Motorcycle Safety and Roadside Barriers

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Dr. Mike Bambach

Transport and Road Safety (TARS) Research, UNSW

Why are road and traffic engineers installing wire-rope barriers?
Reducing tree impacts – chopping down trees to provide large clear zones? Little or no support from environmentalists

Safe System Approach – Safer Roads
Protection against tree impacts & hazards, drains, culverts, median cross over.

Wire-rope in combination with tactile line marking (rumble strips) – very effective in reducing fatal and serious injury fatigue crashes
Elephant in the room!

Large controversy with motorcyclists concerning installation of road safety barrier but in particular wire rope barriers.
All sorts of myths and claims being made concerning roadside barriers.

Project was started to look at the crash data and carry out in-depth analysis of barrier involved crashes in a scientific manner.
New Zealand Fatalities


Percentage of motorcycle death relative to all road deaths

UNSW
Percentage of motorcycle death relative to all road deaths

Motorcyclist killed as a percentage of the total road toll in Australia, NZ and USA

Source:
Road Safety Branch, Infrastructure and Surface Transport Policy, Department of Infrastructure, Transport, Regional Development and Local Government, NZ Transport Agency and FARS website and NZ Transport Agency data
Population of vehicles and motorcycles in Australian jurisdictions and New Zealand

<table>
<thead>
<tr>
<th>State</th>
<th>Total Vehicle Population</th>
<th>Motorcycle Population</th>
<th>Proportion of motorcycles (%) a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>224 076</td>
<td>8 022</td>
<td>3.58%</td>
</tr>
<tr>
<td>New South Wales</td>
<td>4 268 631</td>
<td>122 211</td>
<td>2.86%</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>114 015</td>
<td>3 950</td>
<td>3.46%</td>
</tr>
<tr>
<td>Queensland</td>
<td>2 897 867</td>
<td>110 501</td>
<td>3.81%</td>
</tr>
<tr>
<td>South Australia</td>
<td>1 137 957</td>
<td>33 772</td>
<td>2.97%</td>
</tr>
<tr>
<td>Tasmania</td>
<td>374 846</td>
<td>10 488</td>
<td>2.80%</td>
</tr>
<tr>
<td>Victoria</td>
<td>3 740 726</td>
<td>114 438</td>
<td>3.06%</td>
</tr>
<tr>
<td>Western Australia</td>
<td>1 600 566</td>
<td>59 675</td>
<td>3.73%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>3,308,142</td>
<td>49,283</td>
<td>1.49%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>14 358 684</strong></td>
<td><strong>512,340</strong></td>
<td><strong>2.90%</strong></td>
</tr>
</tbody>
</table>

a Motorcycles as a proportion of the population of registered motor vehicles 2006 data

Australian Motorcycle Registrations ≈ 3.2%
Fatalities ≈ 16% of all road fatalities

New Zealand Motorcycle Registrations ≈ 1.5%
Fatalities ≈ 10% of all road fatalities
Motorcycle impacts into roadside barriers
TARS research project

Partners

WA Office of Road Safety, WA Main Roads
Australian Automobile Association
NSW Centre for Road Safety (formerly RTA – Tf NSW)
NSW Motor Accidents Authority
New Zealand Transport Agency

Research Investigators

Raphael Grzebieta (Team leader)
Mike Bambach (injury mechanisms & statistics)
Hussein Jama (statistics)
Andrew McIntosh (biomechanics)
Rena Friswell (causation & epidemiology)
Rob Smith (motorcycle expert)
Motorcycle impacts into roadside barriers
TARS research project

Scientific Advisory Committee (includes researchers)
Soames Job – NSW Roads and Traffic Authority
Michael de Roos – (formerly) NSW Roads and Traffic Authority
Wal Smart – NSW Roads and Traffic Authority
David Pratt – NSW Roads and Traffic Authority
Iain Cameron – West Australian Office of Road Safety
Brian Kidd – West Australian Main Roads
Jan Karpinski - West Australian Main Roads
Fergus Tate – New Zealand Transport Agency
(formerly Fabian Marsh: New Zealand Land Transport Agency)
Craig Newland – Australian Automobile Association
Dimitra Vlahoporitros – (formerly) NSW Motor Accidents Authority
Clay Gabler – Virginia Tech, USA

Methodology

✓ Statistics (fatalities & serious injury)

✓ Determine causal factors (other vehicle, speed, alcohol, fatigue, bad cornering, inexperience, human error?, etc)

