Submission No 22

MOTORCYCLE SAFETY IN NSW

Organisation:	Transport and Road Safety (TARS) Research Centre, University of NSW
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Motorcycle Safety in NSW

Submission to the NSW Joint Standing Committee on Road Safety (Staysafe) Inquiry

Never Stand Still | Science | Transport and Road Safety (TARS) Research Centre

Mr. Greg Aplin, MP
Chair Staysafe Joint Standing Committee on Road Safety
Staysafe Committee
Parliament House
Macquarie Street
SYDNEY NSW 2000
Via email c/o:
Ms Vedrana Trisic
staysafe@parliament.nsw.gov.au

2nd October 2015

Dear Mr Alpin,

Re: **INQUIRY INTO MOTORCYCLE SAFETY IN NSW**

TARS Research, UNSW are pleased to provide you with our *2015 Submission to the Staysafe Inquiry into Motorcycle Safety in NSW*.

Our submission was prepared and submitted by:

Prof Raphael Grzebieta
Professor (Road Safety)
Transport and Road Safety (TARS) Research Centre,
University of New South Wales

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Both Prof. Grzebieta and Prof. Williamson are prepared to offer expert opinion regarding the TARS Research Centre’s findings and any questions the committee may want to ask in regards to these issues. The Authors have a long history and track record in making submissions to government inquests focussing on various aspects of road safety.

Overview

This submission is made by Prof. Grzebieta and Prof. Williamson on behalf of those individuals who have worked at the Transport and Road Safety (TARS) Research Centre (formerly the Injury Risk Management Research Centre (IRMRC)) at The University of New South Wales (UNSW) on various issues focussing on motorcycle safety.

It is based on research relating to motorcycle road users that has been conducted by a team of researchers working with Prof Grzebieta at UNSW over the past eight years and also research by Prof. Williamson's team focussing on driver fatigue over the past two to three decades. The main area of research that the TARS Research Centre has been involved in that may be of use to the committee relate to motorcycle into roadside barrier fatalities, motorcyclist serious injuries and fatalities in general and rider fatigue.

Terms of Reference:

That the Committee inquire into and report on motorcycle safety in New South Wales with particular reference to:

a. Trends of motorcycle usage, injury and fatality in NSW;

b. Crash and injury risk factors including rider (and driver) behaviour, conspicuity and vehicle instability;

c. The effectiveness of the current action plan to enhance motorcycle safety including communications and education campaigns, road environment improvements, regulation of safety equipment and gear;

d. Strategies of other jurisdictions to improve motorcycle safety;

e. Licensing and rider training; and

f. Any other related matters.

a. Trends of motorcycle usage, injury and fatality in NSW;

The TARS research team have predominantly investigated on-road serious injury and fatality crashes in regards to Australian data which has included data related to NSW. Whilst some of the fatality data is now ten years old in regards to current total fatalities, it does provide information related to proportions of riders that died as a result of striking a roadside barrier and those that were found to have occurred as a result of motorcyclist risky riding behaviour, including excessive speed, alcohol and drug use and disobeying traffic control laws.

Also some US data has been used to assess survivability of motorcycle crashes into fixed objects that relate to Australian conditions. While a lot of the work regarding motorcycle casualties over the past seven years has focussed predominantly on fatalities involving motorcycle impacts into roadside barriers, four studies in total were carried out at TARS that provide information concerning motorcycle fatalities and serious injuries. These studies are:

- analysis of motorcycle impacts into roadside safety barriers that include W-beam, concrete and wire-rope barriers;
- investigation of motorcycle deaths and serious injuries from NSW linked crash and hospital admissions data for the years 2001 to 2009. Around twenty thousand injuries (weighted) were analysed;
- investigation of all motorcycle fatalities that occurred in Australia using information from the National Coroners Information System (NCIS) for the years 2001 to 2006. Around 1,323 Australian fatalities have been accessed and coded;

Results from these studies have been presented at various Australian and international conferences and published in various journals. They are available on-line at:
http://www.tars.unsw.edu.au/research/Current/Motorcycle-barriers/motorcycle-barrier_impacts.html

Key points from these studies are presented in this submission. Prof. Grzebieta on behalf of the IRMRC researchers (now TARS) also made a submission to the NSW Parliamentary Staysafe Committee inquiry into Research Relating to Vulnerable Road Users (submission 54, dated 27/08/2010) which included motorcycle safety.[1] Some of the key points are repeated here albeit with updated data.

General Motorcycle Fatality and Injury Data:

After dramatic reductions in the late 1980's and early 1990's, motorcycle fatalities in Australia rose over the period 2000 to 2010 but now appear to be trending downwards since 2007 over the past 5 years as shown in Figure 1. In contrast NSW fatalities are constant if not tending slightly upwards.

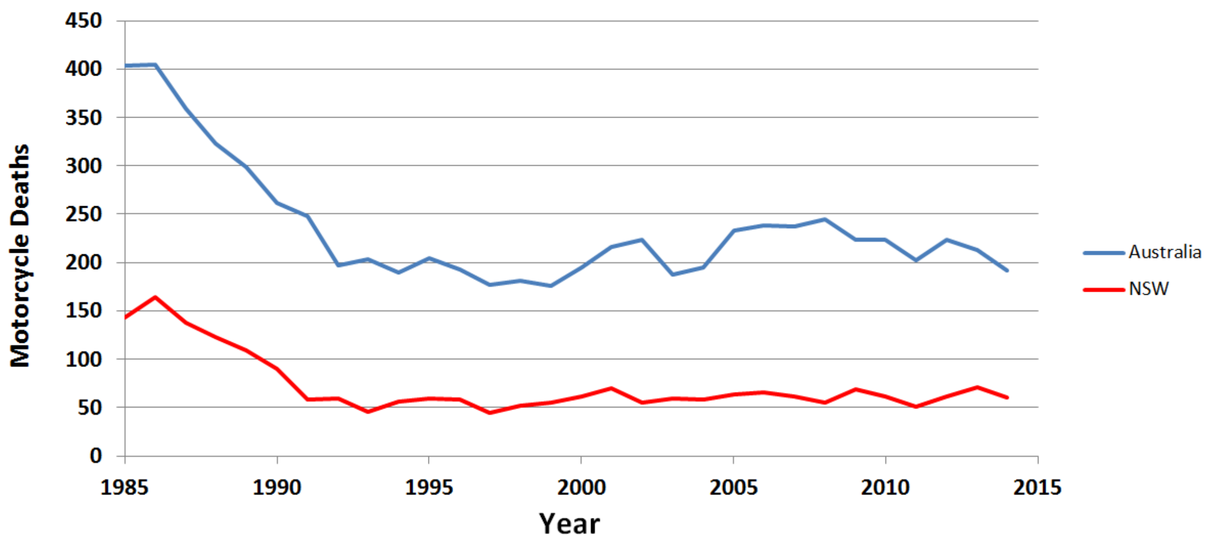

Figure 1: Australian Motorcycle fatalities

While total fatalities for Australia and NSW continue to fall the same cannot be said for motorcycle fatalities relative to all road fatalities. They are rising as indicated in Figure 2. NSW has now reached 20% of all deaths, an alarming trend.

This rise in percentage of motorcycle deaths relative to all road deaths is also the main reason why TARS researchers started to investigate in more detail motorcycle fatalities and injuries over the past seven years. It is clear countermeasures that appear to be working for other road users is not having an effect in regards to motorcycle riders. It was the opinion of TARS researchers that this situation is mainly the result of riders becoming involved in risk behavior such as speed, consuming alcohol and drugs prior to riding and violating traffic laws. TARS researchers also found that there was insufficient research 'independent' of any research funded by motorcycling lobby groups, was being carried out. TARS researchers have tried to address this issue over the past seven years. Nevertheless, it is critical that more such 'independent' work needs to continue to be carried out if any reductions in motorcycle related trauma is to be reduced.

