Severity Indices for Motorcyclist Collisions with Roadside Hazards and Barriers

Never Stand Still | Science | Transport and Road Safety (TARS) Research, School of Aviation

Mike Bambach
Rebecca Mitchell
Raphael Grzebieta

Background

- In Australia, 39% of motorcyclist fatalities result from collisions with fixed objects
- Trees, utility poles, posts and roadside barriers are the fixed hazards most frequently struck (77%)
- The Australian Guide to Road Design provides procedures for the risk-based design process for the deployment of a roadside barrier to protect road users from fixed hazards
- The procedure uses Severity Indices (SI) for different fixed objects
- The guide states: “It should be noted that the severity indices are valid for occupants of light vehicles, and are not suitable for motorcyclists….”
- **What SI values should be used for motorcyclists generally, and especially when considering popular motorcycling routes?**

Aims

- Develop SI values specifically for motorcyclists
- Thereby improve the consideration of motorcyclists in roadside design

Introduction to SI method

- The Austroads Guide to Road Design - Part 6: Roadside Design, Safety and Barriers provides several cost-benefit procedures;

  n is the number of collisions into object

  c is the crash cost relevant to the SI value of object

- Crash cost = $\mathbf{n_1 \times c_1}$
- Treatment cost = ($\mathbf{n_2 \times c_2}$) **+** (installation/maintenance costs)
- Benefit-cost ratio = Crash cost / Treatment cost

  e.g. $SI_{barrier}$ = 2.0 and $c_{barrier}$ = \$11k

  SI_{pole} = 3.7 and c_{pole} = \$84k

- NB: computer programs RISC, RSAP, RSRM and the AASHTO and VicRoads methods are similar

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:

$$MI\ rate = \frac{\sum major\ injuries\ x\ 100}{\sum collisions}$$

'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%)

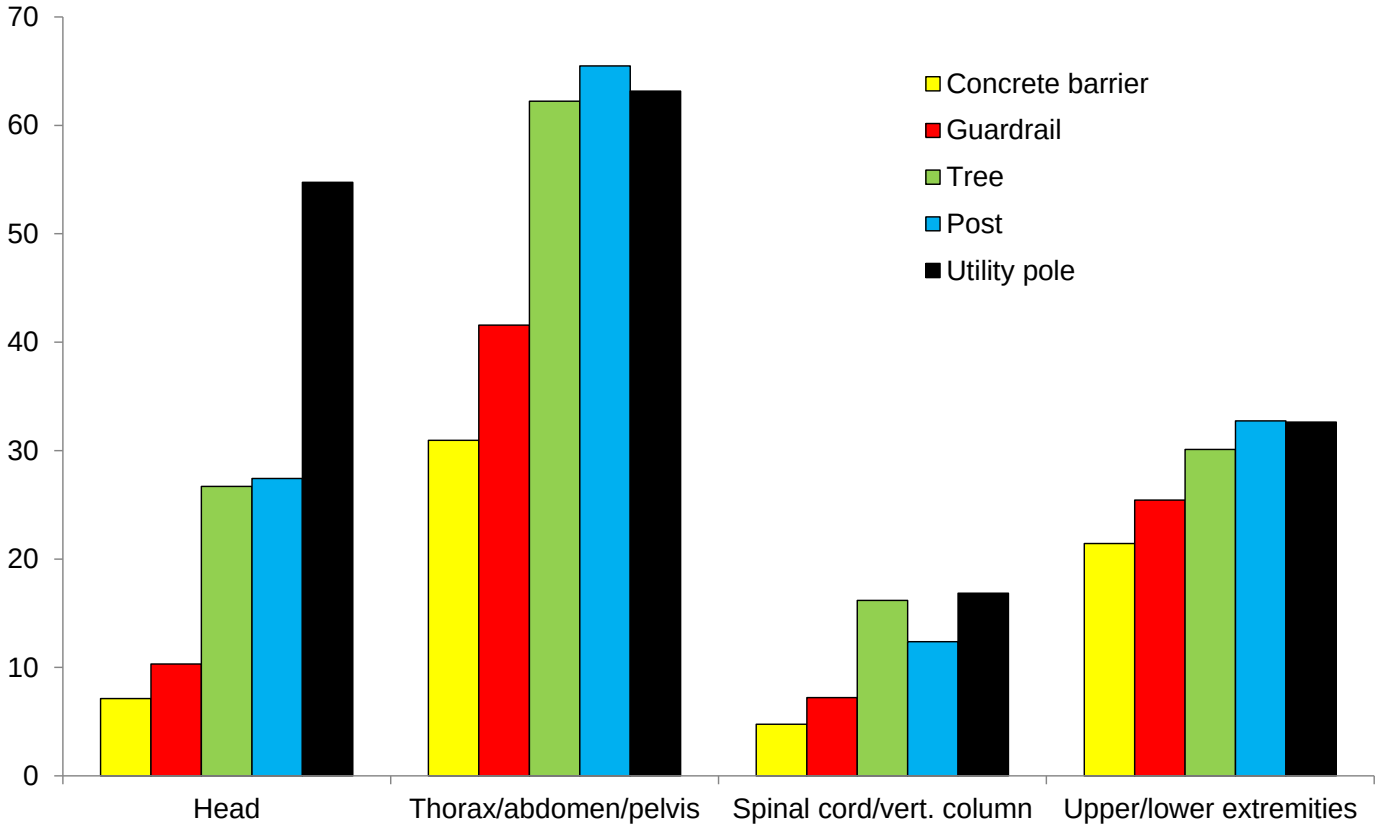
Results – descriptive

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

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

Results – descriptive

Major injuries* per 100 collisions



*ICD-10 injuries with mortality ≥ 3.5%

Results – Severity Indices

	FSI ratio	FSI 95% CL_U	FSI 95% CL_L
Barrier	0.63	0.72	0.55
Post	0.67	0.78	0.56
Tree	0.71	0.79	0.61
Utility pole	0.74	0.91	0.56