✓ Determine biomechanical injury causal mechanism/s
Methodology

✓ Determine survivable and non-survivable impact envelopes

≈ Reconstruct crashes & computer simulation

? Develop / investigate injury mitigation strategies and assess their effectiveness

? Carry out crash tests

Motorcycle impacts into roadside barriers
TARS research project

Motorcycle into Barrier Fatalities

2001 - 2006 National Coroners Information System data

2001 – 2006 Crash Analysis System (CAS) of the New Zealand Transport Agency

In-depth investigation of fatal crashes where information is available

Infrastructure only addressing at best only 6% of fatalities in Australia and 2% in NZ

Motorbike Crashes 2001-2006

<table>
<thead>
<tr>
<th>State</th>
<th>Total MC fatalities</th>
<th>Barrier related MC fatalities</th>
<th>Non-barrier MC fatalities</th>
<th>Not known</th>
<th>Barrier/Known (%)</th>
<th>CI 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Capital Territory</td>
<td>21</td>
<td>4</td>
<td>17</td>
<td>0</td>
<td>19.0%</td>
<td>7.7 - 40.0</td>
</tr>
<tr>
<td>New South Wales</td>
<td>335</td>
<td>23</td>
<td>277</td>
<td>35</td>
<td>7.7%</td>
<td>5.2 - 11.2</td>
</tr>
<tr>
<td>North Territory</td>
<td>19</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0%</td>
<td>~~~</td>
</tr>
<tr>
<td>Queensland</td>
<td>266</td>
<td>13</td>
<td>251</td>
<td>2</td>
<td>4.9%</td>
<td>2.9 - 8.2</td>
</tr>
<tr>
<td>South Australia</td>
<td>121</td>
<td>13</td>
<td>108</td>
<td>0</td>
<td>10.7%</td>
<td>6.4 - 17.5</td>
</tr>
<tr>
<td>Tasmania</td>
<td>48</td>
<td>8</td>
<td>40</td>
<td>0</td>
<td>16.7%</td>
<td>8.7 - 29.6</td>
</tr>
<tr>
<td>Victoria</td>
<td>309</td>
<td>10</td>
<td>299</td>
<td>0</td>
<td>3.2%</td>
<td>2.0 - 6.3</td>
</tr>
<tr>
<td>Western Australia</td>
<td>142</td>
<td>2</td>
<td>140</td>
<td>0</td>
<td>1.4%</td>
<td>0.3 - 4.9</td>
</tr>
<tr>
<td>Total Australia</td>
<td>1261</td>
<td>73</td>
<td>1149</td>
<td>37</td>
<td>6.0%</td>
<td>5.2 - 8.0</td>
</tr>
<tr>
<td>New Zealand</td>
<td>201</td>
<td>4</td>
<td>196</td>
<td>0</td>
<td>2.0%</td>
<td>0.8 - 5.0</td>
</tr>
<tr>
<td>Total</td>
<td>1462</td>
<td>77</td>
<td>834</td>
<td>38</td>
<td>5.4%</td>
<td>4.4 - 6.8</td>
</tr>
</tbody>
</table>

Motorcycle into Barrier Fatalities

National Coroners Information System - findings

Motorbike Crashes 2001-2006

Motorcycle into Barrier Fatalities

TIME of Day (Afternoons)

N=77

- New Zealand
- Australia

Weather Conditions – dry weather

N=77

- New Zealand
- Australia

Motorcycle into Barrier Fatalities

**DAY of Crash** (mostly weekends & recreational for Australia. Weekdays for New Zealand)

<table>
<thead>
<tr>
<th>Day</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mon</td>
<td>1</td>
</tr>
<tr>
<td>Tues</td>
<td>5</td>
</tr>
<tr>
<td>Wed</td>
<td>10</td>
</tr>
<tr>
<td>Thurs</td>
<td>5</td>
</tr>
<tr>
<td>Friday</td>
<td>10</td>
</tr>
<tr>
<td>Sat</td>
<td>22</td>
</tr>
<tr>
<td>Sun</td>
<td>22</td>
</tr>
</tbody>
</table>

N=77

- New Zealand
- Australia


Motorcycle into Barrier Fatalities

**Gender**

Male 71    Females 6 (of which 4 were female pillions)

Worth noting: ABS data shows between 2001 and 2006, only 5.0% of all riders (including pillion passengers) killed in a motorcycle crash were female.

### Motorcycle into Barrier Fatalities

#### Installed Lengths - Australia

W beam comprises 71.5% of the barriers and results in 72.7% of the fatalities; Concrete comprises 8.6% of the barriers and results in 10.4% of the fatalities; and Wire rope comprises 15.9% of the barriers and results in 7.8% of the fatalities.