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[1] http://www.parliament.nsw.gov.au/Prod/parlment/committee.nsf/0/33b2c0934782a5baca2577910023f8f7/$FILE/Submission%20No.%2054%20-%20NSW%20Injury%20Risk%20Management%20Research%20Centre%20(IRMRC).pdf

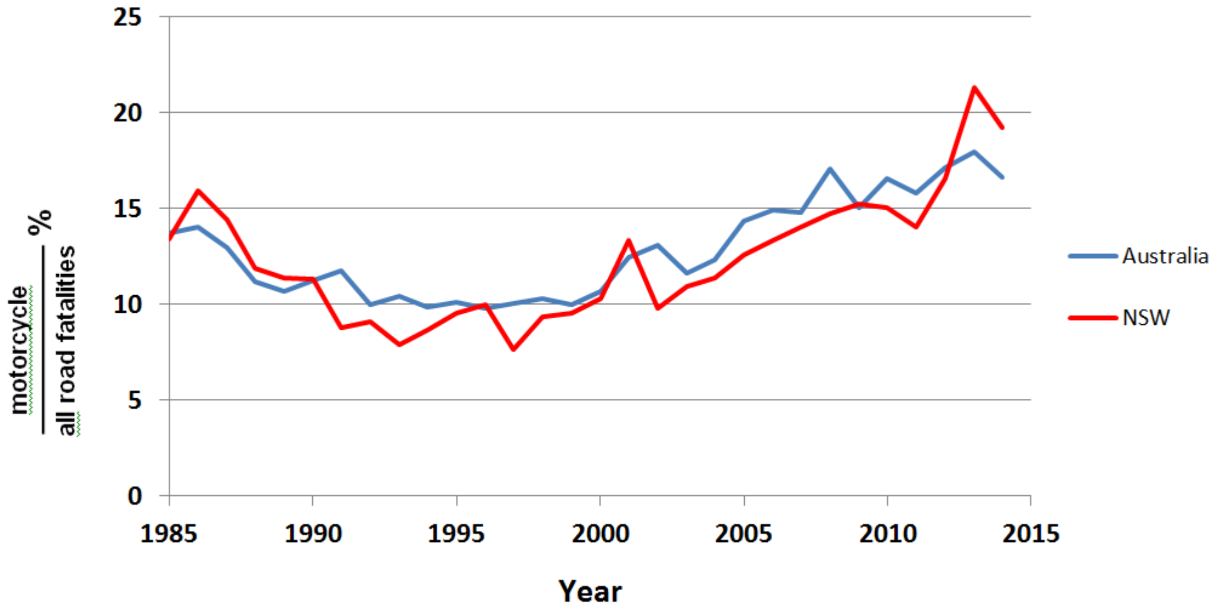

Figure 2: Comparison of motorcycle fatalities to all road fatalities

In terms of serious injuries, TARS initial research focus was on single vehicles crashes. A retrospective case series study, using linked police-reported road crash and hospital admission data in New South Wales, Australia, from 2001 to 2009 was performed.[2] Crude and adjusted relative risks of motorcyclist serious injury were determined for various fixed objects compared to barriers, using serious injury rates and multiple variable logistic regression. Calculated relative risks compared with guardrail for motorcyclists were compared with those determined from the United States and Australian Roadside Design Guides for passenger vehicle occupants. The study identified 1364 motorcyclists seriously injured as a result of single-vehicle collisions with roadside barriers, trees, utility poles, and other fixed roadside infrastructure in NSW.

Serious Injuries

Another study was then carried out by Mitchell and Bambach[3] where a data collection of linked police-reported and hospital data was established, and a weighting procedure was developed to estimate hospital cases not reported to police and fatal cases not admitted to hospital for the years 2001 to 2011. The resulting data collection of an estimated 19,979 hospitalised motorcyclists was then used to provide detailed information on the nature, incidence and risk factors for riders subjected to thoracic trauma. Table 1 shows the descriptive results of the weighted Crashlink data extracted from Bambach and Mitchell's 2104 TARS paper.

Bambach and Mitchell's (2104) also disaggregated serious injuries by three crash modes, where serious thoracic injury was the most frequent serious injury for motorcyclists in non-collision crashes (29.5%) and collisions with fixed objects (25.6%), while serious lower extremity injury occurred most frequently in collisions with motor vehicles (24.8%) followed by serious thoracic injury (19.7%). Figure 3 shows the motorcyclist serious injuries in CrashLink-Weighted (CL-W), NSW2001–2011 disaggregated by body region and collision counterpart.

[2] Bambach M. Mitchell R. Grzebieta R. (2013) The protective effect of roadside barriers for motorcyclists. Traffic Injury Prevention 14, 756-765.

[3] Bambach M. Mitchell R. (2014) The rising burden of serious thoracic trauma sustained by motorcyclists in road traffic crashes. Accident Analysis and Prevention, 62, 248-258.

Table 1: Descriptive results for motorcyclists, CrashLink-Weighted, NSW 2001 [after Bambach and Mitchell, 2014].[3]

	Total motorcyclist casualties	
	n	%
Collision counterpart – none	23,560	48.0
culvert	278	0.6
embankment	608	1.2
fence/guardrail	1672	3.4
median divider	728	1.5
non-specified fixed object	309	0.6
post/pole	586	1.2
tree	833	1.7
two fixed objects	188	0.4
utility pole	240	0.5
non-fixed object	2565	5.2
small motor vehicle	13,753	28.0
large motor vehicle	2484	5.1
other motor vehicle	1277	2.6
Speed limit – 0–50 km/h	15,301	31.2
60	16,569	33.8
70–90	9534	19.4
100–110	7677	15.6
Helmet – not worn	6359	13.0
worn	42,722	87.0
Age ≤ mean of 34 years	27,614	56.3
>mean	21,468	43.7
Traffic infringement – no	48,693	99.2
yes	389	0.8
BAC (g/100 mL) < 0.05	46,530	94.8
≥0.05	2552	5.2
Pillion	2782	5.7
operator	46,294	94.3
Female	5654	11.5
male	43,428	88.5
Intersection location – no	29,253	59.6
yes	19,829	40.4
Rural location	21,716	44.2
metropolitan location	27,365	55.8
Curve location – no	31,439	64.1
yes	17,643	35.9
Highway/freeway – no	40,595	82.7
yes	8486	17.3
Non-sealed roadway	2749	5.6
sealed roadway	46,333	94.4
Wet roadway	6301	12.8
dry roadway	42,781	87.2
Daytime – no	13,205	26.9
yes	35,877	73.1

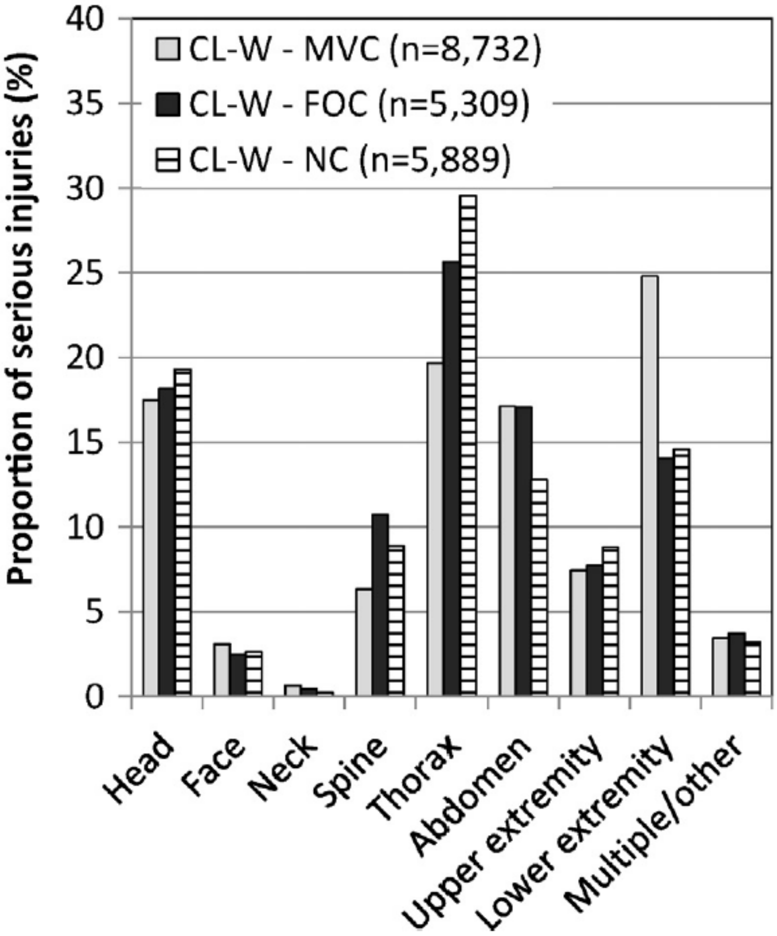

Fig. 3. Motorcyclist serious injuries in CrashLink-Weighted (CL-W), NSW 2001–2011 disaggregated by body region and collision counterpart. (MVC = motor vehicle collision, FOC = fixed object collision and NC = non-collision).

