IRMRC Research Report

MOTORCYCLE CRASHES INTO ROADSIDE BARRIERS STAGE 1: CRASH CHARACTERISTICS AND CAUSAL FACTORS

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Executive Summary

This report presents the results of Stage 1 of the Motorcycle Crashes into Roadside Barriers research project. Stage 1 determines the crash characteristics and causal factors of motorcyclist fatalities in Australia and New Zealand between 2001 and 2006, when a roadside safety barrier was involved in the crash. Stages 2 and 3 of the research are ongoing and will be published in due course. Stage 2 will investigate the injury mechanisms and the biomechanics of the human-barrier interaction. Stage 3 will determine survivability envelopes for different barrier systems and engineering solutions to mitigate injuries.

Roadside barriers are typically concrete, guardrail and wire-rope. There has been a significant concern raised by motorcycle organisations in Australia and overseas regarding the use of wire rope barriers. This research project is intended to inform such public debate and policy, and propose scientifically validated solutions, in regards to the safety or otherwise of motorcycle riders and pillions impacting roadside barriers.

Stage 1 of the work has focussed on accessing detailed information from the Australian National Coroners Information System (NCIS), and the Crash Analysis System (CAS) of the New Zealand Transport Agency. The search methodology and results from this stage are presented in this report. The authors restricted the analysis period to 5 years. It was decided to extract data from NCIS between the years 2001 to 2006 in order to conduct the research because of data consistency between NCIS and other fatality data sources.

Once all motorcycle fatality cases from all jurisdictions in Australia and New Zealand were identified for 2001 to 2006, each case was screened manually using the coroner's findings and the police, autopsy and toxicology reports, in order to determine whether a roadside barrier was involved in the incident.

In total 1462 cases of a roadside fatality involving a motorcycle were identified to have occurred in Australia and New Zealand for the period under review. Of these, 77 cases were positively identified as involving a roadside safety barrier (5.4%), and are the topic of this research project. Unfortunately 152 cases could not be categorised, the majority of which (139 out of 152) occurred in NSW.

In terms of age of motorcyclist killed where a road side barrier is involved, the youngest person killed was 11 years old while the oldest was 70 years old. The mean age of the deceased motorcyclist was 34.2 years and the median was 31 years. Fatalities appear to be biased towards younger people. Around 48.4% are aged between 26 and 39 years old, whereas the 17 to 25 years age group was second highest consisting of 22.1%.

It is males who are predominantly killed in motorcycle crashes into roadside safety barriers. Out of the 77 cases, 71 were male (92.2%) while 6 (7.8%) were female. The majority (4 out of 6) of the females killed were pillion riders, which includes the two minors previously mentioned.

The fatalities of motorcyclists involving impact with a roadside barrier predominantly involved steel W beams (72.7%). This was followed by concrete and wire rope barriers that accounted for 10.4% and 7.8% respectively. 80.8% of fatal crash sites involved a bend in the horizontal alignment of the road.

The mean speed of the posted speed limit on which the motorcycle crashes where a rider was killed and a roadside barrier was involved was 85.6 km/h. Fatalities involving a motorcycle impacting a roadside safety barrier mostly occurred on roads with speed limits above 60 km/h. The majority of the crashes occurred on freeways with posted speed limits of 100km/h or above. This was closely followed by arterial roads that had a posted speed limit of 80km/h.

53.6% of motorcycle fatalities involving a roadside safety barrier occurred on a weekend. 60% occurred on recreational rides. It appears that a motorcycle fatality involving a roadside barrier is least likely to occur on a Monday. Motorcycle crashes involving roadside barriers most frequently occur during afternoons, closely followed by night time crashes.

The road surface was reported to be of good quality in 71 of the 77 fatalities (92.2%). In two cases the road surface had corrugations. In nearly half of the crashes the weather at the time of the crash was described as clear and the road surface as dry. 28.2% of the crashes occurred at night, where the road surface was dry.

The vast majority of motorcyclists killed as a result of collision with a roadside barrier in Australia and New Zealand were wearing a helmet at the time of the crash (97.4%). In 86.1% of cases the motorcycle rider was licensed. This number includes the riders of the motorcycles where a pillion rider was killed.

Speeding or inappropriate speed was found to be the highest single factor that contributed to the crash (27 cases). Alcohol by itself, closely followed by alcohol with a combination of speed (7) and drugs (6) was also a common contributory factor. On average the blood alcohol concentration recorded on the toxicology reports was 0.118%. The range of the alcohol detected in the blood was between 0.02% (lower than the legal limit) to 0.26% (more than 5 times the legal limit). The recorded BAC in 17.9% of the fatalities was higher than the legal limit. Other factors such as avoidance of vehicles and fatigue did not feature highly as contributory factors.

In 55 of the 77 cases the mechanical condition of the motorcycle was inspected after the collision. In 47 of these cases, the inspection reports conclude that there was no mechanical defect that could have contributed to or caused the crash. This data suggests that mechanical problems do not play a major role in motorcycle-barrier impacts.

In summary it appears that rider behaviour plays a significant role in motorcyclist fatalities into roadside barriers. Alcohol, drugs or speed played a role in more than half of the fatal barrier crashes in Australia and New Zealand. Further, crashes occur predominantly on recreational rides. Steel W beam barriers are over-represented in roadside barrier motorcycle fatalities, however this must be viewed in light of exposure.

Funding partners and researchers

This research is funded by the following organisations;

NSW Road and Transport Authority
New Zealand Land Transport Agency (Formerly known as Transit New Zealand)
Western Australia Road Safety Council
NSW Motor Accident Authority
Australian Automobile Association

The first three organisations have a responsibility for the roads in their respective jurisdictions. The motor accident authority (NSW) is charged with taking care of the victims of road trauma. The Australian Automobile Association is a peak national body that represents the interests of motorists in Australia.

During the study period of this report, the Motorcycle into Roadside Barriers Scientific Advisory Committee (MRBSAC) was comprised of the following members:

Dr. Soames Job – NSW Roads and Traffic Authority
Mr. Fabian Marsh – New Zealand Land Transport Agency
Mr. James Cameron, Mr. Craig Newland – Australian Automobile Association
Mr. John Metcalfe (formerly with AAA)
Mr. Brian Kidd and Mr. Jan Karpinski – Main Roads Western Australia
Ms Dimitra Vlahomitros, Ms Nadine King and– NSW Motor Accidents Authority
Mrs Pam Albany (formerly with MAA)
Prof. Raphael Grzebieta – Chair of Road Safety IRMRC, UNSW
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Researchers who have worked on the project to date are:

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Mr Jerome Favand – Research Fellow (formerly with IRMRC), UNSW
Mr Rob Smith - motorcycle instructor and expert specialist

1. Project introduction

The Motorcycle Crashes into Roadside Barriers project seeks to investigate the crash characteristics, causal factors and injury mechanisms that motorcycle riders and pillions are subjected to when they impact a roadside barrier. It also seeks to determine the survivability envelop for motorcyclists crashing into each of the different barrier system types. This survivability envelop will be compared to the survivability envelope for occupants in other vehicles that impact the barriers. There is currently a reasonable amount of knowledge in regards to what is a survivable crash for occupants in cars, trucks and buses that crash into different barrier systems but little credible information concerning survivability of such crashes involving motorcyclists.

Roadside barriers are typically concrete, guardrail and wire-rope. There has been a significant concern raised by motorcycle organisations in Australia and overseas regarding the use of wire rope barriers. This research project is intended to inform such public debate and policy, and propose scientifically validated solutions, in regards to the safety or otherwise of motorcycle riders and pillions impacting roadside barriers.

The project is also exploring how to reduce the injuries to motorcyclists impacting concrete, wire-rope barriers and guardrail systems. The human biomechanical interaction during a crash is being investigated. Innovative injury mitigating engineered solutions will be assessed as well as new solutions explored. In particular any solutions proposed will be assessed in regards to whether they effect a barrier's current crash and redirection characteristics for vehicles such as cars, trucks and buses. The project will also involve computer crash simulation and crash testing that, it is hoped, will demonstrate survivability outcomes for current and upgraded systems.

In summary, the project is providing the following outcomes:

a. A statistical overview of motorcycle rider/pillion passenger involvement in roadside and median barrier crashes employing NCIS data and fatality case files.

b. The causal human factors (speed, alcohol, fatigue, inexperience, bad cornering technique, etc) that lead to motorcycle/rider/pillion impacts into crash barriers and road side hazards.

c. A categorisation of typical crash scenarios that provides impact angle, speed, motorcycle and rider kinematics.

d. Reconstruction of a selected number of representative categorised cases.

e. The causal biomechanical mechanisms related to each barrier system that lead to the serious or fatal injury of the rider/pillion;

f. Rider/pillion survivability impact analysis for each barrier system, i.e. determination of the survivability envelops for different impact scenarios for varying rider configuration, speed and angle of impact and barrier type.

g. Proposed engineering design modifications to road barriers that are effective in reducing injuries to riders and pillions involved in roadside barrier crashes but will not reduce current crash safety characteristics for occupants of vehicles in cars, trucks and busses. The effectiveness of the modifications will be proven using current computer simulation and crash test technology.

This Research Report of Stage 1 provides information that is addressing parts ‘a’ to ‘c’ above. Parts ‘d’ to ‘g’ will be addressed in later stages of the project.