**Wire rope barriers have around half the fatality rate of W beam barriers and around 0.4 of concrete barriers – concrete most dangerous**

<table>
<thead>
<tr>
<th>State</th>
<th>Total road length (kms)</th>
<th>Total length of roadside barriers (kms)</th>
<th>Steel Barrier length (kms)</th>
<th>Concrete barrier length (kms)</th>
<th>Wire rope barrier length (kms)</th>
<th>Other (kms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New South Wales</td>
<td>17,818</td>
<td>2,272.0</td>
<td>1,825.0</td>
<td>152.0</td>
<td>295.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Queensland</td>
<td>35,000</td>
<td>1,511.0</td>
<td>1,118.0</td>
<td>264.0</td>
<td>121.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Tasmania</td>
<td>3,900</td>
<td>521.5</td>
<td>245.2</td>
<td>8.5</td>
<td>88.4</td>
<td>213.9</td>
</tr>
<tr>
<td>Victoria</td>
<td>23,300</td>
<td>1,726.0</td>
<td>1,263.0</td>
<td>*</td>
<td>463.0</td>
<td>*</td>
</tr>
<tr>
<td>Western Australia</td>
<td>18,024</td>
<td>370.0</td>
<td>212.2</td>
<td>60.4</td>
<td>97.2</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total Australian</strong></td>
<td><strong>98,042</strong></td>
<td><strong>6,400.5</strong></td>
<td><strong>4663.4</strong></td>
<td><strong>484.9</strong></td>
<td><strong>1,064.6</strong></td>
<td><strong>221.9</strong></td>
</tr>
<tr>
<td><strong>Total New Zealand</strong></td>
<td><strong>10,800</strong></td>
<td><strong>1,383</strong></td>
<td><strong>902</strong></td>
<td><strong>188</strong></td>
<td><strong>170</strong></td>
<td><strong>123</strong></td>
</tr>
</tbody>
</table>

*These figures refer to the roadways managed by the state authorities and excludes roads managed by the local government authorities such as councils and shires.*

*not available

**Installed lengths of roadside barriers along roads in Australia and New Zealand**

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Motorcycle into Barrier Fatalities

Road type – predominantly bends (N=77)

Motorcycle into Barrier Fatalities

Hazard type protected – mostly trees

Speed a major factor

43 cases – speeding

Average posted maximum speed limit for these cases was 85.6km/h

Average riding speed was 99.1km/h

Instances of rider estimated to be travelling at twice the speed limit, i.e. 200km/h in a 100km/h zone and 150km/h on a 70km/h speed zone
Motorcycle into Barrier Fatalities

Speed, alcohol, drugs or a combination of the three were a factor in 2 in every 3 crashes


Updating NZ motorcycle-barrier crash data
(funder: NZ Accident Compensation Corporation ACC)

• Non-fatal cases – CAS (non-injury, minor injury, serious injury)
• Fatal cases – identified on CAS then Coronial files collected
• Study period: January 2001 to July 2013

Total motorcycle fatalities over this period is around 425, i.e. around 5% of all motorcycle fatalities

Non-injury = 17
Minor injury = 102
Serious injury = 89
Fatal = 20

Non-injury, minor injury, serious injury

Transport and Road Safety (TARS) Research

Total vehicle fatalities over this period is around 4384, i.e. around 0.5% of all road fatalities
Updating NZ motorcycle-barrier crash data
(funder: NZ Accident Compensation Corporation ACC)

- Non-fatal cases – CAS does not provide barrier type
- Fatal cases - barrier types determined from Coronal files:
  - W-beam = 13
  - Wire rope = 3
  - Other = 2 (wood rail and bridge barrier)
  - Open file = 2

Comparison with other single-vehicle fixed-object collisions:
- Post/pole = 97
- Traffic sign = 70
- Tree = 93

Rate of Serious injury or Fatality (FSI ratio):
- Guardrail = 0.47
- Post/pole = 0.61
- Traffic sign = 0.55
- Tree = 0.51

Roadside barriers provide a reduction in injury risk to motorcyclists, compared with trees, posts, signs and utility poles.
Survivability Analysis

No Australian or New Zealand data:

- used US NASS data which is on-line
- weighted sample of 30,000 single-vehicle fixed object collisions – 2000 to 2009
- 50,000 police incident reports sampled from 5.8 million annual police-reported crashes that include a fatality, injury and property damage only crashes.