[after Bambach and Mitchell, 2014][3]

Bambach and Mitchell (2014) further noted that:

> *"The results ……. indicated that the incidence of motorcyclist serious thoracic injury approximately doubled over the study period, as did the number of hospital bed days associated with such motorcyclists. It is also noted that by 2011, while motorcycles represented 3.2% of the registered vehicle fleet in NSW, 24% of road crash-related serious thoracic trauma cases treated in NSW hospitals were motorcyclists. This rising trauma burden is in part due to an increase in motorcyclists on NSW roadways, where from 2001 to 2011 motorcycle registrations increased from 90,000 to 178,670 and motorcycle licences increased from 395,493 to 496,249. However, the age distribution of motorcyclists has changed substantially over the period, where the proportion of motorcyclist casualties that were aged 40+ increased by approximately 50% over the period … . This is supported by data for the age of registered owners of motorcycles in NSW, where between 1995 and 2006 the proportion of those aged less than 26years decreased from 17% to 9%, while the proportion aged 40+ increased from 31% to 54% …"*

b. Crash and injury risk factors including rider (and driver) behaviour, conspicuity and vehicle instability;

The majority of the information presented in this section has been extracted from the TARS publication: *Bambach M.R., Grzebieta R.H., Tebecis R. and Friswell R., Crash characteristics and causal factors of motorcycle fatalities, Proceedings Australia, Australasian Road Safety Research, Policing and Education Conference, 4 - 6 October 2012, Wellington, New Zealand*.[4]

TARS researchers have investigated both fatalities and serious injuries and have identified a number of high risk factors associated with rider fatalities and injuries[3,4] In regards to fatalities, Australian motorcyclists are 30 times more likely to be killed and 37 times more likely to be seriously injured than car occupants per distance travelled. Understanding the crash characteristics and contributing causal factors of motorcyclist fatalities and serious injuries will assist motorcycling groups, road safety practitioners and road authorities to address motorcyclist safety, and reduce road trauma related to this group of vulnerable road users.

Fatality Analysis

A range of factors have been identified by a number of researchers[4] as contributing to motorcycle crashes, their severity and the severity of the motorcyclists' injury(s), namely: speed, age, time of year, experience, alcohol, illicit drug use, time of day, conspicuity, risk taking behaviour, road side environment and helmet use. Motorcycle deaths in NSW as a proportion of all road deaths has now increased from 10% in 1995 to currently around 20% as shown in Figure 2. However, Figure 1 indicates that fatalities in NSW have been fairly constant with a slight rising trend over the past 5 years despite the increase in motorcycle numbers. This is in stark contrast to NSW road fatalities which have halved over the past 20 years from 620 in 1995 to the current 312 in 2014. This indicates that while all other road user fatalities have decreased significantly as a result of various road safety policy trauma countermeasures, the same cannot be said for motorcyclists, i.e. the countermeasures have not been as effective. These figures indicate that initiatives must be taken by motorcycling groups, road safety practitioners and road authorities in order to address motorcyclist safety and attempt to reduce this alarming rising trend of motorcyclist injuries and fatalities relative to all other road fatalities.

What has become obvious to the TARS researchers is that high risk behavior by motorcyclists continues to a major issue in regards to impeding the reduction of motorcycle related trauma.

For example, TARS researchers[4] carried out a retrospective study of fatalities using the Australian National Coroner's Information System (NCIS) during the six year period between 2001 and 2006. Around 1,323 fatal motorcycle crashes were identified. While the data is now around ten years old, the TARS researchers consider the characteristics regarding risky rider behavior would not have changed to any large degree over the past decade. Nevertheless, it would be useful to fund a larger study investigating more recent motorcycle fatality data.

The contributing causal factors in the crash were determined by the investigating police and/or Coronial inquest, and reported in the police summary and/or Coroner's findings. Motorcyclists that were displaying risky riding behaviour were identified (excessive speed, alcohol, drugs or disobeying

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[4] Bambach M.R., Grzebieta R.H., Tebecis R. and Friswell R., Crash characteristics and causal factors of motorcycle fatalities, Proceedings Australia, Australasian Road Safety Research, Policing and Education Conference, 4 - 6 October 2012, Wellington, New Zealand.

a traffic control). Excessive speed includes speed considered excessive for the conditions and/or speed in excess of the speed limit (as determined by the investigating police). Disobeying a traffic control was reported by terms such as failed to give way, failed to stop at a red light or stop sign, riding on the wrong side of the road, racing, etc. It is important to note that causal factors such as risky riding behaviours are identified as *contributing* causal factors, since crashes are often caused by a complex combination of factors and may not accurately be attributed to any one factor. It is possible that some factors identified as being contributing causal factors were in fact simply present rather than contributing.

In multi-vehicle crashes, the vehicle at fault was assessed from the police summary, Coronial finding and the risky riding results. The vehicle deemed to be at fault was that typically described as the vehicle entering/exiting the roadway in front of the other vehicle, performing a turn or U-turn in front of the other vehicle, on the wrong side of the roadway, or disobeying a traffic control. If the other vehicle operator was displaying risky driving, then both vehicles were deemed to be at fault (e.g. a car turned in front of a motorcyclist who was travelling at excessive speed). General characteristics of the fatal motorcycle crashes were:

- Approximately one quarter of the fatalities occurred in each of the eastern board states (NSW (24%), Vic (24%) and Qld (24%)) and around 12% in WA;
- 95% were male;
- 4% were pillions and mostly female;
- the mean age was 33.8 years, and the most frequent age group was 21 to 29 year olds, followed by 31 to 39 year olds;
- the majority of crashes (56%) occurred between Friday and Sunday;
- the month in which the crashes occurred was fairly evenly distributed throughout the year, however there were slightly fewer crashes in the cooler months of June to September;
- the majority of crashes (57% of 828 known cases[5]) occurred between noon and 8pm;
- the majority of crashes (66% of 273 known cases) occurred in fine and dry conditions on a dry roadway surface;
- the location of the crashes was fairly evenly distributed between arterial roads (26%), rural or private roads (26%), freeways or highways (25%) and suburban roads (21%);
- the majority of crashes occurred at bends or intersections (39% and 38% of 957 known cases, respectively), with the remainder on a straight roadway;
- 47% of multi-vehicle crashes occurred at an intersection, and 67% of these involved a vehicle turning in front of the motorcyclist (i.e. the vehicle driver did not see the motorcyclist or misjudged the distance or speed of the motorcyclist);
- 84% of deaths occurred at the crash scene; 15% of fatal crashes occurred while the motorcyclist was on a group ride;
- 42% of motorcycle engine capacities were less than 500cc, 36% were between 500 and 1000cc and 22% were greater than 1000cc (371 known cases);
- the motorcycles were predominantly registered (84% of 411 known cases) and in a roadworthy condition (75% of 75 known cases);
- and a motorcycle helmet was worn in 86% of 299 known cases.

[5] 'Known cases' means where there was sufficient information to identify the relevant characteristic.

The crash events are summarised for all 1,323 fatal motorcycle crashes in Figure 4. Of 1,127 known cases, 630 were multi-vehicle crashes (56%) and 497 were single-vehicle crashes (44%). Cars were the most frequent partner vehicle in the collision (65%), and the motorcyclist impacting the side of the partner vehicle was the most frequent crash orientation (45% of known cases).

Single-vehicle motorcyclist fatalities predominantly resulted from collisions with fixed objects (89%). The most frequently impacted fixed objects were trees (31%), utility poles/posts (21%) and roadside barriers (17%).