2. Ethics approval

Any research into humans including deceased persons requires Human Research Ethics Committee (HREC) approval. HREC approval for the research was obtained from the University of New South Wales in July 2008 whereas approval to access the National Coronial Information (NCIS) system was obtained from the Department of Justice, Victoria on 1st April 2009. Separate ethics approval was also required from the Western Australian (WA) Coroner’s Court to obtain WA information. Approval for access to WA data was obtained on 29th May 2009.

The physical case files held by the Coroner’s courts in Australia and New Zealand have been accessed and coded in terms of the details of the crashes that were available.

3. Background information

Motorcycle crashes are an increasing road safety problem in developed as well as developing countries. Motorcycle registrations are on the increase in Australia (Australian Bureau of Statistics, 2006) and similar trends have been reported in New Zealand (Land Transport New Zealand, 2007) and the United States (US) (Gabler, 2007). The number of motorcyclists killed on the road continues to rise as a percentage of all road fatalities as indicated in Figure 1. Motorcyclists have been shown to be over-represented in road fatalities in Australia, New Zealand (NZ) and the US accounting for 9% or more of the fatalities in these countries in 2007 despite motorcycles accounting for less than 4% of vehicles registered.

The effect of roadway barriers on motorcyclist safety is an emerging area of concern and hence research. Roadway barriers are designed to protect road users from hazards on the side of the road (e.g., trees, poles, cliffs, drains) and from oncoming traffic. In Australia and New Zealand three main types of safety barriers are used: concrete barriers, steel beam barriers and wire-rope (cable) systems. Concrete barriers are typically used on medians where there is no room to accommodate a more flexible barrier’s dynamic deflection such as on city freeways that require high level containment with almost no lateral deflection. Steel barriers fall into four main sub-categories in Australia and New Zealand: W beams which consist of a steel or wooden post supporting a W shaped steel beam, Tubular beams of various geometric shapes (e.g. rectangular or circular hollows sections) supported by posts, Thrie beams which are essentially a double W-beam and the barrier is usually much stiffer than a single guardrail beam, and steel tubular sections on bridge barriers. Wire rope barrier systems in Australia are also frequently installed on freeway median strips. Roadside safety barriers installed along roads in Australia and New Zealand must currently meet the requirements of the Australian and New Zealand Standard, AS/NZS 3845, (Standards Australia, 1999) and minimum safety criteria contained in US NCHRP 350 recommended procedures (Ross et al, 1993). These safety criteria were developed primarily for cars and heavier vehicles, but not for motorcycles. Installation of roadside safety barriers under AS/NZS 3845 is predicated on an assessment that the risk to safety with the barrier is significantly less than the risk without it.

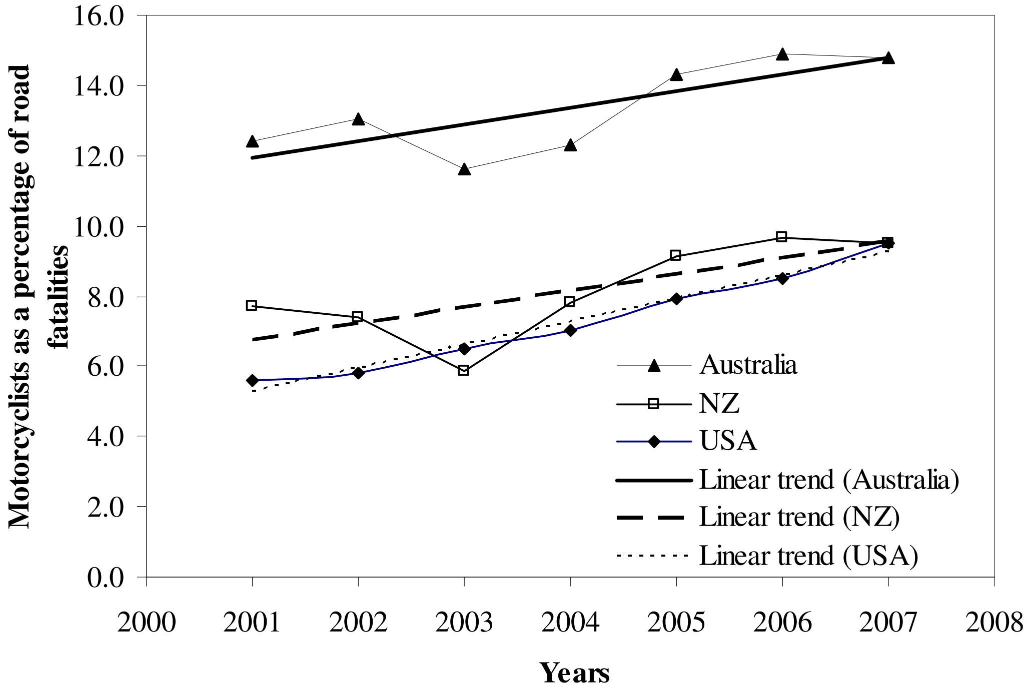

Figure 1: Motorcyclists as a percentage of all road fatalities in Australia, NZ and the USA
(Data sources: Australian Bureau of Statistics, NZ Crash Analysis System and US Fatality Analysis and Reporting System)

It is well established that roadside safety barriers reduce run-off road fatalities for car occupants (Elvik, 1995) and recent evidence from Sweden suggests that median wire rope barriers may produce sizeable reductions (estimates of 32% to 65% reductions) in fatalities and serious injuries for motorcyclists (Carlson, 2009). Nonetheless, the motorcycling community has raised concerns that roadway barriers, particularly wire rope (cable) barriers, may pose a significant safety hazard in their own right for riders (FEMA, 2000). Consistent with these concerns, EuroRAP (2008) reported that hitting a safety barrier is a factor in 8-16% of rider deaths in Europe and that a motorcycle rider is 15 times more likely to be killed than a car occupant as a result of crashing into a roadside barrier.

A better understanding of the nature and circumstances of rider-into-barrier impacts is needed if we are to address the concerns raised by motorcycle riders while enhancing road safety for all road users. To date, very little in-depth crash investigation research has been conducted to investigate the nature or circumstances of motorcyclist-into-barrier crashes.

One of the earliest in-depth studies of crashes involving motorcyclists was conducted in the US state of California (Hurt, Oullet & Thom, 1981). Nine hundred in-depth and on-scene crash investigations were conducted. Additionally, 3600 police crash files were analysed and exposure data was collected. Approximately 20%-25% of crashes were single vehicle crashes. Trees, poles, barriers and guardrails (definition of a guardrail is not provided) together accounted for only 13.7% of severe, serious, incapacitating and fatal injuries (where the Abbreviated Injury Score was 3 or more), whereas nearly half (48.2%) were caused by parts of the motorcycle itself.

In another US study (Gabler 2007), between 2000 and 2005 one in eight motorcyclists who struck a guardrail were fatally injured – a fatality risk over 80 times higher than for car occupants involved in a collision with a guardrail. It was also found that guardrail collisions pose a substantially greater risk for motorcyclists than do concrete barrier collisions. The fatality risk in motorcycle-guardrail collisions is 12%. The fatality risk in motorcycle-concrete barrier collisions is 8%.

Quincy et al. (1988) examined the type of impacts between motorcyclists and guardrails that resulted in death and serious injury in France. The study covered 940 km of highway equipped with guardrail median barriers over its whole length, for the years 1980 to 1982. Eight out of 19 motorcycle fatalities involved running off the road and impacting a guardrail. Thirty eight barrier impacts resulted in fatalities or serious injury, of which 34% involved the motorcycle and rider sliding into the barrier together, 24% involved the rider and motorcycle separating and sliding into the barrier and 42% involved an impact into the barrier without sliding.

In Germany, Berg et al. (2005) examined 57 cases of motorcyclists impacting a roadside barrier. Most (81%) of these crashes involved a steel barrier, but the breakdown of the remaining barriers was not reported. In 51% of these cases, the motorcyclists impacted the barrier while riding in an upright position. 45% of the motorcyclists impacted the barrier while sliding and the remaining 4% impacted the barrier in an inclined riding position. Berg et al. (2005) also reported that the majority of these crashes occurred on bends.

In Australia, safety barriers are involved in fewer motorcycle crashes, fatalities and serious injuries than other fixed roadside objects (Cassell, Clapperton, O'Hare & Congiu, 2006; Gibson & Benatatos, 2000; Haworth, Smith, Brumen & Pronk, 1997). Gibson and Benatatos (2000) conducted a retrospective in-depth investigation of coronial case files for motorcycle-barrier crashes occurring during 1998 and 1999 in the state of New South Wales. Only eight cases were identified to have involved roadside barriers, so the results should be interpreted with caution. Nevertheless, this study reported most of the motorcycle-barrier impacts occurred at shallow angles, and in 7 of the 8 cases were W beams. Fatal injuries were most often the result of barrier post impacts or heavy impact onto the ground. The typical speed of the motorcycle prior to the crash, although difficult to assess, was greater than 60km/h.

There are no recent systematic studies on Australian and New Zealand data of motorcycle fatalities involving roadside safety barriers despite widespread attention by the media and motorcycling community both locally and internationally. A detailed review and presentation of the human, environmental and vehicular factors involved in crashes into roadside barriers is lacking in Australia and New Zealand as well as internationally. The information from this report will enable road safety practitioners and researchers to develop effective countermeasures.

The aim of Stage 1 of this project is to extend the available information concerning motorcycle-into-barrier crashes firstly by providing a national descriptive profile of fatal crashes of this type in Australia and New Zealand over a six year period (2001-2006) and secondly provide much needed data for international comparisons regarding this road safety issue. The profile is based upon a retrospective analysis of Australian and New Zealand coronial files.

