Assessing the Impacts of Pavement Surface Condition on the Performance of Signalised Intersections

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Outline

• Introduction
• Aim and Objectives of the Study
• Data Analysis and Results
• Statistical Analysis
• Conclusions
INTRODUCTION

High Severity and Fatality crash data for Melbourne/Australia over the years (2000 to 2013)
The aim of this study is to assess how pavement surface condition affects performance of signalised intersections in terms of safety.
Study Objectives

• Study how the variation in pavement surface condition affects rate, severity and types of crashes.

• Assess the contribution of condition variables to crash occurrence.
  ▪ This study involves a before and after assessment.
  ▪ The sample includes only sites that were subject to surface treatment during the study period.
Study Area
High Severity (Fatality & Serious Injury) Crash Data (2000-2013)

<table>
<thead>
<tr>
<th>Category</th>
<th>High Severity Crashes %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signalised Intersections</td>
<td>19.2</td>
</tr>
<tr>
<td>Intersections</td>
<td>51.1</td>
</tr>
<tr>
<td>Not at intersections</td>
<td>48.9</td>
</tr>
</tbody>
</table>
Study Area
Fatality Crash Data (2000-2013)

• There are nearly 3700 intersections in the study area. At least 670 of them are signalised.
A large sample of intersections has been identified for which data (condition and crash) over ten years (2003-2013) is available.

Filtering intersections using latitude and longitude coordinates in Google Map to remove unsignalised intersections.

One hundred sites were identified following a staged filtering process.
Intersection included:

- Only intersections (or the immediate 200 m approach) that were subject to Surface treatment.
- Only intersections with crash data over 3 to 5 years before and after treatment.

- For assessment and analysis, pavement condition data of treated length only was used.
Pavement Surface Condition Data

Road Surface Condition

- Skid Resistance in SFC, (SCRIM)
- Pavement Rutting in mm, (Multi Laser Profilometer)
- Pavement Roughness in IRI (m/km), (Multi Laser Profilometer)
Crash Data & Traffic Volume

- Using Crash Stats (2014) database to obtain crash data for 3-5 years before and after treatment for each selected site.

- Traffic volume data for 3-5 years before and after treatment were collected from relevant road agency and used for calculating crash rates.
Analysis approach

- Descriptive analysis for distribution of crashes by different factors
- Assessment of before and after treatment
  - Paired Sample t-test
  - Graphical presentation
- Linear regression and univariate analysis using General Linear Model (GLM)
- Negative Binomial Regression using Generalised Linear Model
Descriptive Analysis (Distribution of crashes)

Distribution of Crashes by DCA Code (Type)

Before Treatment
- Pedestrian: 95
- Cross traffic: 52
- Right turn near: 38
- Head on: 9
- Right turn against: 70
- Rear end: 93

After Treatment
- Pedestrian: 81
- Cross traffic: 47
- Right turn near: 52
- Head on: 29
- Right turn against: 3
- Rear end: 85
- Others: 9

Distribution of Crashes by DCA Code (Type)
Descriptive Analysis (Distribution of crashes)

Distribution of Crashes by Severity

- **Serious Injury**
  - Before Treatment: 413
  - After Treatment: 331

- **Fatality**
  - Before Treatment: 18
  - After Treatment: 10

Distribution of Crashes by Surface Moisture Condition

- **Dry**
  - Before Treatment: 303
  - After Treatment: 277

- **Wet**
  - Before Treatment: 84
  - After Treatment: 51

- **Unknown**
  - Before Treatment: 15
  - After Treatment: 27
Distribution of Crashes by Light Condition

Distribution of Crashes by Road Geometry
Descriptive Analysis (Distribution of crashes)

- Before Treatment
- After Treatment

Speed Zone

Crash Frequency

- 0 km/hr
- 40 km/hr
- 50 km/hr
- 60 km/hr
- 70 km/hr
- 80 km/hr
- 90 km/hr
- 100 km/hr
- Others

Crash Frequency Distribution

- 0 km/hr: 0
- 40 km/hr: 2
- 50 km/hr: 8
- 60 km/hr: 117
- 70 km/hr: 98
- 80 km/hr: 169
- 90 km/hr: 7
- 100 km/hr: 1
- Others: 1

- 40 km/hr: 0
- 50 km/hr: 10
- 60 km/hr: 121
- 70 km/hr: 57
- 80 km/hr: 163
- 90 km/hr: 1
- 100 km/hr: 0
- Others: 2

Assessment of before and after treatment

<table>
<thead>
<tr>
<th>Type of Crash</th>
<th>Pairs</th>
<th>Mean Difference</th>
<th>Std. Deviation</th>
<th>t-stat</th>
<th>df</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High severity crashes</td>
<td>Crash rate before treatment</td>
<td>0.49</td>
<td>2.09</td>
<td>1.93</td>
<td>98</td>
<td>0.006</td>
</tr>
<tr>
<td></td>
<td>Crash rate after treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
High Severity Crashes vs Skid Resistance (SFC)
High Severity Crashes vs Roughness, IRI (m/km)

Before Treatment

After Treatment
High Severity Crashes vs Roughness, IRI (m/km)
High Severity Crashes vs Rutting (mm)
High Severity Crashes vs Rutting (mm)
Negative Binomial Regression