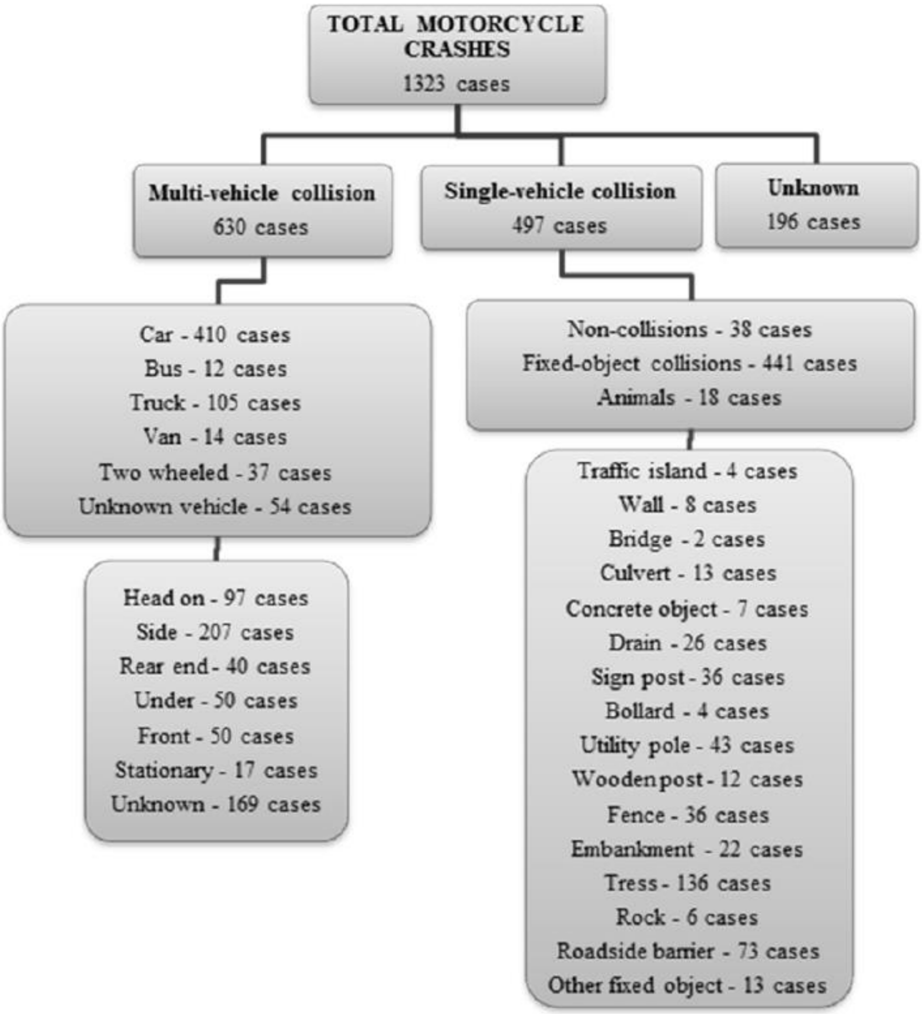

Figure 4: Crash events of fatal motorcycle crashes (n=1,323)
[After Bambach et al, 2012][4]

Analysis of the 764 available toxicology reports indicated that 233 motorcyclists (30%) had consumed alcohol prior to the crash, of which 167 (72%) had alcohol levels above the legal limit of a BAC of 0.05. The alcohol levels are plotted in Figure 5, where it is evident that the majority of alcohol-affected motorcyclists had a BAC above 0.1 (60%).

Of the 764 known cases, illicit drugs were 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%). The types of illicit drugs detected are plotted in Figure 6, where the majority was cannabis (68%). Of those motorcyclists that consumed cannabis, 63% had THC concentrations in excess of 5μg/L, which approximates to consumption of one cigarette within 6 hours (of the sample being taken). A total of 359 motorcyclists had consumed alcohol and/or drugs prior to the crash (47%).

In regards to the alcohol consumption Keall et al (2013)[6] identified that the risk to motorcyclists with a BAC of 0.05 has a risk of a fatality 165 times that of a car or van driver with a BAC of 0.05 (see: Figure 7). In other words, the data shown in the TARS research results for motorcycle fatalities and series injuries[2,3,4], where alcohol is shown to be a major risk factor and contributor to the crash, it becomes clear that trauma related to alcohol would be high if riders decide to drink and ride given the results presented by Keall et al (2013).

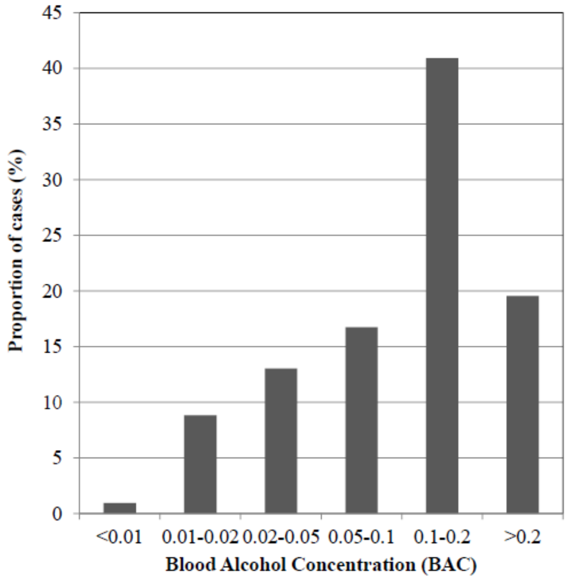

Figure 5: BAC levels for motorcyclist where alcohol was present in the toxicology report (n=233)

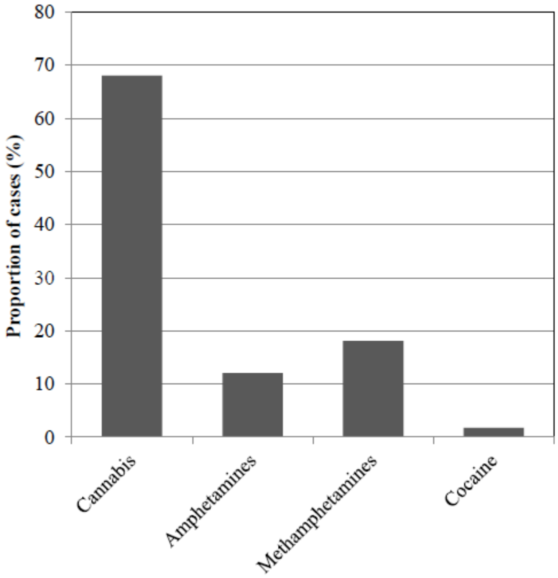

Figure 6: Types of drugs for motorcyclists where drugs were present in the toxicology report (n=207)

[After Bambach et al, 2012][4]

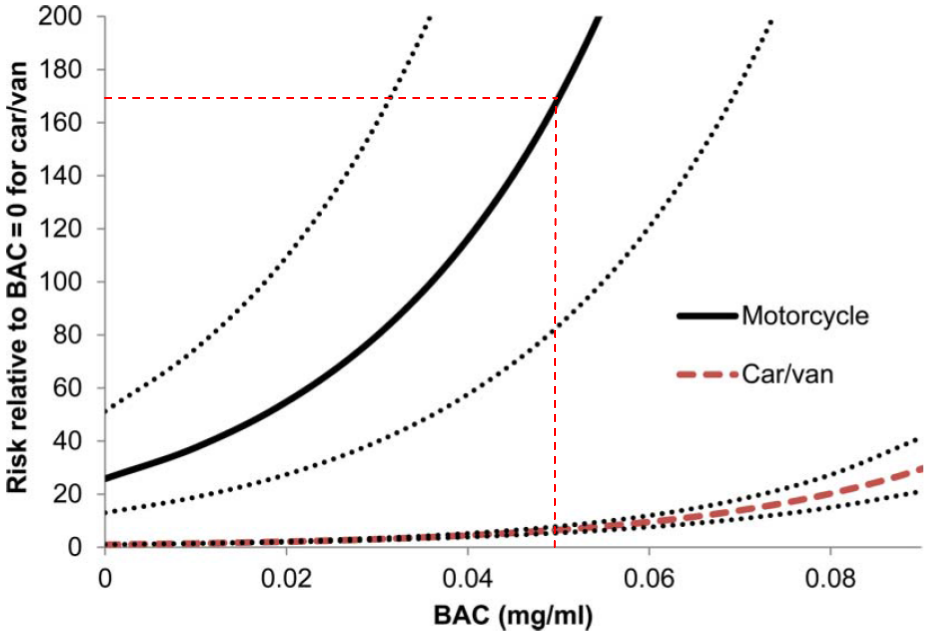

Figure 7: Risk for car/van driver or motorcycle rider of fatal injury relative to a car/van driver with BAC = 0, with 95 percent confidence intervals (dotted lines) [After Keall et al, 2013][6]

6 Keall M.D, Clark B. & Rudin-Brown C.M., Preliminary Estimation Of Motorcyclist Fatal Injury Risk By BAC Level Relative To Car/Van Drivers, Traffic Injury Prevention, Volume 14, Issue 1, 2013, DOI:10.1080/15389588.2012.678510

Riding a motorcycle requires a significant skill level greatly superior to driving a car in order to avoid making an error and having a crash. In other words, a motorcycle has an extremely low threshold error tolerance compared to any other vehicle in terms of crash susceptibility, mainly because of its inherent unstable nature. Only the most competent and responsible riders should be allowed to ride such a vehicle. Unfortunately, we have the reverse situation where less responsible individuals are allowed to ride these vehicles with relatively little training or screening.

After considering Figure 6, the key question to ask is '*why does our society continue to allow a rider to numb their brain with either alcohol or drugs when riding such a complex vehicle?*' One countermeasure that would have an immediate effect on reducing motorcycle trauma would be set BAC for all motorcyclist and scooter riders to 0.02 similar to Sweden's limit which is a world's best practise country for road safety. Regular random breathalyser tests should then be carried out at known motorcycle popular routes such as along coast lines and on mountainous curvy roads.