4. Search Methodology

4.1 Coronial data from Australia and New Zealand

This study is based on the information contained in the Australian National Coroners Information System (NCIS) and in the New Zealand Crash Analysis System (CAS). The NCIS is an internet-based data storage and retrieval system that contains coronial cases from all Australian states dating from the middle of 2000. CAS is an internet-based database of all vehicle crashes that are reported to the police in New Zealand.

4.1.1 Case identification in Australian jurisdictions

The NCIS database includes all reportable deaths which include roadway fatalities. Variables coded in the NCIS include demographic information about the person, object involved and the place of death. Each death record in the NCIS should also have attached to it an initial police, autopsy and toxicology report. Each case also usually has the finding of the cause of death as recorded by the investigating coroner. Further detailed information is usually available where an inquest was held to establish the cause of death. However, not all NCIS cases have these additional documents available on-line. In these instances, the original paper case files must be requested through the individual coroners' courts. In a few cases paper case files did not contain all the documents required to reconstruct the crash.

Ethical approval to access and use the data was obtained from the Human Research Ethics Committees (HREC) of the University of New South Wales, and from the Departments of Justice in Victoria and Western Australia.

As the first step in identifying motorcycle-barrier crashes in the NCIS database, the initial query was designed as follows:

1) All jurisdictions were searched
2) Employment field was left blank
3) Time field was left blank
4) Query object was chosen as a mechanism
5) The mechanism that caused the death was defined as blunt force
6) Level 2 of the mechanism was defined as a transport injury event
7) Level 3 of the mechanism was defined as motorcyclist/motorcycle rider
8) The vehicle details were defined as two wheeled motor vehicle
9) The vehicle was further defined as a motorcycle

The output from the database contained the particulars of the deceased such as the sex, age, date of birth and date of death. An output of up to three levels of the medical cause of death, location where the death occurred and the crash vehicle counterpart was requested. The automated data search produced a total of 1339 fatalities involving a motorcyclist including a pillion passenger for the years 2000 to 2006.

4.1.2 Case identification in New Zealand

Data on motorcycle crashes in New Zealand were obtained from the Crash Analysis System (CAS). CAS is managed by the New Zealand Transport Agency. The case data search for New Zealand cases was significantly less complicated than for Australia. Two hundred and one motorcycle fatalities were identified for the 2001-2006 period, of which only four fatalities involved a roadside barrier. Once the four cases involving or potentially involving a roadside barrier were identified using the text descriptions in the database, the police briefs of these cases were requested from the New Zealand Coroner through the New Zealand Transport Agency.

4.2 Protocol for examining crash characteristics

Once the cases involving or potentially involving roadside safety barriers were isolated in NCIS and CAS, a request was made to the coroner in each state in Australia and to the New Zealand Coroner for permission to view the police reports. The level of detail included in the police briefs prepared for the coroners varied within and between states and for New Zealand, but was usually of sufficient quality to enable a basic reconstruction of the crash events in most cases.

The research team identified a set of descriptors to characterise human, vehicle and environmental crash factors by reviewing papers on motorcycle crash reconstruction (Gibson and Benatatos, 2000; Lin and Kraus, 2009; Quincy et al., 1988 and Berg et al., 2005).

The following information was extracted with regards to the human factors; demographics, riding licence status, the primary purpose of the journey, the wearing of a helmet and riding behaviour including an estimate of the riding speed prior to the crash were obtained from the police briefs. Other human factors examined included the presence of alcohol and other drugs in the deceased's blood which were obtained from toxicology reports. These tests were carried out on a sample of blood from the deceased at state government analytical laboratories, screened for a panel of common drugs and alcohol. In a few instances the toxicology tests were not performed because the injured rider was conveyed to hospital in a critical state and medical care was given priority over the blood collection.

The environmental factors considered included the road surface condition, road type and road horizontal alignment. The barrier factors examined included the barrier type and the hazard being protected against. The weather and temporal factors were also examined. The vehicle factors examined included the motorcycle registration and the mechanical condition of the motorcycle prior to the crash. An inspection of the motorcycle was carried out by a qualified police mechanic in all Australian jurisdictions except in Tasmania where it was carried out by a qualified mechanic from the Department of Transport. In New Zealand, these reports were written by accredited independent third parties. The mechanical condition of the motorcycle prior to the collision was obtained from these reports. However, these reports were not always available. Table 1 shows the availability of the various reports.

Jurisdiction	Documents available for;			
	Total Fatalities	Police reports	Mechanical inspections	Toxicology reports
Australian Capital Territory	4	4	3	4
New South Wales	23	19	13	22
North Territory	0	0	0	0
Queensland	13	12	11	12
South Australia	13	13	7	13
Tasmania	8	7	7	7
Victoria	10	10	8	9
Western Australia	2	2	2	2
New Zealand	4	4	4	4
Total	**77**	**71**	**55**	**73**

Table 1: Availability of various reports in Australia and New Zealand

5. Results

5.1 Motorcycle registrations and roadside barrier exposure

The number of motorcycle registrations and their percentage with regards to all registered vehicles are presented in Table 2. The data were obtained from the ABS (Australian Bureau of Statistics, 2006) and Land Transport New Zealand (Land Transport New Zealand, 2007). The data show that motorcycles constitute a relatively small proportion of the vehicle population in Australia and New Zealand (less than 4% for Australia and less than 2% for New Zealand).

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

[a] Motorcycles as a proportion of the population of registered motor vehicles

Table 2: Population of vehicles and motorcycles in Australian jurisdictions and New Zealand

All jurisdictions in Australia and New Zealand were approached to provide information about the length and type of roadway barrier that were installed on their roadways. Table 3 shows installed lengths of the roadside barriers provided by state road authorities in Australia, i.e.

New South Wales, Queensland, Tasmania, Victoria and Western Australia, and by New Zealand for the roads under their management. The lengths provided in Table 3 exclude roads managed by local government authorities such as councils and shires. In Australia, the lengths of roads in Table 2 form a small proportion of the road network where for example, in Victoria, the total road network is approximately 150,000 Kilometres but the state road authority controls only about 23,000 Kilometres. Nevertheless, the state barrier type data can possibly be used to estimate exposure as the motorcycle fatalities predominantly occurred on main roads managed by state authorities.

State	Total road length (kms)[a]	Total length of roadside barriers (kms)	Steel Barrier length (kms)	Concrete barrier length (kms)	Wire rope barrier length (kms)	Other (kms)
New South Wales	17,818	2,272.0	1,825.0	152.0	295.0	0.0
Queensland	35,000	1,511.0	1,118.0	264.0	121.0	8.0
Tasmania	3,900	521.5	245.2	8.5	88.4	213.9
Victoria	23,300	1 726.0	1 263.0	*	463.0	*
Western Australia	18,024	370.0	212.2	60.4	97.2	0.0
Total Australian	**98,042**	**6,400.5**	**4663.4**	**484.9**	**1,064.6**	**221.9**
Total New Zealand	**10,800**	**1383**	**902**	**188**	**170**	**123**

[a] 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

Table 3: Installed lengths of roadside barriers along roads in Australia and New Zealand

5.2 Australian data reliability

To gauge the reliability of the Australian data, the annual motorcycle deaths identified from the NCIS was compared to the motorcycle deaths recorded by the Australian Department of Infrastructure, Transport, Regional Development and Local Government (DITRL) and the Australian Bureau of Statistics (ABS). Figure 2 shows that the data extracted from the NCIS, DITRL and ABS were generally in agreement. However, the data from ABS consistently reported a slightly higher number of deaths than that from NCIS or DITRL. The NCIS data for 2000 and 2006 appear to stand out as being least consistent with the other databases. The NCIS began operations in June 2000 and the state of Queensland joined in January 2001, therefore the data in 2000 are incomplete. At the time the search was conducted, there were many 2006 cases still open resulting in the lower NCIS totals.

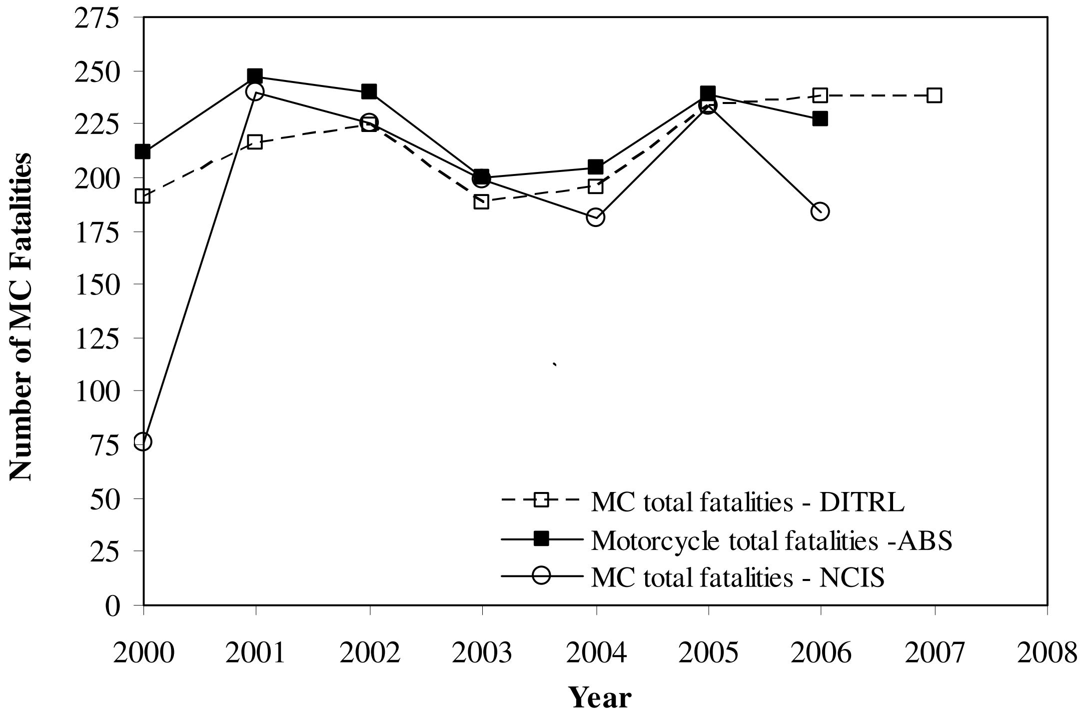

Figure 2: Comparison of fatal motorcycle crashes in Australian jurisdictions from various sources (2000 to 2007)

