The Effect of Road Characteristics on the Incidence of Farm Vehicle-related Crashes: A GIS-based Matched Case-Control Study

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Background
• Motor vehicle crashes on rural roads result in more fatalities and injuries than those on urban roads
• Large slow-moving farm vehicles are known hazards
• Road characteristics like number of lanes, road dividers, exits, shoulders may influence motor vehicle crashes

Methods
• Farm vehicle-related crashes (FVC) from nine Midwestern States, 2005-2010 – 6848 crashes with x and y coordinates
• Road segment data was collected from Environmental Systems Research Institute – almost 6.5 million road segments with information on length, elevation, ZIP code, road type, speed limits, state, and unique ID

Exposure Assessment
• Sinuosity of road segment is defined as the % deviation from a straight line, straight road segment has 0% sinuosity

Outcome assessment
• Case: A road segment that had a farm vehicle-related crash (6848 case road segments)
• Control: A road segment that did not have a farm vehicle-related crash

Matching:
• Based on potential confounders identified using directed acyclic graphs (figure 3): ZIP code, road segment length, type of road

Sensitivity analysis
• 1:1 case-control matching – 6848 cases: 6808 controls
• 1:2 case-control matching – 6848 cases: 13566 controls
• Comparing all road segments with FVCs to non-FVCs segments – 6848 FVCs: 6484963 non-FVCs

Statistical Analyses
• Matched data – Conditional logistic regression adjusted for ZIP code, segment length, & road type
• Unmatched data – Log linear (risk) regression adjusted for state, segment length, & road type
• Odds and risk ratios with 95% CI are reported
• Since the outcome is rare (0.1% of all road segments had FVCs) odds ratios approximate risk ratios

Table 1: Effect of gradient of road segments on the incidence of FVCs

<table>
<thead>
<tr>
<th>Exposure categories</th>
<th>Matched data (1:1) - 6848 cases: 6808 controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1%</td>
<td>3030 2889 Referent Referent</td>
</tr>
<tr>
<td>1-5%</td>
<td>3002 2926 0.98 (0.91, 1.05) 0.93 (0.85, 1.01)</td>
</tr>
<tr>
<td>6% - 10%</td>
<td>569 686 0.79 (0.70, 0.89) 0.68 (0.58, 0.79)</td>
</tr>
<tr>
<td>&gt;10%</td>
<td>247 307 0.77 (0.64, 0.91) 0.60 (0.49, 0.75)</td>
</tr>
</tbody>
</table>

Table 2: Effect of sinuosity of road segments on the incidence of FVCs

<table>
<thead>
<tr>
<th>Exposure categories</th>
<th>Matched data (1:1) - 6848 cases: 6808 controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1%</td>
<td>1565 10637 Referent Referent</td>
</tr>
<tr>
<td>1-5%</td>
<td>737 10577 0.64 (0.58, 0.70) 0.57 (0.51, 0.64)</td>
</tr>
<tr>
<td>6% - 10%</td>
<td>65 147 0.40 (0.30, 0.54) 0.33 (0.24, 0.45)</td>
</tr>
<tr>
<td>&gt;10%</td>
<td>21 74 0.43 (0.29, 0.65) 0.37 (0.24, 0.56)</td>
</tr>
<tr>
<td>&gt;20%</td>
<td>21 85 0.28 (0.17, 0.46) 0.21 (0.13, 0.36)</td>
</tr>
</tbody>
</table>

Limitations
• Per our definition of sinuosity, we assume that all road segments with similar deviation from a straight line are same
• Intersections could be potential confounders - the number of intersections is hard to estimate from Esri data
• Could not measure the number of farm vehicles on a road – maybe highly sinuous and hilly roads witness less farm vehicles

Conclusions
• Increased sinuosity of road segments reduces incidence of farm vehicle-related crashes
• Increased gradient of road segments reduces incidence of farm vehicle-related crashes

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