Survivability Analysis

Single variable logistic regression model developed for fatality risk from fixed object collisions as function of travel speed
Odds ratios for the probability of fatality conditional upon a motorcyclist being involved in a collision with a fixed object assuming all other variables remain the same ($n_{weighted} = 29,305$)

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>pole vs barrier</td>
<td>1.888</td>
<td>0.918, 3.882</td>
</tr>
<tr>
<td>tree vs barrier</td>
<td>3.587</td>
<td>1.841, 6.990</td>
</tr>
<tr>
<td>other vs barrier</td>
<td>0.853</td>
<td>0.484, 1.504</td>
</tr>
</tbody>
</table>

What is a survivable impact?

20 km/h?

What is a survivable impact?

Hitting an object at 30 km/h is equivalent to jumping off the roof of a house.

At 60 km/h, driving off a 3 story building.

At 80 km/h, driving off a 6 story building.

At 100 km/h, driving off a 10 storey building.
Motorcyclist - What is a survivable impact?

Motorcyclist fatality risk profiles, rural roadway departure into a tree or utility pole, for road safety measures; a) None, b) Install a barrier, c) Speed not exceeding the speed limit, d) Helmet use, e) All measures (b, c and d).


Methods

- **Design** – retrospective analysis of linked police-reported crash data and hospitalisation data in NSW, 2001 – 2009 (inclusive)
- **Data sources** – Admitted Patient Data Collection (APDC – NSW Health) and CrashLink (Centre for Road Safety, Transport for NSW)
- **Data linkage** – probabilistic data linkage performed by the Centre for Health Record Linkage (CHeReL)
- **Inclusions** – motorcyclists in CrashLink that were injured or killed as a result of a single-vehicle collision with a fixed object (W-beam/guardrail, concrete barrier, culvert, embankment, post, tree and utility pole)
- **Statistical analysis** – SI values determined from three methods; FSI ratios, major injury rates and logistic regression
Methods

• **FSI ratios** – fatally or seriously injured persons as a ratio of all persons:

\[
FSI = \frac{\sum FSI_i}{\sum Persons_i}
\]

‘seriously injured’ is defined as admitted to hospital (linked APDC record)

• **Major injury rates** – number of individual major injuries sustained per 100 motorcyclist collisions:

\[
MI\ rate = \frac{\sum major\ injuries \times 100}{\sum\ collisions}
\]

‘major injury’ is defined as an ICD-10 injury code with a mortality ≥ 3.5%

• **Logistic regression** – odds ratios of fixed objects compared with barriers, controlling for confounding using crash variables in CrashLink

Results – descriptive

1,364 – motorcyclists in single-vehicle collisions with fixed objects

352 – tree (26%)
291 – guardrail (21%)
247 – embankment (18%)
226 – post (17%)
111 – culvert (8%)
95 – utility pole (7%)
42 – concrete barrier (3%)
Results – descriptive

1,364 – motorcyclists in single-vehicle collisions with fixed objects

<table>
<thead>
<tr>
<th>Condition</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speeding related</td>
<td>967</td>
<td>70.9</td>
</tr>
<tr>
<td>BAC over 0.05</td>
<td>156</td>
<td>11.4</td>
</tr>
<tr>
<td>Curve location</td>
<td>1076</td>
<td>78.9</td>
</tr>
<tr>
<td>Dry roadway</td>
<td>1235</td>
<td>90.5</td>
</tr>
<tr>
<td>Helmet</td>
<td>1196</td>
<td>87.7</td>
</tr>
<tr>
<td>Operator</td>
<td>1271</td>
<td>93.2</td>
</tr>
<tr>
<td>Male</td>
<td>1235</td>
<td>90.5</td>
</tr>
<tr>
<td>Intersection location</td>
<td>157</td>
<td>11.5</td>
</tr>
<tr>
<td>Speed zone &lt;100km/h</td>
<td>961</td>
<td>70.5</td>
</tr>
<tr>
<td>Highway/freeway location</td>
<td>256</td>
<td>18.8</td>
</tr>
<tr>
<td>Sealed roadway</td>
<td>1256</td>
<td>92.1</td>
</tr>
<tr>
<td>Occurred in daytime</td>
<td>1041</td>
<td>76.3</td>
</tr>
<tr>
<td>Equipment failure</td>
<td>19</td>
<td>1.4</td>
</tr>
<tr>
<td>Fatigue related</td>
<td>291</td>
<td>21.3</td>
</tr>
<tr>
<td>Seriously injured</td>
<td>756</td>
<td>55.4</td>
</tr>
<tr>
<td>Fatally injured</td>
<td>130</td>
<td>9.5</td>
</tr>
<tr>
<td>FSI</td>
<td>886</td>
<td>65.0</td>
</tr>
</tbody>
</table>