In addition to the difficulties associated with the NCIS data for the years 2000 and 2006, there are a number of reasons why motorcycle fatality numbers differ between data sources. These include issues such as coding errors, missing data and variations in the definition of a road fatality. For example, ABS data refer to underlying cause of death which may include a long period of complicating illnesses as a result of injury sustained in a motorcycle crash. Nevertheless, the data from all sources are in reasonably close agreement for the years 2001 to 2006.

5.3 Crashes by jurisdiction

In total 1462 cases of a roadside fatality involving a motorcycle were identified to have occurred in Australia and New Zealand (Table 4). Motorcycle off road and racing fatalities were excluded. Motorcycle fatalities in Australia as a result of impacting a roadside barrier were 6.0% of the known cases. Motorcycle fatalities due to roadside barriers were a smaller percentage of all motorcycle fatalities in New Zealand (2%) than in Australia and this difference is statistically significant. As shown in Figure 3, seventy seven cases (5.4%) were positively identified as involving a roadside safety barrier. A further 38 cases (2.6%) could not be categorised due to insufficient information in the NCIS. The majority of these indeterminate cases occurred in NSW. Indeed, 34 of the 335 cases in NSW, or nearly 10%, of the total motorcycle fatality cases in NSW did not provide any details other than the gender and age of the deceased in the NCIS database.

State	Total MC fatalities	Barrier related MC fatalities	Non-barrier MC fatalities	Not known	Barrier/ Known (%)	CI 95%
Australian Capital Territory	21	4	17	0	19.0%	0.077 – 0.400
New South Wales	335	23	277	35	7.7%	0.052 – 0.112
North Territory	19	0	0	0	0%	----
Queensland	266	13	251	2	4.9%	0.029 – 0.082
South Australia	121	13	108	0	10.7%	0.064 – 0.175
Tasmania	48	8	40	0	16.7%	0.087 – 0.296
Victoria	309	10	299	0	3.2%	0.020 – 0.063
Western Australia	142	2	140	0	1.4%	0.003 – 0.049
Total Australia	**1261**	**73**	**1149**	**37**	**6.0%**	**0.052 – 0.080**
New Zealand	**201**	**4**	**196**	**1**	**2.0%**	**0.008 – 0.050**
Total	**1462**	**77**	**834**	**38**	**5.4%**	0.044 – 0.068

Table 4: Breakdown of motorcycle crashes in Australia and New Zealand

In regards to topography in these jurisdictions, Australia's population is concentrated along the eastern and southeastern coasts. The Great Dividing Range being the eastern highlands, runs from Queensland, through NSW and Victoria and south down to Tasmanian. It separates the relatively narrow Eastern Coastal Plain from the rest of the continent, i.e. the Central Lowlands and the Western Plateau that includes significant parts of Western Australia, South Australia and the Northern Territory. The majority of Australian motorcycle recreational riding occurs in the eastern and southeastern coastal regions, along the whole of the Great Diving Range and in the Adelaide hills north of Adelaide.

New Zealand encompasses two main hilly and mountainous islands, where the North Island is the smaller land mass, less mountainous than the South Island and contains about three quarters of the population. Recreational riding occurs over the whole of both islands.

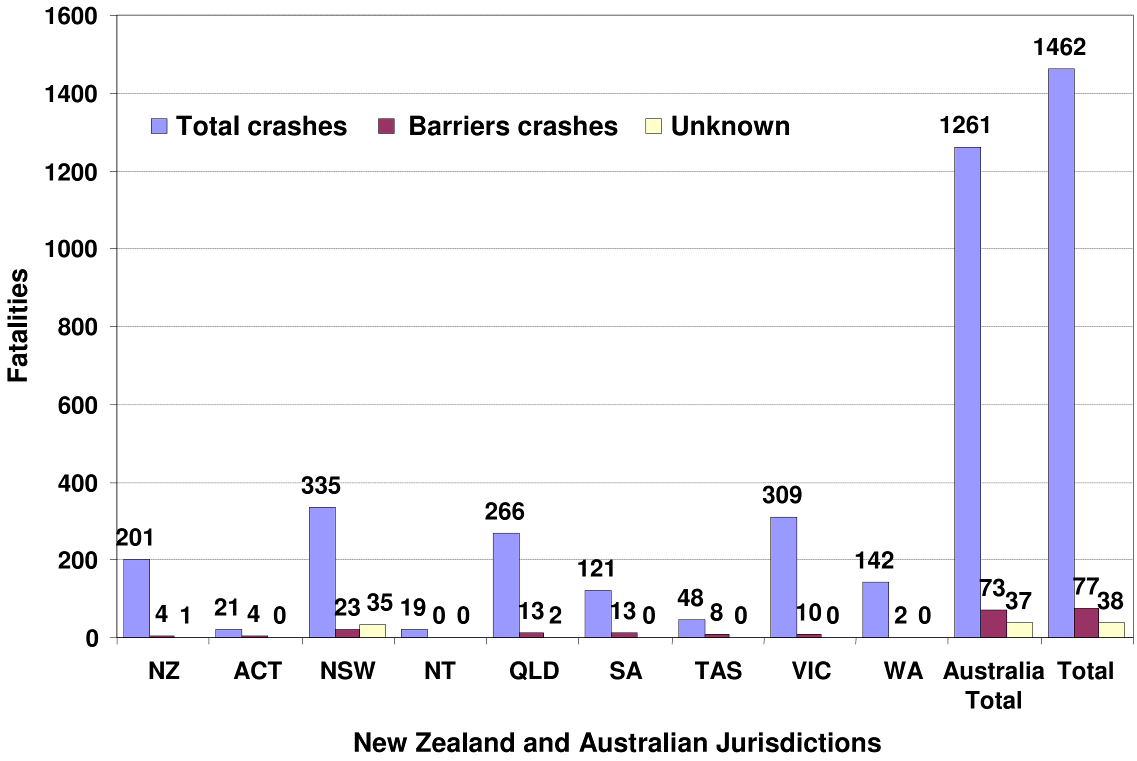

Figure 3: Fatal motorcycle crashes in Australian jurisdictions and New Zealand (2001 to 2006)

The percentage of motorcycle roadside fatalities for NSW that involved a barrier impact is similar to the percentage (8%) reported by Gibson and Benatatos (2000) for 1998/1999. However, the current data reveal some variation between the various states in Australia (Table 4). The Australian Capital Territory (ACT) and Tasmania registered the highest percentages of motorcyclist fatalities involving impacting a roadside safety barrier. This may be a reflection of the low number of motorcycle fatalities being recorded in these jurisdictions. However, the Northern Territory had a similar number of cases to the ACT but recorded zero motorcycle fatalities involving a roadside barrier. This suggests that variations in exposure to roadside safety barriers are probably a factor in the jurisdictional variation in cases.

In the state of South Australia, many of the fatalities involving a roadway barrier (5 out of 13) occurred on the same stretch of road on a popular recreational ride route. These deaths invariably involved a young motorcycle rider (youngest 25 yrs, oldest 34 yrs) riding recreationally on weekends (4 on Saturday, 1 on Sunday). Western Australia recorded very few motorcyclist fatalities in roadside barrier crashes. Considering that Western Australia has more registered motorcycles, it is interesting to consider the role of exposure to barriers. Unfortunately, barrier exposure data for South Australian could not be obtained.

5.4 Crash types

The fatalities involving motorcycles and roadside barriers in Australia and New Zealand primarily involved a single vehicle running off the road (85.7%). In the remaining 14.3% of cases, another vehicle was involved either by inflicting the fatal injuries after the rider had impacted a barrier or the rider took evasive action to avoid a vehicle before impacting into a roadside barrier. A small number of the motorcycles riders (7.7%) were found to have a pillion passenger. The overwhelming majority of the crashes (80.5%) resulted in death at the scene of the crash.

5.5 Human factors

5.5.1 Demographics

Figure 4 shows the breakdown into age groups of motorcyclist fatalities involving a roadside safety barrier in Australia and New Zealand. The youngest and oldest persons killed were 11 and 70 years old respectively. The mean age was 34.2 years and the median was 31 years and 72.3% are aged less than 40 years. The largest group of motorcyclists killed as a result of a collision with a roadside barrier are aged between 26 and 39 years (48.4%). The 17 to 25 years age group was second highest consisting of 22.1%. The fact that riders in the 26 to 39 years age bracket are involved in the majority of the fatalities may be related to their crash risk and possible lack of experience (Harrison & Christie, 2005) but it also may be a reflection of the distribution of the motorcycle riding population. Unfortunately the national age distribution of the Australian motorcycling population was not available.