Before Treatment

Mean = .61
Std. Dev. = 1.093
N = 212

After Treatment

Mean = .40
Std. Dev. = .834
N = 212

Crash Frequency

Frequency
## Statistical Analysis-Before Treatment

### High Severity Crashes (N=212)

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficient</th>
<th>Std Error</th>
<th>P value</th>
<th>Exp (B)</th>
<th>IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>-.036</td>
<td>.1800</td>
<td>.843</td>
<td>.965</td>
<td></td>
</tr>
<tr>
<td>[Light_Condition, Night = .00]</td>
<td>-.450</td>
<td>.2366</td>
<td>.05</td>
<td>.638</td>
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</tr>
<tr>
<td>[Light_Condition, Day = 1.00]</td>
<td>0a</td>
<td>.</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>[Surface_MC, Wet = .00]</td>
<td>-1.206</td>
<td>.2525</td>
<td>.000</td>
<td>.299</td>
<td></td>
</tr>
<tr>
<td>[Surface_MC, Dry = 1.00]</td>
<td>0a</td>
<td>.</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CRoughness</td>
<td>-.017</td>
<td>.0983</td>
<td>.866</td>
<td>.984</td>
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</tr>
<tr>
<td>CRutting</td>
<td>-.029</td>
<td>.0495</td>
<td>.563</td>
<td>.972</td>
<td></td>
</tr>
<tr>
<td>CSkid Resistance</td>
<td>-2.989</td>
<td>1.9668</td>
<td>.129</td>
<td>.050</td>
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</tr>
<tr>
<td>CSpeed Limit</td>
<td>-.023</td>
<td>.0189</td>
<td>.227</td>
<td>.977</td>
<td></td>
</tr>
<tr>
<td>CRoughness*Log Traffic Volume</td>
<td>.007</td>
<td>.5699</td>
<td>.990</td>
<td>1.007</td>
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</tr>
<tr>
<td>CRutting*Log Traffic Volume</td>
<td>.044</td>
<td>.1768</td>
<td>.801</td>
<td>1.045</td>
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<tr>
<td>(Scale) 1b</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Negative binomial (Dispersion parameter)</td>
<td>.877</td>
<td>.3271</td>
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<td></td>
</tr>
<tr>
<td>Deviance/df</td>
<td>0.874</td>
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</tbody>
</table>
### Statistical Analysis - After Treatment

#### Parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Coefficient</th>
<th>Std Error</th>
<th>P value</th>
<th>Exp (B) IRR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.144</td>
<td>.1681</td>
<td>.392</td>
<td>.866</td>
</tr>
<tr>
<td>[Light Condition, Night = .00]</td>
<td>-1.041</td>
<td>.2739</td>
<td>.000</td>
<td>.353</td>
</tr>
<tr>
<td>[Light Condition, Day = 1.00]</td>
<td>0a</td>
<td>.</td>
<td>.</td>
<td>1</td>
</tr>
<tr>
<td>[Surface MC, Wet = .00]</td>
<td>-1.354</td>
<td>.2939</td>
<td>.000</td>
<td>.258</td>
</tr>
<tr>
<td>[Surface MC, Dry = 1.00]</td>
<td>0a</td>
<td>.</td>
<td>.</td>
<td>1</td>
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<tr>
<td>CRoughness</td>
<td>.047</td>
<td>.1498</td>
<td>.751</td>
<td>1.049</td>
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<tr>
<td>CRutting</td>
<td>-.118</td>
<td>.0866</td>
<td>.173</td>
<td>.889</td>
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<tr>
<td>Cskid Resistance</td>
<td>-1.575</td>
<td>2.4406</td>
<td>.519</td>
<td>.207</td>
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<td>CSpeed Limit</td>
<td>.011</td>
<td>.0201</td>
<td>.573</td>
<td>1.011</td>
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<tr>
<td>CRutting* Log Traffic Volume</td>
<td>-.395</td>
<td>.2974</td>
<td>.184</td>
<td>.674</td>
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<tr>
<td>CRutting* Speed Limit</td>
<td>-.035</td>
<td>.0114</td>
<td>.002</td>
<td>.965</td>
</tr>
</tbody>
</table>

**Note:**

- a: Scale
- b: Negative binomial (Dispersion parameter)

**Deviance/df:** 0.77
Conclusions

1. Statistically significant reductions were observed between before and after treatment in average crash rates for high severity crashes.

2. Overall the results indicate that negative binomial model fits the data well and is a suitable model for applying in crash frequency analysis.

2. Skid Resistance
   a) The relationship of crash rate fluctuates with respect to the different categories of skid resistance but generally smaller percentages of crashes are associated with the higher SFC categories.
   b) Skid resistance has significant contribution to crash occurrence, before treatment, through its interaction with log traffic volume.
Conclusions

3. Surface Roughness
   a) Before treatment, a fluctuating relationship between crash rates and different categories of roughness was found.
   b) After treatment, a decrease in crash rates was observed with increasing roughness.
   c) Has no significant contribution to crash occurrence before or after.

4. Rutting
   a) Before treatment a fluctuating pattern with a non obvious trend can be observed.
   b) After treatment the higher ranges of rutting are associated with lower crash rates.
   c) Has a significant contribution to crash occurrence, after treatment, through its interaction with speed limit.
Thank you for your attention