The NCIS study also found that there were 355 motorcyclists (27% of 1,323) for whom excessive speed was identified by police and reported in the police summary and 146 motorcyclists that were reported to have disobeyed a traffic control (11%). Of all 1,323 motorcycle fatalities, there were 663 motorcyclists (50%) for whom risky riding behaviour of any type was identified as a contributing causal factor in the crash (speed, alcohol, drugs, disobeying a traffic control, or any combination). A statistical analysis was performed in order to establish motorcyclist characteristics that were associated with risky riding behaviour. These results indicate that males, less than 35 year olds, riding in the evening on weekends, suburban areas, unregistered motorcycles and single-vehicle crashes were statistically significantly more likely to have risky riding behaviour identified as a contributing causal factor in the fatal crash. Motorcyclists on a group ride or performing paid work duties were less likely to have been demonstrating risky riding.

The analysis of the vehicle at fault in the NCIS study indicated that in 482 multi-vehicle crashes where fault could be established (77%), the motorcyclist was the vehicle at fault in 246 cases (51%), the other vehicle was at fault in 151 cases (31%) and both were at fault in 85 cases (18%). Most of the dual-fault crashes involved another vehicle initiating the crash while the motorcyclist demonstrated risky riding behaviour.

Considering all 482 multi-vehicle crashes where fault was established and the 479 single vehicle crashes (not including collisions with animals) that may be attributed to the motorcyclists' fault, the motorcyclist was at fault or partially at fault in 810 cases (84%) and another vehicle was at fault or partially at fault in 236 cases (25%). Of the 810 crashes where the motorcyclist was at fault or partially at fault, risky riding was identified as a contributing causal factor in 569 cases (70%).

In a small number of cases other factors were identified as contributing to the cause of the crash, including an animal on the roadway, a pothole, loose gravel, high wind, fatigue or a possible medical condition (4%). Many cases for which no contributing causal factors were established were described simply as the motorcyclist lost control.

In summary, the TARS analysis of the NCIS fatality data[4] indicated:

- motorcyclists killed were predominantly helmeted males between the ages of 21 and 39, riding on weekends in the afternoons or evenings in fine, dry conditions, i.e. younger males as being over-represented in motorcycle trauma;
- 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%). The most common

crash modes were a motorcyclist impacting the side of a car at an intersection for the former, or a tree, utility pole, post or roadside barrier on a bend for the latter. Therefore intersection design, road user behaviour at intersections and roadside design have a significant influence on motorcyclist safety;

- The analysis of at fault in fatal motorcycle crashes indicated that while another vehicle was at fault or partially at fault in 49% of multi-vehicle crashes, due to the high number of single-vehicle crashes another vehicle was at fault or partially at fault in only 25% of all crashes. Of all fatal crashes, the motorcyclist was at fault or partially at fault in 84% of crashes, and of these, the motorcyclist was demonstrating risky riding behaviour in 70% of crashes (speed, alcohol, drugs, disobeying a traffic control, or any combination). These results indicate that while other vehicles are initiating some fatal motorcycle crashes, a large proportion are occurring as a result of motorcyclist risky riding behaviour;
- Of particular note was that of known cases, 47% of motorcyclists had consumed alcohol and/or drugs prior to the crash;
- Motorcyclists in fatal crashes while on a group ride were 1.5 times less likely to be demonstrating risky riding behaviour, which indicates that group riding may have a positive influence on discouraging risky riding. This might result from peer mentoring and increased understanding of risks amongst motorcycle club/group participants discouraging risky riding, and from scheduled rides offering opportunities for riders to plan ahead and manage alcohol/drug consumption;
- Motorcyclists that were on paid work duties at the time of the fatal crash were 2.3 times less likely to be demonstrating risky riding, which is understandable given the professional nature of the motorcycle usage. It is also possible that those people who choose to ride in groups or for work are less likely to engage in risky riding behaviour regardless of the type of riding they undertake.

c. <u>The effectiveness of the current action plan to enhance motorcycle safety including communications and education campaigns, road environment improvements, regulation of safety equipment and gear;</u>

The plan highlights as presented on the Transport for NSW website: http://roadsafety.transport.nsw.gov.au/aboutthecentre/strategies/nswmotorcyclesafetystrategy/index.html is provided as follows:

Strategy highlights:

- A $3 million program to review and provide safety works on popular motorcycle routes
- A targeted communication strategy for motorcyclists and other road users
- A lane filtering trial in Sydney's CBD
- Develop and promote technical support to encourage road asset owners to consider motorcycle safety when designing, constructing and maintaining the road network
- Further research on motorcycle crashes, the impact of fatigue on motorcyclists, motorcycle licensing and rider training
- Research and develop new ways to promote information on motorcycle features, helmet standards and protective clothing

<u>The plan to review and provide safety works on popular motorcycle routes</u>, while useful, will provide little return in terms of reducing road trauma. For example, injury crashes into roadside hazards constitute a small number of incidents as shown in Table 1. Nevertheless, analyses by TARS researchers of motorcycle striking barriers[2] and the NCIS fatalities[4] indicates that targeting popular motorcycling routes will be more effective than targeting all roads.

<u>Any communication strategy for motorcyclists</u> needs to address the issue of high risk behaviour. It is the 'elephant in the room' so to speak politically. In the NCIS study[4] approximately 1 in every 2 motorcyclists was at fault, undertaking some form of risky behaviour, i.e. speeding, consuming alcohol, taking a drug, and violating a traffic law or any combination of these. In the TARS extensive 'motorcycle impacts into road safety barriers' study[7,8], approximately 2 in every 3 riders were at fault, undertaking some form of risky behaviour. Any communication strategy must be coupled with an appropriate enforcement strategy where high risk behaviour such as speeding, consumption of alcohol and drugs and violating traffic laws are strongly targeted. Targeting high risk behaviour will provide the best return for dollars invested (cost – benefit ratio) over all other proposed countermeasures.

For example, in 2011/2012, TARS researchers[9] investigated United Sates (US) National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS) data from 2000

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[7] Grzebieta R.H., Jama H., McIntosh A., Friswell R., Favand J., Attard M., Smith R., (2009) Overview of Motorcycle Crash Fatalities Involving Road Safety Barriers, Journal of the Australasian College of Road Safety, November, Vol. 20 No. 4, pp. 42 – 52. (also published in Proceedings Road Safety Research, Policing and Education Conference, Sydney, Australia, November 2009), http://www.acrs.org.au/srcfiles/ACRS-Journal-20No4Web.pdf

[8] Jama H.H., Grzebieta R.H, Friswell R., McIntosh A.S., Characteristics of fatal motorcycle crashes into roadside safety barriers in Australia and New Zealand, Accident Analysis and Prevention, Vol. 43, Iss. 3, 2011.

[9] Bambach M. and Grzebieta R.H., (2012). Fatality Risk Mitigation For Rural Motorcycle Collisions With Trees And Utility Poles, Proc. TRB 91st Annual Meeting, Washington DC.

to 2009 (inclusive), which was readily on-line, to determine the fatality risk of motorcyclists colliding with trees and utility poles following a departure from a rural roadway. US and Australian rural roads and motorcyclist behaviour share many similar characteristics. Real-world data of fatality cases from 2000 to 2009 in the US were collected, and a fatality risk analysis was performed to investigate the benefits that various road safety measures may have in the reduction of the fatality risk in these cases. The benefits were expressed in terms of the resulting reductions in fatality risk, calculated using logistic regression modelling.

Analysis of the US data indicated that 52% of the more than 11,500 fixed object motorcycle fatalities occurred on rural roadways. Fatality risk mitigation techniques investigated were: changes to the roadside environment, including the installation of roadside barriers; rider behaviour/enforcement issues such as riding at the speed limit; wearing a helmet; and policy issues such as reducing the speed limit.

From this US FARS database it was determined that for the years from 2000 to 2009 (inclusive), there were: 11,681 fatal fixed object motorcycle crashes; 1,964 fatal single-vehicle rural motorcycle collisions with trees or poles; and 782 of these 1,964 cases contained known values for the required model variables. The countermeasures considered included:

1. Install a roadside safety barrier to protect motorcyclists from the tree or utility pole;
2. Travel speed not exceeding the speed limit;
3. Helmet use;
4. All of techniques 1, 2 and 3;
5. A reduced speed limit.

Figure 8 shows the fatality risk profiles presented for the various road safety countermeasures investigated for the 782 cases indicated by the black dots. It is clear that when all five measures are implemented the fatality risk falls dramatically to very low levels.

On the issue of rider fatigue, while the TARS researchers would welcome further studies researching the effects of fatigue on motorcyclist, it is clear that alcohol and drug taking are presently a significant risk that can be immediately addressed and would provide and immediate benefit in terms of trauma reduction. Adopting a BAC limit of 0.02 for all riders and increasing enforcement for detection of alcohol and drugs, particularly at well-known popular rider routes, would provide substantial reductions in fatalities and serious injuries.