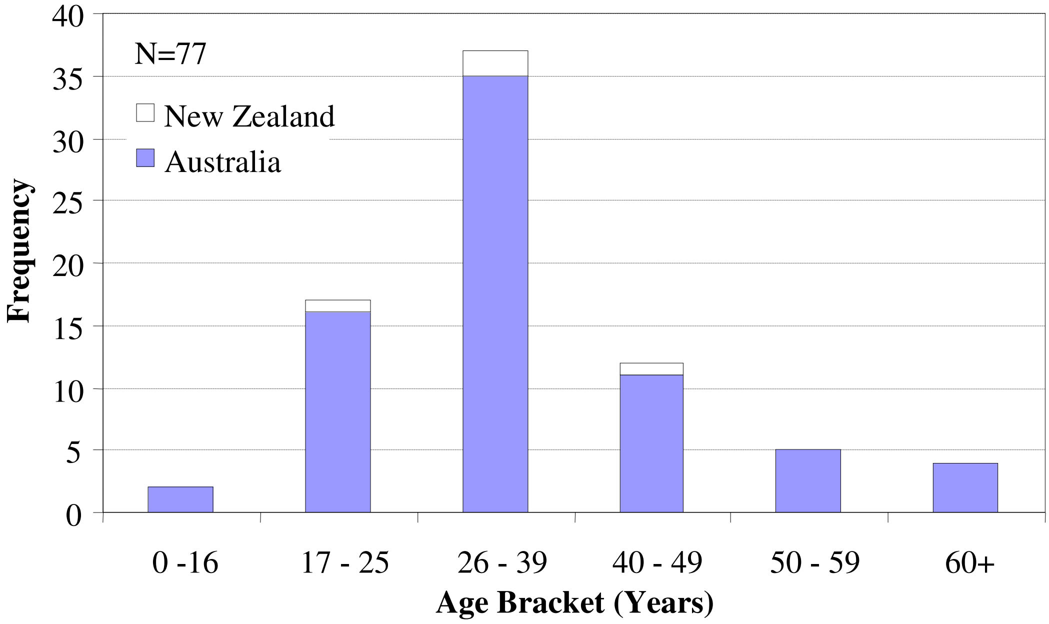

Figure 4: Age distribution of motorcyclist fatalities involving a roadside safety barrier in Australia and New Zealand (2001 to 2006)

More males than females were killed in motorcycle crashes into roadside safety barriers. Out of the 77 fatalities, 92.2% were male. The majority (4 out of 6) of the females killed were pillion passengers. In all the four cases where a female pillion was killed, a male was in control of the motorcycle and survived the crash. Although the percentage of females killed in a crash into a roadside barrier was relatively small (7.8%), it is comparable to the overall number of females killed as a result of riding a motorcycle. According to ABS data, between 2001 and 2006, 5.0% of all riders (including pillion passengers) killed in a motorcycle crash were female. The low number of female fatalities is likely to be a reflection of exposure. For example, in the state of New South Wales, 89.3% of motorcycle licence holders are male.

5.5.2 Wearing of a crash helmet

It is well documented that wearing of a good quality crash helmet reduces the risk of fatality. Deutermann (2004) calculated the effectiveness of wearing a motorcycle helmet in preventing a death to be 37% based on 1993-2002 US data. In Australia and New Zealand, wearing a helmet while riding a motorcycle is mandatory and these helmets must meet the Australian and New Zealand Standard, AS/NZS1698 (Standards Australia, 2006). The vast majority of motorcyclists killed as a result of collision with a roadside barrier in Australia were known to be wearing a helmet at the time of the crash (97.4%). In the case where the rider was not wearing a crash helmet, the crash occurred at night and the rider had consumed alcohol prior to the crash event. There was a single case with insufficient information to determine the use of a helmet.

5.5.3 Alcohol and other drugs

The risks of having a fatal crash as a result of alcohol are well documented. Alcohol was detected in 29.9% of the cases. In 4 cases the toxicology report was not available. However in some instances, the taking of a blood sample was delayed by other medical interventions and this may have led to under-reporting. Nevertheless, this under-reporting is likely to be relatively small considering 80.5% of the crashes resulted in death at the scene of the crash. The blood alcohol concentration (BAC) was found to be between 0.02-0.05% in 10 cases, but three out of these 10 were on a learners or provisional licence which means they were legally over the blood alcohol limit for their licence class. The recorded BAC in 17.9% of the fatalities was higher than the legal limit. The general legal blood alcohol limit is 0.05% and 0.08% in Australian and New Zealand respectively. On average, the blood alcohol concentration recorded on the toxicology reports was 0.118% (SD =0.0008, range 0.02% to 0.26%).

It has been argued that motorcycle riders are more vulnerable than other vehicle drivers to the effect of alcohol because of its effect on balance, motor co-ordination and judgement, all of which are required to operate an inherently highly dynamic vehicle which readily becomes unstable in adverse riding conditions. Colburn et al. (1994) in their simulator study, reported an increase in run off the road type crashes due to alcohol. Run off the road type crashes invariably lead to a collision with a roadside barrier where one exists and collision with the hazard where one does not exist.

Other drugs, especially in combination with alcohol, also increase the risk of a motorcycle crash. In the present study only 16.7% of the cases had consumed drugs including cannabis, cocaine, amphetamines, and methamphetamines according to the toxicology tests. Soderstrom et al. (1995) reported US motorcycle riders were more likely to use cannabis sativa (marijuana) prior to a crash than car drivers. In fact 32% of motorcycle riders treated in Maryland (USA) trauma centres during 1990-1991 had used cannabis as compared to 2.7% of car drivers. When age was controlled, similar results were found in New Jersey (USA), with 44% of motorcycle riders being drug affected while 28% of car drivers were drug affected. The authors are not aware of any similar studies in Australia or New Zealand.

5.5.4 Riding speed

Determining the speed at which a motorcycle was ridden before a collision is difficult. There were rarely any skid marks to examine at the scene of the crash for a number of the cases where the police investigation files were obtained. However, information from riding companions, independent witnesses and throw distances can provide an estimate of the speed. In the case of curved roads which are the majority of the road sections involved in this study, police crash reconstruction usually involves the determination of "critical curve speeds". Critical curve speeds are usually calculated using well established engineering formulae and then an experienced police officer rides a motorcycle through the road at the maximum possible speed. In the majority of the cases, the speed from calculations and ride-outs are in close agreement.

There were 47 cases where an estimate of the speed of the motorcycle prior to impact was recorded. Out of these cases, 43 were suspected to involve inappropriate speed. The rider was travelling at a speed higher than the posted maximum speed limit. The average posted maximum speed limit for these cases was 85.6km/h while the average riding speed was 99.1km/h. The difference of the means is statistically significant ($t_{(64)}=2.0$, $p=0.011$). Additionally, there were instances where the rider speed was much higher than the posted maximum speed limit such as a rider estimated to have travelled at 200km/h in a 100km/h zone and another rider estimated to have travelled at 150km/h on a 70km/h speed zone. Furthermore, out of the 43 cases where speeding was suspected, 7 had also consumed alcohol which was detected in the blood, 3 were affected by drugs and 5 had consumed alcohol and drugs.

5.5.5 Rider license

In Australian jurisdictions, motorcycle riders are required to undergo training and pass a written test before being allowed to develop their skills further on the road. This licence is termed as a learner's permit which is converted to a probationary licence after passing a further test. The probationary licence is converted to a full licence after a qualifying period. In 86.1% of the current cases, the motorcycle rider held a riders licence. There was one case where the licence was revoked and the rider in that case was also speeding and recorded a BAC above the legal limit. In 4 out of the 77 cases, the motorcycle rider had a learners permit. Three out of these 4 riders registered a BAC. In one case the BAC was 0.21% or 4 times more than the legal limit applying to experienced riders. In one case, the rider was riding a motorcycle with an engine capacity higher than permitted. In four cases the riders did not have a license to ride a motorcycle and three of those were also impaired by alcohol. There was insufficient information in 15 cases to determine whether the rider held a licence to ride a motorcycle or not.

5.6 Environmental factors

5.6.1 Barrier type and exposure

Figure 5 shows that fatalities of motorcyclists involving impact with a roadside barrier predominantly involve W beams (72.7%). This was followed by concrete and wire rope barriers that accounted for 10.4% and 7.8% respectively. An additional 3.9% of impacts involved steel barriers, but there was insufficient information available to determine whether these barriers refer to W beams, Tubular or Thrie Beam steel barriers. These fatality proportions may be compared to the proportions of barriers installed (Table 3), which shows that: 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. Therefore assuming the probability of a fatality occurring across the network of barriers is similar, wire rope barriers have around half the fatality rate of W beam barriers.

