<th>Physical/psychological factors</th>
<th>Drug use/alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorcycle training/traffic convictions</td>
<td>Comprehensive Data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rider-related factors/Exposure</td>
<td></td>
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</tbody>
</table>

Conceptual Framework

Research Question

- How different “policy-sensitive” factors relate to the risk of motorcycle injury crashes?

- Data: Orange County, California.
- 351 cases (riders involved in injury crashes)
- Similarly-at-risk 702 matched controls (riders not involved in injury crashes)
- Cases matched with controls by time of day, day of week, road type, urban/rural, location, & travel direction.

Proposed Approach:

- Random parameters logit models.
- Random parameters logit with heterogeneity-in-means.
- Models operating at individual observation & matched-triplet levels.

Motivation:

- Captures between-observation or between-triplet unobserved & observed heterogeneity.
- More accurate estimates/deeper insights.

Model Selection

<table>
<thead>
<tr>
<th>Goodness of Fit Measures</th>
<th>Models for individual observations (ignoring matched-triplet structure)</th>
<th>Models for matched triplets (accounting for matched-triplet structure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed parameter logit</td>
<td>Model 1*</td>
<td>Model 2**</td>
</tr>
<tr>
<td>Random parameter logit</td>
<td>Model 1*</td>
<td>Model 2**</td>
</tr>
</tbody>
</table>

- Degrees of Freedom
- Log-likelihood with constant only, Log-likelihood with random parameters
- Chi-square statistics
- AIC

Model 4 highlighted in bold is the best-fit model.

Selected Results (Relative Risk Estimates)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 Fixed Parameter Logit</th>
<th>Model 2 Random Parameter Logit</th>
<th>Model 4 Random Parameter Logit - Heterogeneity Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure-related factors</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Total miles driven prior to event</td>
<td>↓ -0.300</td>
<td>↓ -2.57</td>
<td>↑ -0.80</td>
</tr>
<tr>
<td>Number of traffic violations in last 5 years</td>
<td>↓ 56.05</td>
<td>↑ 22.38</td>
<td>↑ 26.58</td>
</tr>
<tr>
<td>Two traffic violations</td>
<td>↓ 128.87</td>
<td>↓ 127.28</td>
<td></td>
</tr>
<tr>
<td>Three traffic violations</td>
<td>↓ 62.26</td>
<td>↓ -99.89</td>
<td>↓ -101.00</td>
</tr>
</tbody>
</table>

- Clothing color
  - Lower clothing motorcycle-oriented ↓ -77.62 | ↓ -96.91 | ↓ -99.85 |
  - Dark upper body clothing color: Red |
  - ↑ 209.88 | ↓ 254.31 | ↓ 297.49 |

- Driver-related factors
  - Motorcycle license being held by the rider for ≥30 or more years |
  - 3 hours or less sleep ↑ -38.18 | ↓ -35.85 | ↓ -33.43 |
  - Female driver ↑ 150.80 | ↓ 151.54 | | |
  - Hispanic or Latinx driver ↓ -52.94 | ↓ -58.19 | ↓ -61.17 |
  - African American ↑ 72.29 | ↓ 101.78 | ↓ 115.98 |
  - Driver age in years ↓ -2.66 | ↓ -2.96 | ↓ -3.92 |
  - Driver weight in pounds ↓ -0.399 | ↓ -0.60 | ↓ -0.70 |
  - Driver is college/university graduate ↓ -25.55 | ↓ -25.32 | ↓ -24.42 |

- Trip-related factors
  - Trip purpose: Urban/School, Work |
  - 1053 days increased risk of crash |
  - Trips during a weekend |
  - Trips in the evening |

- Frequency of road use
- Type of road use
  - Road used daily |
  - Road used once per month |
  - Road used once per year |

- Type of helmet coverage
  - DOT compliant least intrusive helmet |
  - Motorcycle helmet coverage |

- Year of training
  - 5 years or more |
  - 4 years or less |

- Speed before crash/injury
  - Experienced by the rider |
  - Experienced by the police |

- Injury crash a more probable outcome.

- If the rider's speed is > 50 mph, events in which rider also consumed alcohol or multiple drugs significantly increased the mean of the random parameter making injury crash a more probable outcome.

Illustration: Observed & Unobserved Heterogeneity Effects

Despite significant unobserved heterogeneity, the mean effect = 0.97, the mean of the random parameter for speed variable varies as a function of alcohol or multiple drugs involvement (observed heterogeneity).

Effects of speed in crash propensity (probability density)

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