It should be noted that TARS researchers have carried out a major study funded by the Australian Research Council into the effects of fatigue. Fatigue is a phenomenon that everyone knows. It makes you become less alert and responsive to things around you. It makes needing to continue to work much harder, and require much more effort. It increases the risk that your performance becomes less accurate and less safe. Fatigue while driving, for example, makes the task of getting from A to B much harder.

Everyone knows what causes fatigue, as well. Too little sleep, or too long since sleep, result in you become increasingly fatigued. Simply doing a single task like driving/riding for long periods can also become monotonous and increase fatigue. The current Australian National Road Safety Strategy, for example, mentions fatigue and driving only once as a generic example of 'impaired driving' despite evidence that fatigue is involved in around 20 percent of crashes at least, a level similar to the involvement of alcohol.

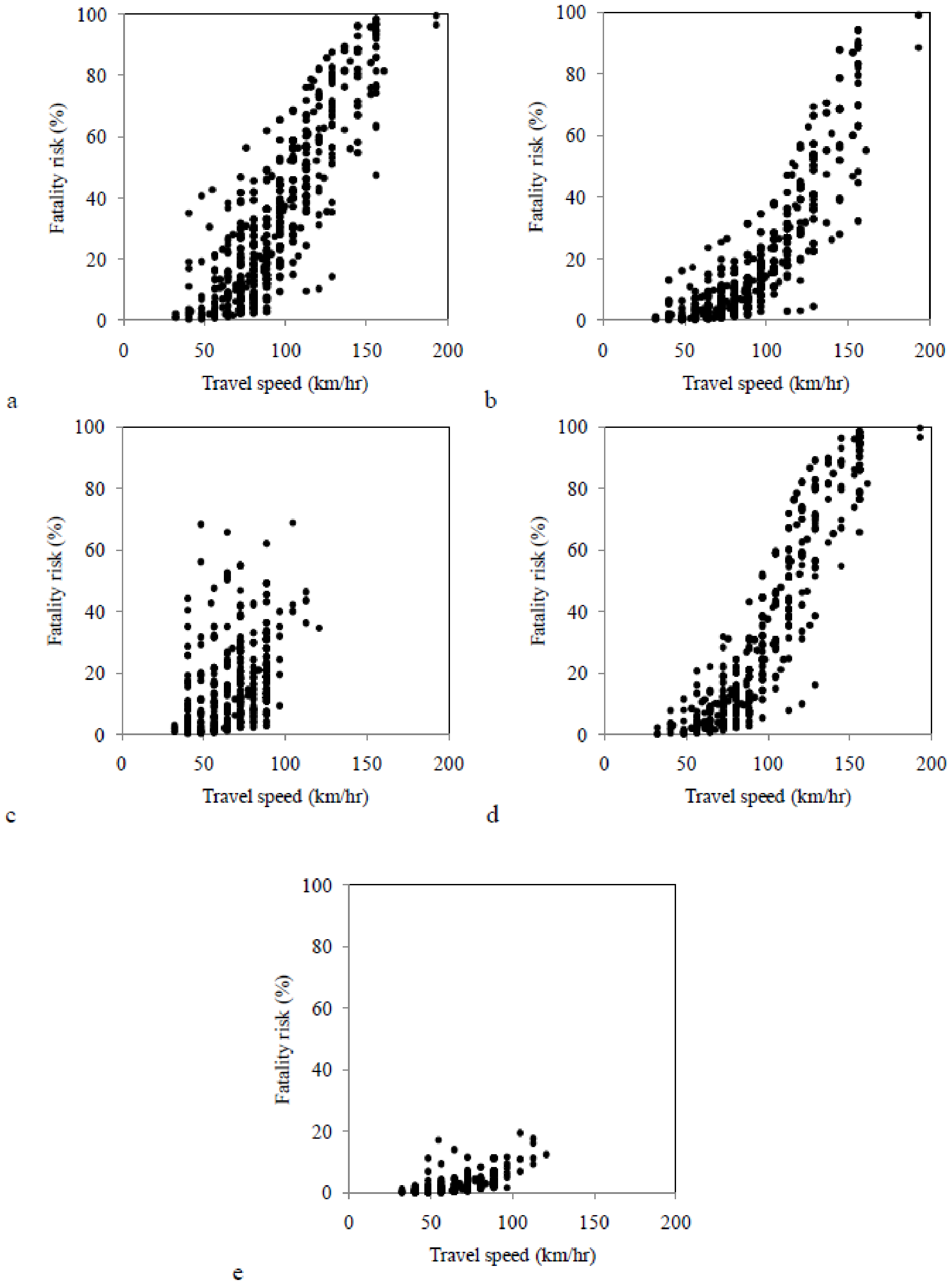

Figure 8: Motorcyclist fatality risk profiles, conditional upon a rural roadway departure into a tree or utility pole, for road safety measures; a) None, b) Install a barrier, c) Speed not exceeding the speed limit, d) Helmet use, e) All measures (b, c and d) [After Bambach and Grzebieta, 2012][9]

<u>*Countermeasures for fatigue*</u> typically rely on increasing awareness or education about the symptoms and causes of fatigue. Unlike other road safety problems, there are no clear exposure limits and fatigue management approaches take the form of guidance rather than prescribing specific actions through regulation. On the road fatigue management strategies involve suggestions of driving limits and advice to people to take regular breaks (e.g., every two hours) or when they feel tired. A major assumption inherent in this advisory approach is that drivers/riders have access to information about their levels of fatigue and drowsiness and are able to make the decision to stop

and rest before their performance is sufficiently adversely affected that their risk of crashing becomes too high. There is considerable debate about the validity of this assumption.

There is good evidence that people can detect decreasing alertness and increasing fatigue and sleepiness such as when sleep deprived[10], when required to work at vulnerable times in the circadian rhythm[11] or for prolonged periods without a break.[12] A study by Nilsson, et al.[13] showed that drivers in a simulator could judge when they should stop driving due to fatigue, apparently based on their physical symptoms. Although driver ratings of fatigue were very similar just before they chose to stop, this occurred at very different times, after only 40 minutes for some drivers and as long as 180 minutes for others. The same characteristics would be expected in riders albeit the concentration levels would be higher because of the requirement to control such a complex machine and hence causing greater fatigue. These results challenge the current one-size-fits-all approaches to fatigue management that are based on advisory limits on the length of work or drive time. Rather they suggest that encouraging drivers/riders to respond to fatigue state may be more useful.

A recent study by our TARS group[14] investigated the extent to which we have access to information about our current fatigue state and levels of drowsiness, and their implications for detection of changes in driving performance and the likelihood of crashes. The purpose of this study was to determine whether relying on subjective fatigue states would provide a valid estimate of safety-relevant driving performance effects or whether other indicators would be more useful.

Three groups of drivers (n=90 total) did a two-hour drive on monotonous roads in a driving simulator. Fatigue was induced by the drive occurring in the early afternoon following a night of reduced sleep. The study design looked at ratings of fatigue and sleepiness, likelihood of falling asleep and the likelihood of crashing across the drive but also looked at whether making ratings artificially reduced sleepiness or made drivers more aware that they could crash. One group of drivers rated sleepiness, likelihood of falling asleep and of crashing at regular intervals across the drive. One group rated sleepiness and falling asleep, but pressed a button on the steering wheel if they thought a crash was likely. The third group made no ratings but signalled the likelihood of crashing by button-pressing.

The results showed that drivers can report increasing fatigue especially across the earlier part of the drive and can detect the likelihood of falling asleep prior to crashing. The results were similar whether or not drivers made regular ratings of crash likelihood or not. Clearly, drivers can make an informed decision to drive or not drive when tired; they have the information they need to do so. One would expect motorcycle riders could also make an informed decision to ride or not ride when tired.

This study indicates that, just the same as for other decisions safe road behaviour such as whether to speed or not or to drink and ride, riders can decide whether to continue to ride when fatigued or to

[10] Dinges, D.F. Pack, F. Williams, K. Gillen, K.A. Powell, J.W. Ott, G.E. Aptowicz, C. Pack, A.I. (1997) Cumulative sleepiness, mood disturbance, and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. Sleep, 20(4) 267-277.

[11] Monk, T. H. (1991). Circadian aspects of subjective sleepiness: A behavioural messenger? Sleep, sleepiness and performance. T. H. Monk. Chichester, John Wiley & Sons: 39-63.

[12] Rosa, R. R. and M. J. Colligan (1988). Long workdays versus restdays: Assessing fatigue and alertness with a portable performance battery. Human Factors 30(3): 305-317.