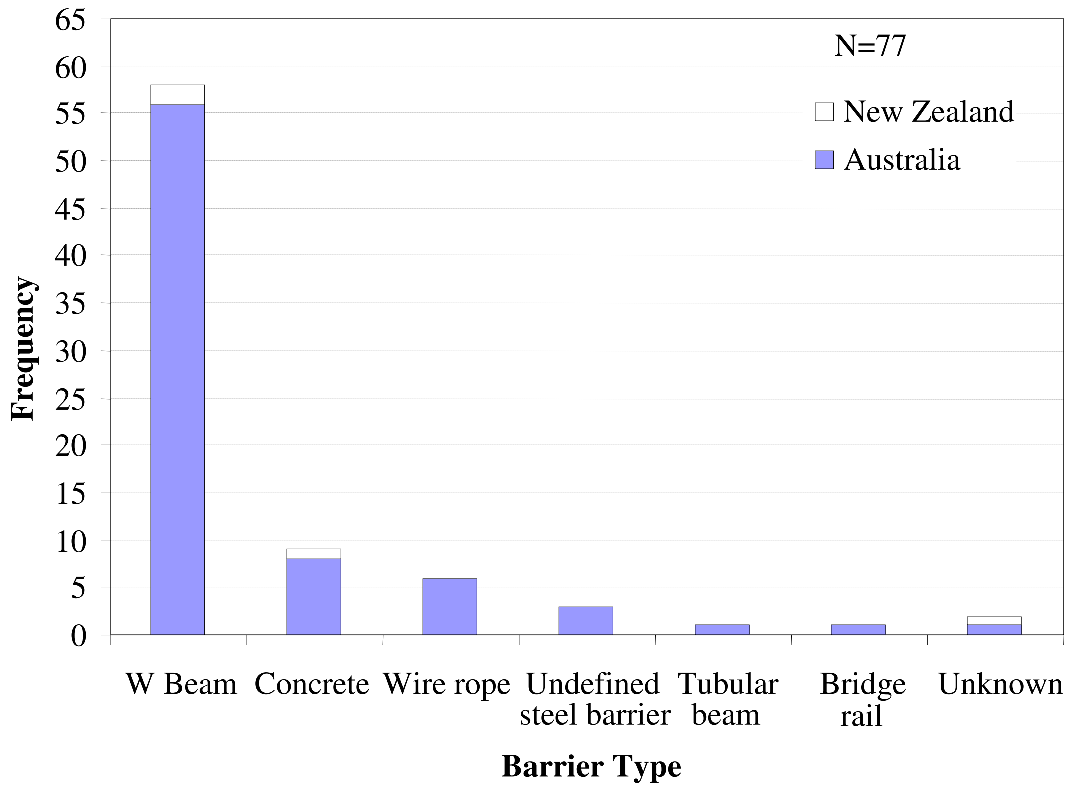

Figure 5: Roadside barrier types involved in motorcyclist fatalities in Australia and New Zealand (2000 to 2006)

Roadway barriers are typically installed on about 6.5% of the road networks controlled by state authorities and steel barriers such as W beams, Thrie beams and Tubular beams are used more widely than other barrier types (Table 3; Section 5.1). Therefore predominance of the involvement of W beams in the crashes seems to be related to their prevalence along the roads. Furthermore, W beams are usually installed on curved roads where most of the crashes occurred.

5.6.2 Hazards and people behind the barrier

Figure 6 shows the main hazards being protected by the barrier systems. Trees were the most common form of hazard being protected by the safety barriers (35.1%) followed by medians and embankments that were naturally occurring or created as a result of a raised roadway with each constituting 18.2% of cases. Culverts, pedestrians and road workers each constituted a small number of cases where it was found road workers were protected using temporary concrete barriers. In 5.2% of cases, there was insufficient information to determine the hazard being protected against.

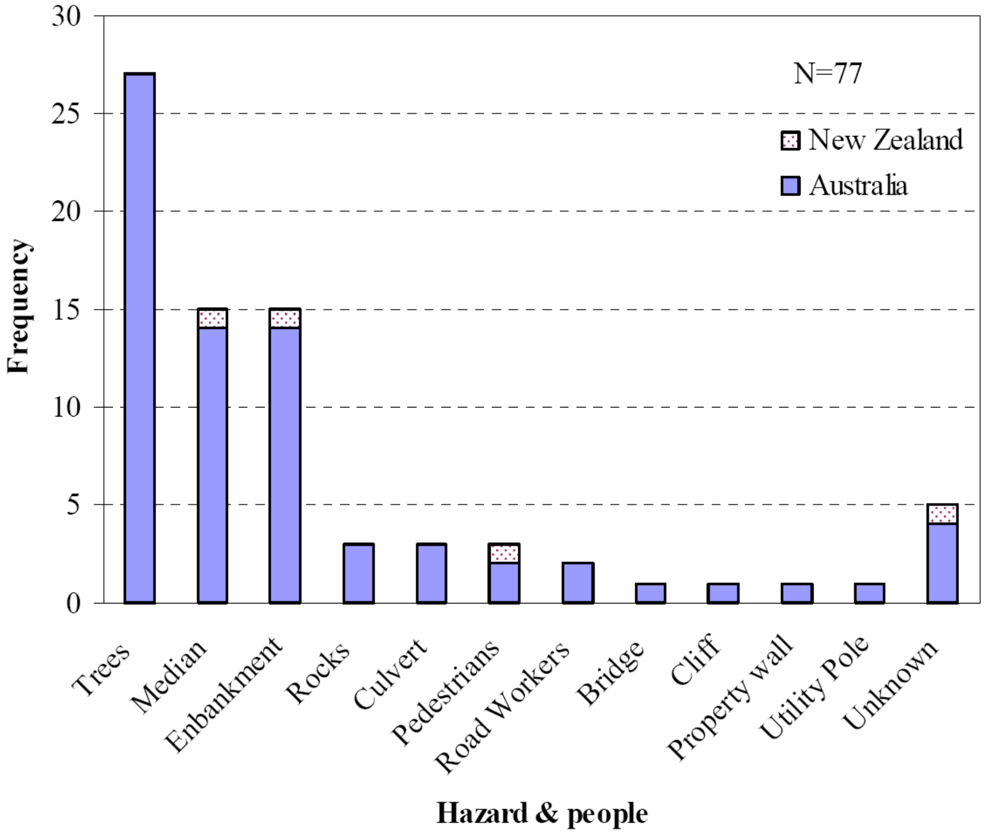

Figure 6: Hazards and people behind roadside barriers involved in motorcyclist fatalities in Australia and New Zealand (2001 to 2006)

If the barrier had not been present and the hazards otherwise untreated, the motorcyclist would still have been at risk of crashing into a hazard such as a tree, embankment, oncoming opposing traffic, culvert or workers and injuring themselves or hitting another person and injuring them.

Of particular interest are the findings by Daniello and Gabler (2009) looking at US motorcycle crashes, that the risk of a motorcyclist dying as a result of impacting a tree as opposed to impacting a W-Beam barrier is double (2), i.e. there is half the risk of dying colliding with a roadside barrier as opposed to running off the road and colliding with a tree. Similarly the risk of dying when striking a sign post, utility pole or other support is 1.5 times the risk of dying when striking a W-beam. In the case of concrete barriers, the risk of dying hitting the hazard changes respectively to 3.5 (tree) and 2.6 (post, signs, etc) times that of hitting the barrier. No values for wire-rope barriers are presently available.

5.6.3 Road type

Fatalities involving a motorcycle impacting a roadside safety barrier mostly occurred on roads with speed limits above 60 km/h. This is consistent with the findings of Gibson and Benatatos (2000). Figure 7 shows that the majority of the crashes occurred on arterial roads. Arterial roads were categorised as roads with speed limits ranging from 60km/h to 100km/h which consist of one or more lanes of traffic travelling in each direction with junctions. This distinguished them from freeways. Arterials accounted for 69.8% of the fatalities. Freeways with speed limits of between 100 and 110km/h accounted for 23.3% of cases. Freeways were categorised as roads which have 2 or more lanes travelling in the same direction with the traffic travelling in the opposite direction separated by a median barrier and no junctions but instead with exit ramps. Suburban roads with speed limits of between 50 and 60km/h accounted for only 5.5% of the fatalities.

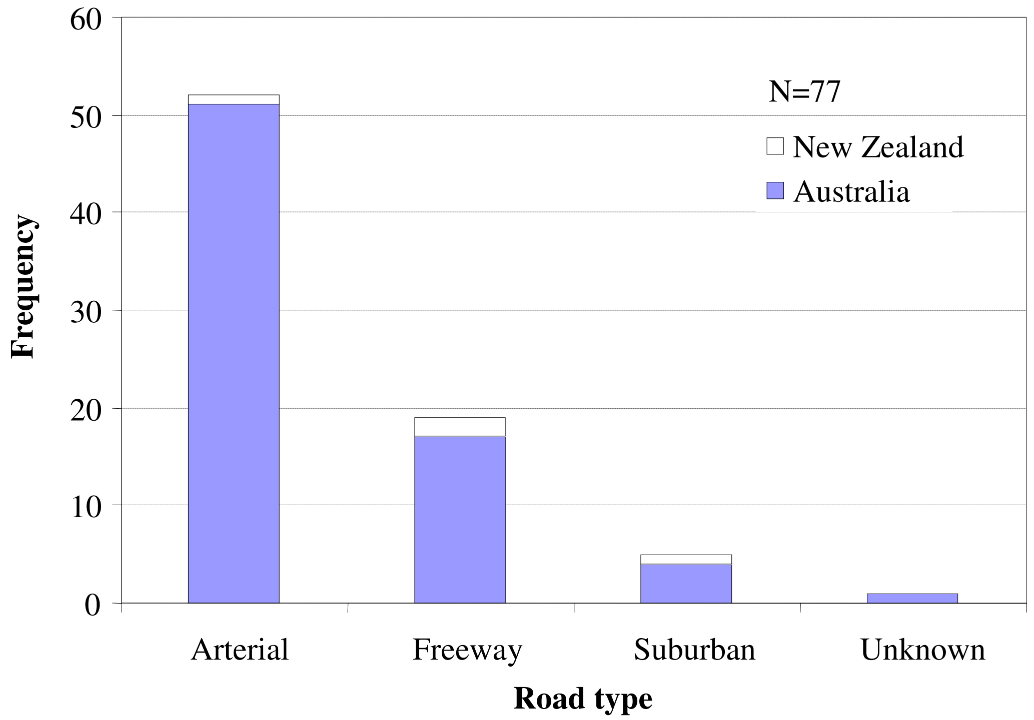

Figure 7: Road type in barrier impact resulting in a motorcyclist fatality in Australia and New Zealand (2001 to 2006)

It was possible to determine the speed limit applicable to the road in 72 cases. The largest number of fatalities occurred on roads with a speed limit of 100km/h (37), followed by 80km/h (22) and 60km/h (10). The observed difference between road types is probably a reflection of differences in the extent of barrier exposure and also the effect of speed on crash severity. Barrier installation is less likely on suburban roads than on arterial roads and dual carriageway freeways. More fatalities occur on higher speed roads since a fall from a motorcycle at high speed is associated with higher energy that has to be dissipated than a fall at a lower speed.