Results – descriptive

Major injuries* per 100 collisions

*ICD-10 injuries with mortality ≥ 3.5%
Results – Severity Indices

<table>
<thead>
<tr>
<th></th>
<th>FSI ratio</th>
<th>FSI 95% CL_U</th>
<th>FSI 95% CL_L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>0.63</td>
<td>0.72</td>
<td>0.55</td>
</tr>
<tr>
<td>Post</td>
<td>0.67</td>
<td>0.78</td>
<td>0.56</td>
</tr>
<tr>
<td>Tree</td>
<td>0.71</td>
<td>0.79</td>
<td>0.61</td>
</tr>
<tr>
<td>Utility pole</td>
<td>0.74</td>
<td>0.91</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Barrier = guardrail + concrete barrier aggregated

<table>
<thead>
<tr>
<th></th>
<th>FSI ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>0.63</td>
</tr>
<tr>
<td>Post</td>
<td>0.67</td>
</tr>
<tr>
<td>Tree</td>
<td>0.71</td>
</tr>
<tr>
<td>Utility pole</td>
<td>0.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Major injury rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>74</td>
</tr>
<tr>
<td>Post</td>
<td>138</td>
</tr>
<tr>
<td>Tree</td>
<td>135</td>
</tr>
<tr>
<td>Utility pole</td>
<td>167</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>FSI Relative to barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>1</td>
</tr>
<tr>
<td>Post</td>
<td>1.06</td>
</tr>
<tr>
<td>Tree</td>
<td>1.11</td>
</tr>
<tr>
<td>Utility pole</td>
<td>1.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Logistic regression* Relative to barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>1</td>
</tr>
<tr>
<td>Post</td>
<td>1.26</td>
</tr>
<tr>
<td>Tree</td>
<td>1.34</td>
</tr>
<tr>
<td>Utility pole</td>
<td>1.40</td>
</tr>
</tbody>
</table>

*outcome = sustaining at least one major injury or killed

<table>
<thead>
<tr>
<th></th>
<th>Major injury rate Relative to barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>1</td>
</tr>
<tr>
<td>Post</td>
<td>1.67</td>
</tr>
<tr>
<td>Tree</td>
<td>1.65</td>
</tr>
<tr>
<td>Utility pole</td>
<td>2.07</td>
</tr>
</tbody>
</table>
Results – Severity Indices

• FSI method has been proposed for passenger vehicle occupants (Jurewicz et al 2012)

<table>
<thead>
<tr>
<th>FSI Relative to barriers</th>
<th>FSI (Jurewicz et al 2012) Relative to barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barrier</td>
<td>passenger vehicles</td>
</tr>
<tr>
<td>Post</td>
<td>0.36</td>
</tr>
<tr>
<td>Tree</td>
<td>0.52</td>
</tr>
<tr>
<td>Utility pole</td>
<td>0.55</td>
</tr>
</tbody>
</table>

• Magnitudes of motorcycle FSI are larger than those for passenger vehicle occupants (motorcyclists are unprotected by a structure)


• Relative to barriers, magnitudes for motorcyclists are smaller (barriers are less effective in reducing injury risk for motorcyclists than for passenger vehicle occupants)

there is scope to improve roadside barriers for motorcyclist collisions
Impact kinematics:

Motorcycle into Barrier Fatalities

Other studies

DEKRA – Germany

82% involved a steel barrier

51% of 57 cases analysed motorcycle impacted the barrier while driving in an upright position

45% occurred where the motorcycle slid on its side on the road surface before it first struck the barrier.


Motorcycle into Barrier Fatalities


Motorcycle into Barrier Fatalities

a) Number of motorcyclists who received 1 or more AIS 3+ injuries in each body region; b) Number of motorcyclists who received the most severe injury (MAIS) in each body region (and % of total of 70)