[13] Nilsson, J. P., Sodestrom, M., Karlsson, A. U., Leander, M., Åkerstedt, T., Lindroth, N. E. & Axelsson, J. (2005). Less effective executive functioning after one night's sleep deprivation. Journal of Sleep Research, 14, 1-6.

[14] Williamson, A., Friswell, R., Olivier, J., & Grzebieta, R. (2014). Are drivers aware of sleepiness and increasing crash risk while driving?. Accident Analysis & Prevention, 70, 225-234.

ride at all. This has implications for safety advice to riders and for people in other hazardous settings as well. We need to change our safety messages about fatigue from reminding people about the symptoms of fatigue; people are already aware of them. Rather we need to encourage people to respond to early signs of fatigue by taking action to reduce it. This can include taking rest breaks, changing activity and stopping to nap or sleep where appropriate. Our current TARS research is looking at what factors might motivate people to respond to signs of fatigue and sleepiness.

In regards to personal protection (helmets, body armour, etc), TARS researchers Bambach and Mitchell[3] have identified thoracic injury to be the most frequently occurring serious injury sustained by on-road motorcyclists, closely followed by head and lower extremity serious injury. They have suggested that establishing standards to assess the performance of motorcyclist chest protection devices and developing technologies for motorcycle air-bags, and campaigns to encourage their use amongst on-road motorcyclists, particularly for older riders, would provide benefit to motorcyclists.

Helmets. Another area which the TARS researchers have investigated relates to helmets. Australia has a strong history of leading the world in regards to a world-class helmet standard for motorcycle safety. The introduction of online retailing, increased globalisation and variable exchange rates have led to an increased accessibility of internationally manufactured helmets. TARS researchers have studied the level of risk associated with online purchasing of motorcycle helmets in Australia, specifically considering the attitudes and beliefs of motorcyclists on international standards and helmet products. A survey was conducted of 245 Australian motorcyclists in the Sydney metropolitan area regarding motorcyclists personal history, perceptions and opinions of motorcycle helmets.

Whilst few motorcyclists surveyed had experienced online or non-standard approved helmet purchases, a substantial number indicated they would purchase motorcycle helmets online if the product was Australian Standards approved. Several risk factors were identified indicating an increased likelihood of online or non-standard helmet purchases including; a perceived financial incentive to purchase helmets online, limited knowledge of the legal implications of online sales and a high perception of the protection provided by international motorcycle helmet standards.

Whilst online and non-standard helmet use is low, such trading may substantially affect the integrity of the enforcement of the Australian standard until such time that the Australian helmet standard is harmonised with other international helmet standards. The online retail of motorcycle helmets should be closely monitored to determine the prevalence or trends in online and non-standard helmet use in Australia. In addition, information provided to motorcyclists regarding motorcycle helmet use, such as during licensing, should highlight the legal and safety risks of online purchases.

In regards to helmet standards, Prof Grzebieta is a member of the Australian Standards committee CS-076 which is responsible for the Australian helmet standard AS/NZS 1698. A paper written by Adjunct Professor Andrew McIntosh (Chair of CS 076 and former TARS Adjunct) and co-authored by Prof. Grzebieta highlights a number of issues concerning harmonisation of helmet standards.[15]

There are a number of major motorcycle helmet standards, e.g. AS/NZS 1698, DOT, JIS T 8133, Snell M2010 and UN/ECE 22. With international trade agreements, on-line purchasing, and motorcycling growth there is a need to assess whether there is scope for harmonising motorcycle helmet standards. The results of impact performance tests on 31 helmets that met at least AS/NZS 1698 and

[15] McIntosh A. and Grzebieta R.H., (2013) Motorcycle Helmet Standards – Harmonisation and Specialisation?, Proc. 23rd International Technical Conference on the Enhanced Safety of Vehicles, Seoul, Korea, Paper Number 13-0160-O, May 27-30, 2013.

combinations of other standards were assessed by standard certification by McIntosh who carried out the tests at the Roads and Maritime Services (RMS) Crashlab facility.[15]

Motorcycle helmets have been shown to reduce the risk of death by 42% and head injury by 69%. Mild traumatic brain injury appears to be the prevalent form of injury suffered by helmeted motorcyclists. Although there are differences between each standard, some potentially would make at best only a marginal difference in a crash. Some, such as Snell M2010 appear to be associated with heavier helmets. Oblique helmet testing can identify performance differences between helmets that are related to injury mechanisms not assessed directly by current standards. The climate and road environment are issues that need to be considered and might lead to helmet specialisation as found in JIS T 8133. In other words, operators of low powered motorcycles in hot and humid climates might have a helmet certified to a different part of a common standard compared to operators of high powered motorcycles ridden at speed on major roads. Also critical to the motorcyclists is the incorporation of a quality control system including batch testing.

There are many commonalities between each standard, but there are subtle to substantial differences also. All standards have tests of acceleration management, retention system strength and stability. No standard has a true oblique impact test and chin bar assessment is varied. There are no studies that compare the performance of helmets in real world crashes by standard certification. There were few significant differences in helmet performance in lab tests by standard certification, particularly when only full-face helmets were included in the analysis. In the 31 tests carried out by McIntosh at Crashlab there was an overall correlation (Pearson Correlation = 0.60 ($p<0.01$)) between helmet mass and impact performance.

Despite the differences in the performance requirements between the standards, there is no evidence from crash or epidemiological studies that helmets meeting one standard are 'better' than those meeting another. Comparative terms such as "stricter", "tougher", "better" are often used to compare standards, however such terms are inappropriate; the requirements are in most cases just different. Where a standard could be "stricter", for example, is if under the same impact conditions the pass criterion for peak headform acceleration in one standard was lower than another or if there are a larger range of characteristics assessed. The question of 'which is the "strictest" standard', is very difficult to address because of multiple confounding factors. All helmet standards address the characteristics that are considered fundamental to preventing trauma: impact energy attenuation (or acceleration management); stability; retention system strength; vision; and, internal and external projections. Nevertheless, there are some common deficiencies in all the helmet standards:

- Lack of oblique impact test that can be used to assess the helmet's ability to manage linear and angular head kinematics and minimise brain injury risks;
- Impacts in the real world are frequently below the test line. Therefore, there is an opportunity to assess, and possibly improve, helmet performance across the range of impacts that occur to motorcyclists;
- No standard has a load distribution test (e.g. AS/NZS 2512). This test would be a more suitable method for assessing the effects of internal projections on head loads specific to the relevant injury mechanisms. It would also be more relevant than the penetration test (which the Australian standard is unique in this requirement) in terms of both construction quality and assessing a specific head loading mechanism.

- Head acceleration criteria are too high. The probable cause for the success of helmets is that many manufacturers do not make minimum performance only helmets, but within limits, produce helmets that exceed by a large margin the standard requirements.

- There is confusion concerning the need for repeat impact tests and what they represent. One explanation is that a second impact might occur and the helmet should provide protection in those circumstances. The other explanation is that the first and second impact combined are equivalent to a higher severity impact.

- Consideration for how new technologies be included inside helmets, e.g. communication devices and emergency management alerts, and how these should be tested to ensure that they do not cause harm.

- Absence, except in UN/ECE 22, of a comprehensive continuous control or batch control processes for motorcycle helmets. Such a system should also require independent approval of the certification bodies and test laboratories, e.g. International Laboratory Accreditation Cooperation, and the prevention of batches of helmets entering the market unless batch testing is successful. There is a real risk that helmets appearing to meet a standard could be dumped in a market when that batch or model no longer complies with the standard.

The potential to harmonise motorcycle helmet standards does exist as do a number of mechanisms, e.g. ISO and UN/ECE. There are also treaties that encourage international harmonisation of standards, e.g. free trade. One barrier is representation. The actual technical aspects of the standard should not necessarily be a barrier to harmonisation, except where the end result would be a standard with fewer requirements and a worsening of performance requirements. The emerging issue may not be harmonisation, rather specialisation might be the key issue.

These issues indicate opportunities exist for harmonisation, specialisation and improvement in motorcycle helmet standards that will benefit motorcyclists, government, trade and road safety groups.

d. Strategies of other jurisdictions to improve motorcycle safety;
e. Licensing and rider training;

Associate Professor Teresa Senserrick from TARS is currently involved in a major study in Victoria funded by Vicroads focussed on Motorcycle rider Graduated Licensing Scheme. At the time of this submission the study was not complete and no information was available.

The Authors on behalf of TARS have no further information in relation to these remaining items that can be provided by TARS researchers.

f. Any other related matters.