Figure 8 shows the horizontal alignment of the road site where a motorcyclist died and where an impact into a roadside barrier was involved. 80.8% of fatal crash sites involved a bend in the horizontal alignment of the road. Nearly an equal number of cases involved a left hand and right hand bend with 28 and 26 cases involved respectively. A further 8 cases were described only as a bend. Unfortunately, there was insufficient information in the records to determine the radius of the curvature of the bends involved. Only 14.1% of cases occurred on a straight section of the road and 3.8% occurred at an intersection.

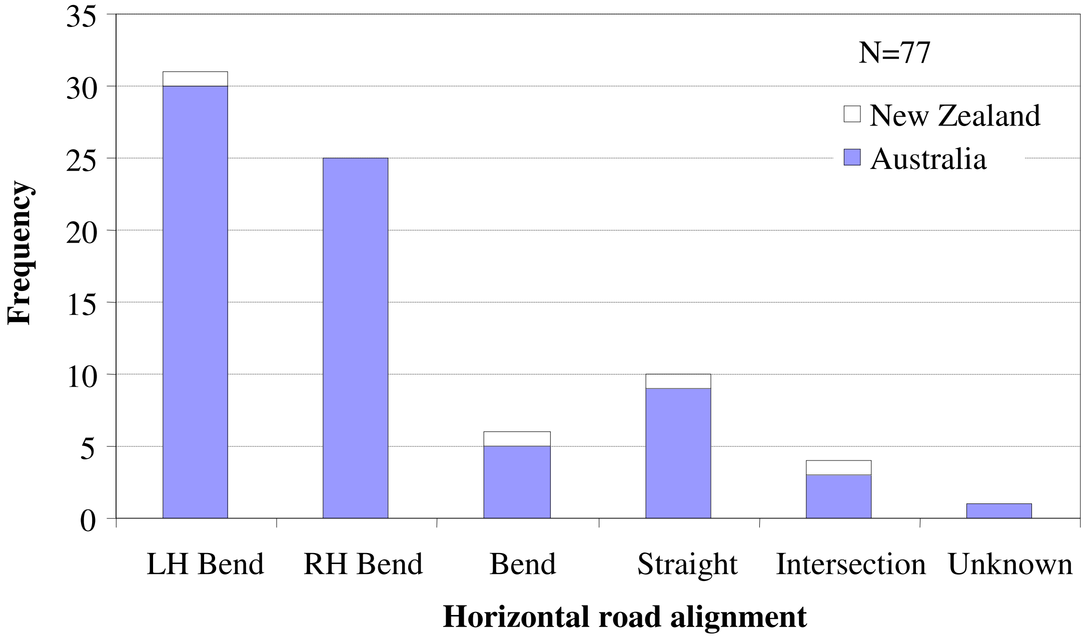

Figure 8: Horizontal alignment of roadside barrier impacted resulting in a fatality in Australian jurisdictions and New Zealand (2001 to 2006)

The predominance of fatalities on bends is not surprising. It is harder to control a motorcycle on a bend than it is on a straight part of the road. This was exacerbated by inappropriate speed in 17 out of the 72 cases where it was observed that the posted advisory speed was ignored on a bend. It is also likely that the driving/riding challenges posed by bends make them more suitable candidates for barrier installation, so that exposure to barriers is probably greater for curves than for straight road sections.

5.6.4 Day and time of crash

Figure 9 shows that 54% of motorcycle fatalities involving a roadside safety barrier occurred on a weekend, with 21 fatalities associated with each day. The rest of the week witnessed 35 fatalities with an average of 7 deaths for each day. In 46 cases motorcyclists were on a recreational ride, which explains the high frequency of fatalities on a weekend. Driving as a recreational activity is generally known to be a predictor of crashes (Clarke, Ward, Bartle & Truman, 2006; Gregersen & Berg, 1994).

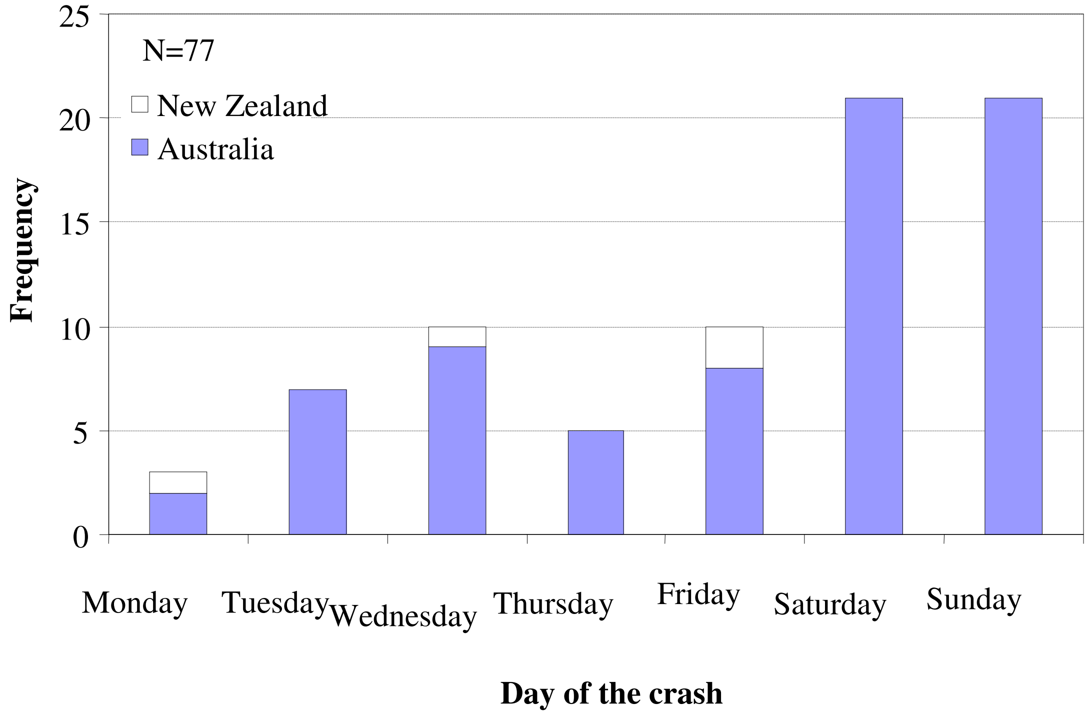

Figure 9: Day of the crash of motorcyclist fatalities involving impact into a roadside safety barrier in Australia and New Zealand (2001 to 2006)

Figure 10 shows that barrier crashes primarily occurred during daylight hours, particularly in the afternoon. This pattern probably reflects exposure, with riders more likely to engage in recreational riding in the afternoon, but it may also be related to fatigue as the recreational riders are likely to be returning from a ride later in the day and may be tired.

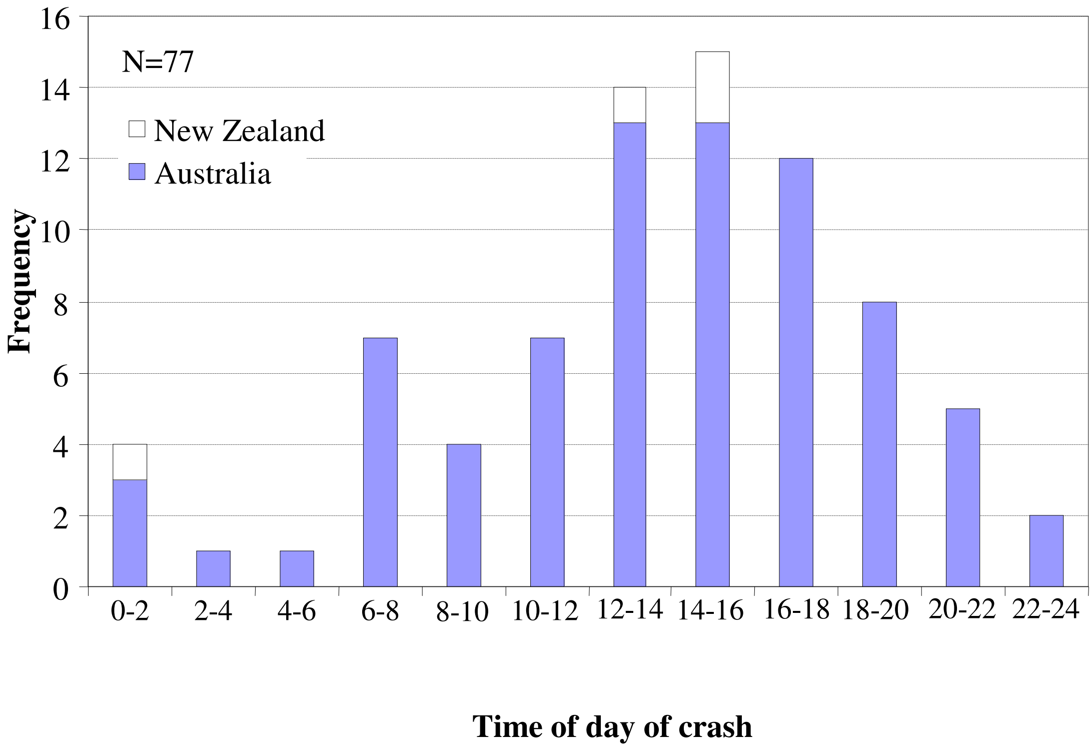

Figure 10: Time of Crash of motorcyclist fatalities involving impact into a roadside safety barrier in Australia and New Zealand (2001 to 2006)