Impact kinematics

<table>
<thead>
<tr>
<th>Injured body region</th>
<th>Odds ratio</th>
<th>95% CI lower</th>
<th>95% CI upper</th>
<th>Chi-squared</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head</td>
<td>0.97</td>
<td>0.33</td>
<td>2.84</td>
<td></td>
<td>0.960</td>
</tr>
<tr>
<td>Neck</td>
<td>0.23</td>
<td>0.02</td>
<td>2.40</td>
<td></td>
<td>0.186</td>
</tr>
<tr>
<td>Thorax</td>
<td>4.67</td>
<td>1.08</td>
<td>20.14</td>
<td></td>
<td>0.029</td>
</tr>
<tr>
<td>Abdomen</td>
<td>2.04</td>
<td>0.47</td>
<td>8.91</td>
<td></td>
<td>0.329</td>
</tr>
<tr>
<td>Spine</td>
<td>1.46</td>
<td>0.37</td>
<td>5.71</td>
<td></td>
<td>0.584</td>
</tr>
<tr>
<td>Upper ext.</td>
<td>0.37</td>
<td>0.03</td>
<td>4.30</td>
<td></td>
<td>0.409</td>
</tr>
<tr>
<td>Lower ext.</td>
<td>1.75</td>
<td>0.56</td>
<td>5.45</td>
<td></td>
<td>0.326</td>
</tr>
<tr>
<td>Pelvis</td>
<td>9.41</td>
<td>1.10</td>
<td>80.54</td>
<td></td>
<td>0.011</td>
</tr>
</tbody>
</table>

Odds ratios and 95% confidence intervals for injuries occurring to those that crashed sliding into a W beam, compared to those impacting a W beam in the upright posture.
ECE Standard – Only head injury criterion

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Biomechanical limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resultant head acceleration</td>
<td>220 g</td>
</tr>
<tr>
<td>HIC</td>
<td>1000</td>
</tr>
<tr>
<td>Neck flexional moment</td>
<td>190 Nm</td>
</tr>
<tr>
<td>Neck extension moment</td>
<td>57 Nm</td>
</tr>
</tbody>
</table>

60 km/h


---

ECE Standard – No thorax Injury

<table>
<thead>
<tr>
<th>Barrier type</th>
<th>Angle (°)</th>
<th>Barrier impact speed range (km/h)</th>
<th>ISS</th>
<th>MAIS</th>
<th>MAIS body region(s)</th>
<th>AIS3+ injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>W beam</td>
<td>80°</td>
<td>50-83</td>
<td>32</td>
<td>5</td>
<td>Thorax</td>
<td>&gt;3 ribs fractured, lacerated aorta, ruptured diaphragm, haemopericardium, pelvic ring fracture</td>
</tr>
<tr>
<td>W beam</td>
<td>27-64</td>
<td>75</td>
<td>6</td>
<td>4</td>
<td>Thorax</td>
<td>&gt;3 ribs fractured, venricular rupture of the heart, major haemothorax, major spleen laceration, cerebral subdural hematoma</td>
</tr>
<tr>
<td>W beam</td>
<td>16</td>
<td>49-66</td>
<td>75</td>
<td>5</td>
<td>Thorax, Spine</td>
<td>Bilateral flail chest, perforated heart, haemothorax, cervical cord laceration, humoral cord laceration</td>
</tr>
<tr>
<td>Wire rope</td>
<td>32-65</td>
<td>16</td>
<td>4</td>
<td>5</td>
<td>Thorax</td>
<td>&gt;3 ribs fractured, major haemothorax</td>
</tr>
<tr>
<td>W beam</td>
<td>26-63</td>
<td>43</td>
<td>5</td>
<td>3</td>
<td>Spine</td>
<td>Thoracic cord laceration with fracture, haemothorax, intracerebral hematomas, femur fractures</td>
</tr>
<tr>
<td>W beam</td>
<td>18</td>
<td>29-66</td>
<td>18</td>
<td>3</td>
<td>Thorax, Lower ext.</td>
<td>&gt;3 ribs fractured, major unilateral lung contusion, unilateral lung laceration, haemothorax, open tibia shaft fracture</td>
</tr>
<tr>
<td>W beam</td>
<td>9</td>
<td>61-82</td>
<td>9</td>
<td>3</td>
<td>Thorax</td>
<td>&gt;3 ribs fractured, haemothorax</td>
</tr>
<tr>
<td>W beam</td>
<td>10</td>
<td>50-83</td>
<td>32</td>
<td>4</td>
<td>Thorax, Upper ext.</td>
<td>&gt;3 ribs fractured, lacerated aorta, minor unilateral lung laceration, haemothorax, arm amputation at shoulder</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>60°</td>
<td>16</td>
<td>4</td>
<td>Thorax</td>
<td>&gt;3 ribs fractured, bilateral lung contusion, major haemothorax</td>
</tr>
<tr>
<td>W beam</td>
<td>24</td>
<td>40-62</td>
<td>41</td>
<td>5</td>
<td>Abdomen</td>
<td>Unilateral flail chest with &gt;3 ribs fractured, major unilateral lung laceration, ruptured diaphragm, stomach, intest and spleen, renal artery and vein lacerations, major haemothorax</td>
</tr>
<tr>
<td>W beam</td>
<td>32</td>
<td>55-77</td>
<td>18</td>
<td>3</td>
<td>Thorax, Lower ext.</td>
<td>&gt;3 ribs fractured, both femurs fractured</td>
</tr>
</tbody>
</table>