Barrier = guardrail + concrete barrier aggregated

Results – Severity Indices

	FSI ratio
Barrier	0.63
Post	0.67
Tree	0.71
Utility pole	0.74

	Major injury rate
Barrier	74
Post	138
Tree	135
Utility pole	167

Results – Severity Indices

	FSI ratio
Barrier	0.63
Post	0.67
Tree	0.71
Utility pole	0.74

	FSI Relative to barriers
Barrier	1
Post	1.06
Tree	1.11
Utility pole	1.16

	Logistic regression* Relative to barriers
Barrier	1
Post	1.26
Tree	1.34
Utility pole	1.40

*outcome = sustaining at least one major injury or killed

	Major injury rate
Barrier	74
Post	138
Tree	135
Utility pole	167

	Major injury rate Relative to barriers
Barrier	1
Post	1.67
Tree	1.65
Utility pole	2.07

Results – Severity Indices

Outcome = hospitalised

Outcome = at least one major injury

Outcome = sum of all major injuries

	FSI Relative to barriers
Barrier	1
Post	1.06
Tree	1.11
Utility pole	1.16

	Logistic regression* Relative to barriers
Barrier	1
Post	1.26
Tree	1.34
Utility pole	1.40

	Major injury rate Relative to barriers
Barrier	1
Post	1.67
Tree	1.65
Utility pole	2.07

Results – Severity Indices

Greater injury severity considered produces greater SI values

	FSI Relative to barriers
Barrier	1
Post	1.06
Tree	1.11
Utility pole	1.16

	Logistic regression* Relative to barriers
Barrier	1
Post	1.26
Tree	1.34
Utility pole	1.40

	Major injury rate Relative to barriers
Barrier	1
Post	1.67
Tree	1.65
Utility pole	2.07

Results – Severity Indices

	Current SI (Austroads) passenger vehicles
Barrier	1
Post	1.58
Tree	1.70
Utility pole	1.89

	FSI Relative to barriers
Barrier	1
Post	1.06
Tree	1.11
Utility pole	1.16

	Logistic regression* Relative to barriers
Barrier	1
Post	1.26
Tree	1.34
Utility pole	1.40

	Major injury rate Relative to barriers
Barrier	1
Post	1.67
Tree	1.65
Utility pole	2.07

Results – Severity Indices

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

	FSI	FSI Relative to barriers motorcyclists
Barrier	0.63	1
Post	0.67	1.06
Tree	0.71	1.11
Utility pole	0.74	1.16

	FSI (Jurewicz et al 2012) passenger vehicles	FSI (Jurewicz et al 2012) Relative to barriers passenger vehicles
Barrier	0.36	1
Post	--	--
Tree	0.52	1.44
Utility pole	0.55	1.53

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

Jurewicz, C, Lim, A., McLean, J. and Phillips, C., 2012. Improving Roadside Safety: Stage 3: interim report, Austroads.

Results – Severity Indices

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

	FSI	FSI Relative to barriers motorcyclists
Barrier	0.63	1
Post	0.67	1.06
Tree	0.71	1.11
Utility pole	0.74	1.16

	FSI (Jurewicz et al 2012) passenger vehicles	FSI (Jurewicz et al 2012) Relative to barriers passenger vehicles
Barrier	0.36	1
Post	--	--
Tree	0.52	1.44
Utility pole	0.55	1.53

- 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

Limitations

- Non-injured motorcyclists were excluded; there were only 67 in CrashLink, indicating that such crashes are very rarely reported to police
- 7 wire rope barrier collisions were excluded (sample size too small and too flexible to be aggregated with guardrail and concrete barriers)
- Not all crashes are reported to police; 54% of motorcyclists hospitalised following collisions with fixed objects in the APDC were recorded in CrashLink
- Probabilistic linkage errors are possible – CHeReL estimated false positives and false negatives to be 0.4% and 0.5%
- The FSI 95% confidence intervals were quite wide due to limited case counts

Conclusions

- Fixed objects in the roadside provide a significant hazard to motorcyclists
- Current SI values are for passenger vehicle occupants and are not relevant to motorcyclists
- SI values have been derived specifically for motorcyclists using three different methods
- Motorcycle-specific design procedures will assist authorities in improving the safety of the roadway environment for motorcyclists
- Roadside barriers provide a substantial reduction in injury risk to motorcyclists, compared with trees, posts and utility poles
- However, the risk reduction provided by barriers is less for motorcyclists than vehicle occupants – barrier design specific to motorcyclists might further improve the protective effect of barriers

Acknowledgements

- NSW Ministry of Health for providing access to information in the NSW Admitted Patients Data Collection
- Centre for Health Record Linkage for conducting the record linkage, particularly Katie Irvine and Michael Smith
- Centre for Road Safety at Transport for NSW for providing access to CrashLink, particularly Margaret Prendergast, Bill Pink, Stewart Hay, Andrew Graham, Phil Sparkes, Ben Barnes and Hassan Raisianzadeh