Night time crashes were not associated with any day of the week. Night time crashes were often associated with speed or alcohol with 10 out of the 15 cases registering blood alcohol level above the legal limit. Speeding was suspected in 8 out of the 15 crashes that occurred at night while in 3 out of the 15 cases speeding was suspected plus alcohol was found in the blood of the deceased.

5.6.5 Road surface and weather factors

In 71 out of the 77 fatalities the road surface was described by the police as in good condition. Examples of descriptors used by police indicating the surface condition of the road were: "there is no evidence of a road defect", "the surface of the road was free from debris, oil or any foreign matter" and "I did not see any foreign substances or objects on the road surface", etc. In three cases, the road surface was described by the police as poor and in two cases the road surface had corrugations.

In nearly half of the cases, the weather was described as "clear and dry" or "fine day" and the road surface condition was dry (Figure 11). This was followed by dark conditions with dry road surface in which 28.2% of the fatalities occurred. In 16.7% the description of the weather was insufficient. These results are not surprising as dry conditions are conducive to riding a motorcycle. The authors suspect that the lower numbers for wet conditions reflect exposure, i.e. riders chose not to ride in wet or rainy conditions.

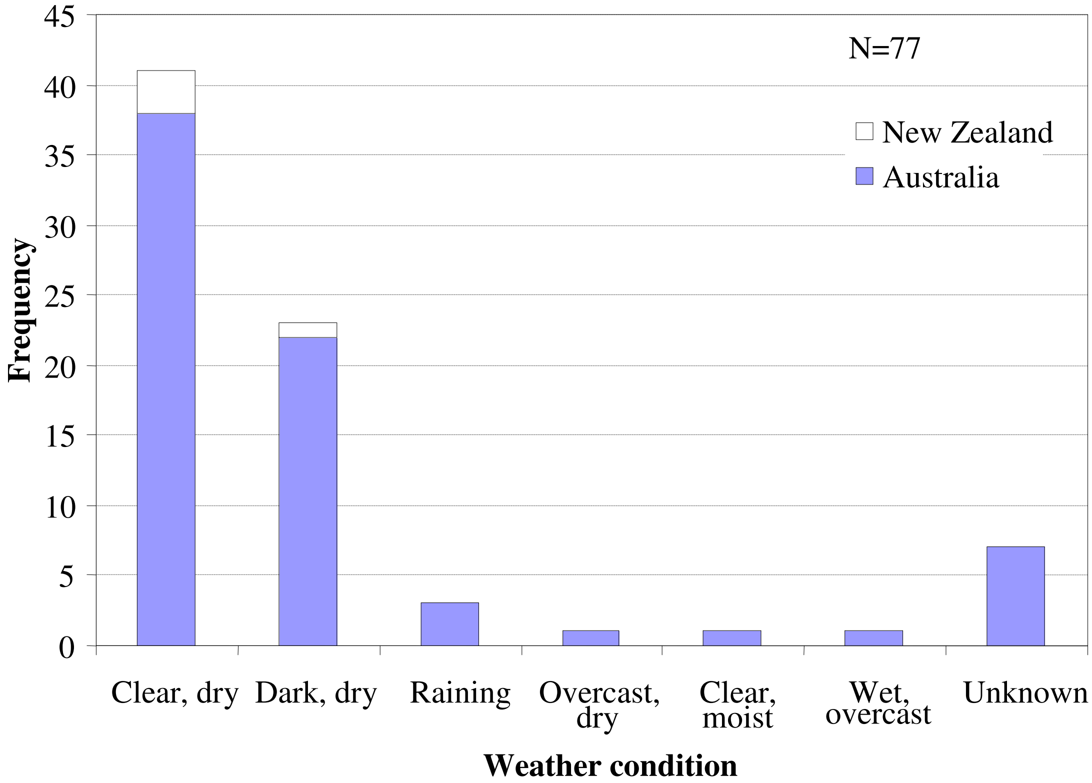

Figure 11: Weather condition at the time of a crash involving a motorcyclist fatality and a roadside safety barrier in Australia and New Zealand (2001 to 2006)

5.7 Vehicular factors

5.7.1 Mechanical condition of the motorcycle

In 55 out of the 77 cases, there was an examination of the mechanical condition of the motorcycle after the collision. In 47 of these cases, the inspection reports conclude that there was no mechanical defect that could have contributed or caused the crash. In the remaining cases, the motorcycle was found to be in poor condition; five with worn out tyres. These data suggest that mechanical problems do not play a major role in motorcycle-barrier impacts.

5.7.2 Registration of motorcycle

In the majority (77.9%) of cases, the motorcycles were registered. In four cases the motorcycles were unregistered. In all these four cases, the rider had also consumed alcohol. In the remaining 13 cases, there was insufficient information to determine if the motorcycle was registered or not.

5.8 Crash contributory factors

A summary of the main factors that contributed to the crash were isolated from the police reports (Figure 12). Speeding or inappropriate speed was found to be the highest single factor that contributed to the crash (27 cases). Alcohol by itself, closely followed by alcohol with a combination of speed (7) and drugs (6) was also a common contributory factor. Other factors such as avoidance of vehicles and fatigue did not feature highly as contributory factors.

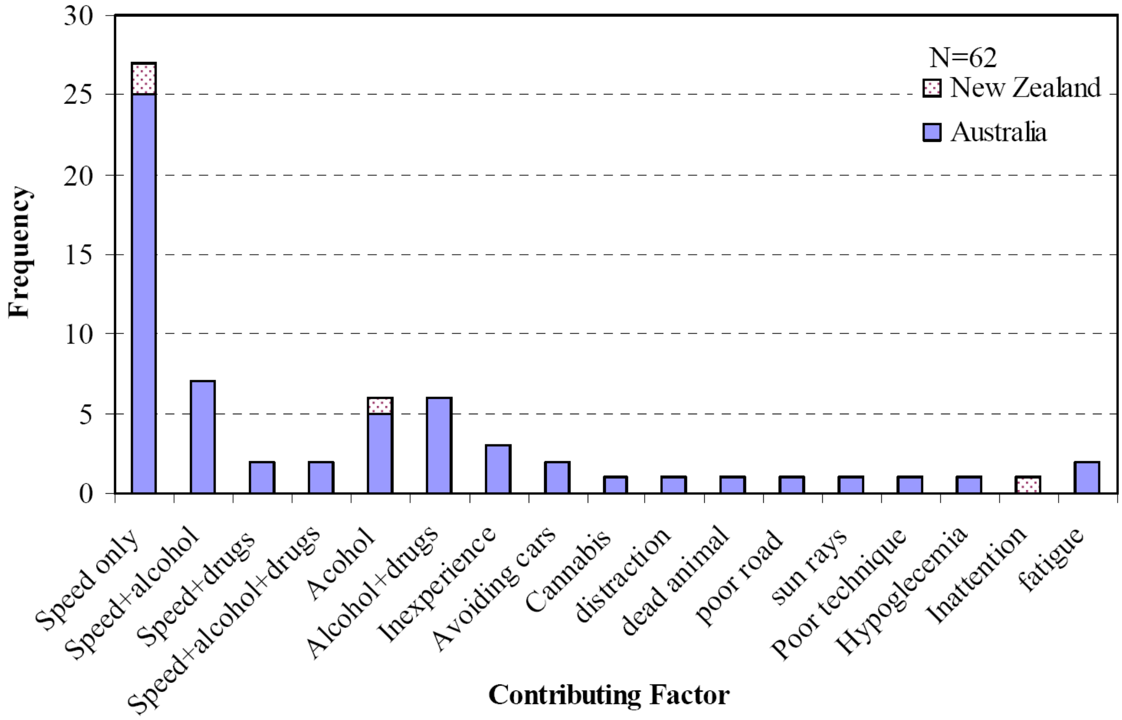

Figure 12: Crash contributory factors of motorcyclist fatalities involving a roadside safety barrier in Australia and New Zealand (2001 to 2006)

6. Further work

Stages 2 and 3 of the research are ongoing and will be published in due course. Stage 2 will investigate the injury mechanisms and the biomechanics of the human-barrier interaction. Stage 3 will determine survivability envelopes for different barrier systems and engineering solutions to mitigate injuries. These stages will complete parts 'd' to 'g' of the project outcomes listed in the section titled Project background.

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