* pre-crash speed shown since slide measurements were not available

Top of W-beam is very dangerous

Motorcycle into Barrier Fatalities

Wire-rope barrier installation

• NZ Centenial Highway

  – 1996 to 2000: 8 fatalities, 2 serious injury and 7 minor

  – 2001 to 2004 removed passing lanes & wide yellow double tactile lines & reflectors & signs: 4 fatalities 2 serious injuries 2 minor injuries

  – 2005 to 2009 installed wire-rope median barriers and dropped speed limit to 80 km/h: **No fatalities, No serious injuries**, 3 minor injuries.


**New Zealand**

**Centennial Highway – actual incident**

Source: Fabian Marsh, New Zealand Transport Agency, Wellington
Having found 2 in every 3 fatalities involved speed, alcohol drugs or a combination of any one of these, decided to look at all motorcycle fatalities for the same period.

**2001 - 2006**

**TOTAL MOTORCYCLE FATALITIES IN AUSTRALIA**

<table>
<thead>
<tr>
<th></th>
<th>ACT</th>
<th>NSW</th>
<th>NT</th>
<th>QLD</th>
<th>SA</th>
<th>TAS</th>
<th>VIC</th>
<th>WA</th>
<th>TOTAL</th>
</tr>
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<tbody>
<tr>
<td>2001</td>
<td>2</td>
<td>66</td>
<td>5</td>
<td>36</td>
<td>17</td>
<td>7</td>
<td>69</td>
<td>33</td>
<td>235</td>
</tr>
<tr>
<td>2002</td>
<td>2</td>
<td>51</td>
<td>4</td>
<td>54</td>
<td>23</td>
<td>10</td>
<td>61</td>
<td>24</td>
<td>229</td>
</tr>
<tr>
<td>2003</td>
<td>1</td>
<td>59</td>
<td>1</td>
<td>43</td>
<td>15</td>
<td>11</td>
<td>41</td>
<td>25</td>
<td>196</td>
</tr>
<tr>
<td>2004</td>
<td>4</td>
<td>38</td>
<td>0</td>
<td>50</td>
<td>21</td>
<td>7</td>
<td>40</td>
<td>25</td>
<td>185</td>
</tr>
<tr>
<td>2005</td>
<td>9</td>
<td>55</td>
<td>3</td>
<td>72</td>
<td>21</td>
<td>7</td>
<td>52</td>
<td>26</td>
<td>245</td>
</tr>
<tr>
<td>2006</td>
<td>3</td>
<td>49</td>
<td>6</td>
<td>61</td>
<td>28</td>
<td>7</td>
<td>49</td>
<td>30</td>
<td>233</td>
</tr>
</tbody>
</table>

*number of closed cases increased since the barrier study completed in 2008 – this most recent study carried out in Sept 2011

**Total Fatalities 1323***

*All fatalities*
All fatalities

![Bar chart showing total fatalities by Australian jurisdictions.](chart1)

All fatalities – day of crash

![Bar chart showing fatalities by day of the week.](chart2)
All fatalities – weather

All fatalities – road alignment
All fatalities - gender

Of 1323 fatalities, 95% were male and 5% of riders and pillion passengers (4%) were female.

22 out of 65 crashes (1 in every 3) involving a female fatality were pillion passengers.

All fatalities – crash mode

Motorcycle fatalities predominantly occur as a result of a collision with another vehicle (56%) or a single-vehicle collision with a fixed roadside object (39%).

Most common crash modes were a motorcyclist impacting the side of a car at an intersection, or a tree, utility pole, post or roadside barrier on a bend.
764 available toxicology reports available

359 motorcyclists had consumed alcohol and/or drugs prior to the crash (47% of 764)

233 motorcyclists (30%) had consumed alcohol prior to the crash [167 (72% of the 233) had alcohol levels above the legal limit of a BAC of 0.05]

illicit drugs detected for 207 motorcyclists (27%)

102 motorcyclists (13%) used more than one type of illicit drug and 81 motorcyclists used illicit drugs and alcohol (11%)

majority was cannabis (68%)

All fatalities – speed

355 motorcyclists excessive speed was identified

excessive speed as a proportion of all 1,323 cases was 27%

146 motorcyclists disobeyed a traffic control (11%)
663 motorcyclists (50%) of all 1,323 fatalities, risky riding behaviour was identified as a contributing causal factor in the crash (speed, alcohol, drugs, disobeying a traffic control, or any combination)

1 in every 2 crashes


Motorcycle impacts into roadside barriers
TARS research project – SIMULATION PHASE

Australasian motorcycle-barrier data

- 47% upright posture, 44% sliding posture
- 30-50% of serious injuries (AIS3+) are thoracic
- We need a motorcyclist-barrier crash test protocol that includes thoracic injury measures and upright collision postures

Crash tests are expensive – test protocols can be assessed first with computer simulations
- Total Human Model for Safety (THUMS) 50th percentile adult male
- High-resolution CT scans, around 2 million elements
- NCAC steel W-beam barrier model, around 125,000 elements
Possible chest injury mechanisms

- Post impact – lateral
- Post impact - frontal
- W-beam impact
Head-neck injury mechanism
Some possible crash test protocols with ATDs
Reconstruct crashes & computer simulation
Currently underway

Develop / investigate injury mitigation strategies and assess their effectiveness (Post padding, rub rails, post caps and covers, pole and sign protection – what are their limitations – at what speeds can one survive and at what injury level?)
Future work

Carry out crash tests – measure impact loads and confirm simulations.

Develop the current ECE standard to also include the Thorax injury measures and an upright test. Incorporate this into AS/NZ Australian Standard for Road Safety Barriers. Can be used for any system that is used to protect other hazards.

Summary

• Motorcycle fatalities resulting from roadside barriers crashes are low at around 5 to 6% - around 1.5 per year nation wide of around 35 fatalities

• Speed, alcohol, drugs or combination of any three in 2 out of every 3 fatalities

(this compares to 1 in every 2 for all motorcycle fatalities)
Summary

• About a 50/50 split between sliding and impacting upright

• Guardrail impacts are the most dangerous and often struck – mostly exposure an issue

• Concrete barrier impacts can also be dangerous but low numbers – all upright – no sliding fatalities

• Wire-rope fatal impacts are also low.

70 – 80% reduction in road fatalities wherever installed which is why they are being installed

Summary

• Cheese cutter effect is a Myth that needs to be strongly rebutted

• Cutting a tensioned cable will cut you in half is a Myth (myth busters ‘pig test’)

• Solutions exist to reduce motorcycle fatalities – but credible science must be used so as not to effect all road users and gains to date – rub rails and skirting should not cause a vehicle to launch
Summary

• Predominantly chest injuries - European motorcycle barrier standard - no chest injury measurement or criterion - only HIC

• Trees and poles greater fatality risk than roadside barriers – indicates deployment of a barrier to protect road users from trees and poles reduces motorcyclists risk

• 95% killed in motorcycle crashes are male - large proportion of females killed are pillions. Training/education needs to target males

Recommendations

• Retrofitting roadside barriers and infrastructure furniture with padding, rub rails, etc. and installing more expensive motorcycle ‘friendly’ barriers will have minimal effect on reducing motorcycle fatalities and injuries. Such crashes only constitute around 6% of motorcycle fatalities and serious injuries and only around 0.5% of all road users fatalities.

• Installing roadside and median barriers – particularly wire-rope barriers - has a beneficial effect of around 50 to 60% in terms of reducing motorcycle casualties.
Recommendations

• Installing more median and roadside barriers and addressing drunk, drugged, speeding or disobeying a road law (e.g. running a red light) risky behaviour will yield greater gains in reducing casualties.

• Target higher volume/higher serious casualty motorcycle routes (Great Ocean Road, Gorge Road, etc.) for any retrofit or motorcycle friendly routes but combine with speed enforcement to account for risk compensation phenomenon.

BASYC motorcycle barrier protection

Recommendations

• Require that a person must have a full driver’s licence before they can apply for a motorcycle licence.

• "returning" riders: Re-testing at various intervals in order to retain licence currency (once obtained it seems they remain forever, even if no riding has occurred for years.)

• Require ISA speed limiters for motorcycles.

• Require alcohol interlocks for motorcycles.

Recommendations

• Require ABS breaking.

• For barrier testing, introduce an upright test and require measurement of chest accelerations and compression.

• Continue research on frangible posts for motorcycle impact for wire-rope barriers

• Continue research on post padding, rub rails, post caps, etc.
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Australian Automobile Association
NSW Centre for Road Safety (Trans for NSW)
NSW Motor Accidents Authority
New Zealand Land Transport Agency

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