The following is replicated from an earlier submission to Staysafe regarding an earlier inquiry focussing on vulnerable road users.[1]

Motorcycle Impacts Into Roadside Barriers Study:

This study effectively arose as a result of motorcyclists in Europe, US, Australia and New Zealand vocalising serious concerns over the installation of wire-rope barriers (WRBs). News items appear from time to time by motorcyclists regarding wire-rope barriers (WRBs).[16] Claims are sometimes made that these barriers are dangerous and act like 'cheese cutters', and that WRBs have been banned in other countries, with absolutely no supporting proof. All of the concerns have been found to be completely unfounded once the statistical data, the circumstances of the crash and crash forensics were investigated carefully. Claims that WRBs have been banned in other countries are also completely erroneous. In fact quite the opposite has been found. Anywhere wire-rope barrier systems have been installed they have found to have a dramatic effect in reducing fatalities and serious injuries for all road users including motorcyclists. Moreover, the term 'cheese cutters' is a myth promulgated by an ill informed recalcitrant vocal minority of motorcyclists who do not understand how riders are seriously injured or killed when impacting roadside barriers.

This section presents some of the key results of this research investigating motorcycle crashes into roadside safety barriers. The material is extracted essentially from reports and research papers published to date by the authors of this submission.[7,8,17,18,19,20] Some of the statistics have also been extracted from a Flinders University report by Henley and Harrison.[21] It refers to Australia in general albeit there is a breakdown of some of the findings for NSW.

In 2007 in Australia:

- the proportion of registered vehicles on the road that were motorcycles was 4.5%, however the proportion of the total number of road user fatalities that were motorcyclists was 15%. Motorcycle fatalities are over represented in terms of road crash fatalities.
- the number of fatalities per billion vehicle kilometres travelled was 3.9 for cars and 116.9 for motorcycles - motorcyclists were 30 times more likely to be killed than car occupants per distance travelled;
- the number of serious injuries (non-fatal injury requiring hospital admission) per 100 million vehicle kilometres travelled was 10.3 for cars and 385 for motorcycles - motorcyclists were 37 times more likely to be seriously injured than car occupants per distance travelled;

[16] http://www.lukehartsuyker.com.au/mediacentre/mediareleases/2011/447-hartsuyker-raises-danger-of-wire-rope-barriers-raised-in-federal-parliament.html

[17] Bambach, M.R., Grzebieta, R.H. and McIntosh, A.S., (2010), Crash characteristics of motorcyclists impacting road side barriers, Proc. Australasian Road Safety Research, Policing and Education Conference, Canberra, Australia.

[18] Bambach M., Grzebieta R.H., McIntosh A., 2011 Injury typology of fatal motorcycle collisions with roadside barriers in Australia and New Zealand, Accident Analysis & Prevention, in press, doi:10.1016/j.aap.2011.06.016.

[19] Bambach M. R., Grzebieta R. H., Olivier J. & McIntosh A. S. (2011): Fatality Risk for Motorcyclists in Fixed Object Collisions, Journal of Transportation Safety & Security, 3:3, 222-235.

[20] Grzebieta R., Bambach M., McIntosh A., Friswell R., Jama H., (2011), Fatal Motorcycle-Into-Road-Safety-Barrier Crashes, Proc. Road Safety Research, Policing and Education Conference, Perth, Australia.

[21] AIHW: Henley G and Harrison J.E., 2009, Serious injury due to land transport accidents, Australia 2006-07, Injury and statistics series No. 53. Cat. N. INJCAT 129. Canberra: AIHW.

- the serious injury rate per 100,000 population (age-standardised) for motorcyclists was 35.3, and has increased steadily from 24 in 2001. Actual case numbers of seriously injured motorcyclists increased from 4,642 in 2001 to 7,303 in 2007 (an increase of more than 50% in only 6 years).

In NSW

- in 2007, in NSW, the number of serious injuries per 100 million vehicle kilometres travelled was 10.8 for cars and 370 for motorcycles - motorcyclists were 34 times more likely to be seriously injured than car occupants per distance travelled (Table 2);

Table 2: Population of vehicles and motorcycles in Australian jurisdictions and New Zealand in 2006

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

The percentage of Australia's road fatalities that are motorcyclists has increased over the last decade and is much higher as a percentage of road users than in the USA and New Zealand as shown in Figure 9. A breakdown of the percentages for each state is shown in Table 3.

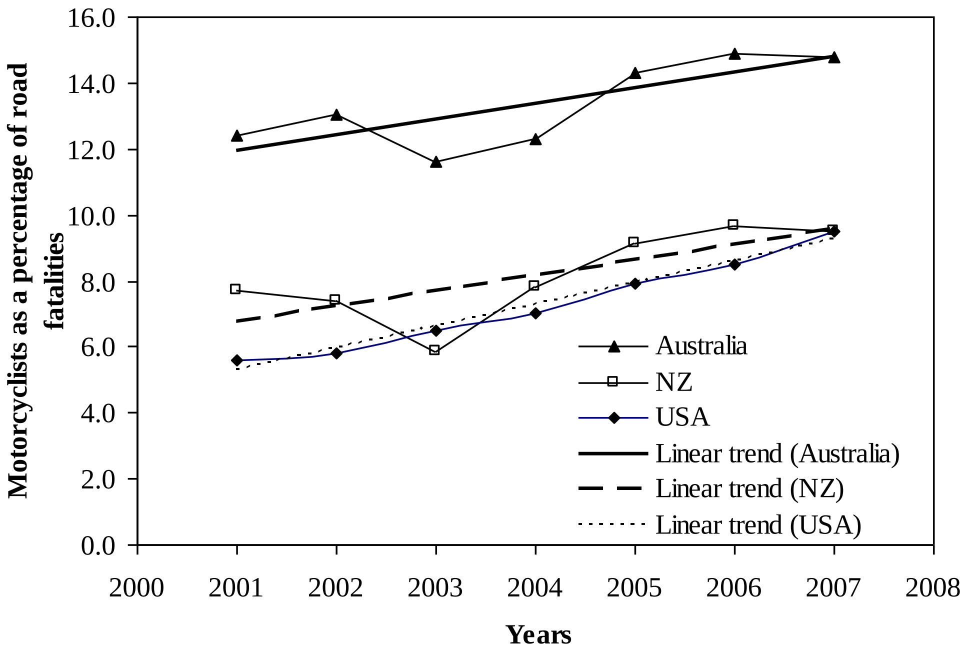

Figure 9: Motorcyclists as a percentage of all road fatalities in Australia, NZ and the USA
(Data sources: Australian Bureau of Statistics, NZ Crash Analysis System and US Fatality Analysis and Reporting System)

Table 3: Breakdown of motorcycle crashes in Australia and New Zealand

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

There was approximately one fatality per year Australia wide in regards to wire-rope barriers, i.e. 0.4% of all motorcycle fatalities. W-beam related motorcycle fatalities constitute around 4.4% of all rider fatalities. Half of the motorcyclists strike the barrier upright whereas half slide into the barrier. The raw number of motorcycle fatalities involving road side barriers is presently around 15 per annum compared to about 200 to 230 motorcycle fatalities and around 1300 road fatalities each year in Australia.

It has been proposed by motorcycle advocates, motorcycling clubs and Australian Motorcycling Council, etc, that all W-beam barriers be retrofitted with shrouds or rub-rails that reduce the severity of the impact for motorcyclists sliding into the posts. Considering that only half of those riders killed and injured slide into the barrier, it is clear that **any initiatives involving major design changes to roadside barriers or retrofitting W-beam barriers to make them 'motorcycle friendly' when struck will be costly if applied to all roadside barriers in Australia and will have little effect on reducing motorcycle fatalities overall**. However this does not mean that we should not install such systems when the opportunity arises. Whenever a brownfields site is being upgraded or greenfield site is being constructed, consideration should be given to installing rub-rails that are compliant with the current Australian Road Safety Barrier Systems standard to any W-beam installation.

Figure 10 shows 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 were compared to the proportions of barriers installed,[22] which showed 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

[22] Grzebieta R.H., Jama H., Bambach M., Friswell R., McIntosh A., Favand J., (2010) Motorcycle Crashes into Road Side Barriers Stage 1: Crash Characteristics and Casual Factors, IRMRC Research Report, UNSW.

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 presently in Australia.

In a single-vehicle motorcycle collision with a fixed object, trees and poles were found to be particularly hazardous, and more so than barriers. Of particular interest are the findings by Daniello and Gabler (2009)[23] 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, 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. Similar values were confirmed by the authors of this submission[19] in a recent analysis where it was found that the risk of being killed when striking a barrier is 3.6 times less than when striking a tree.

In regards to when motorcycle into barrier fatalities occur, Figures 11, 12, 13 and 14 imply that such crashes are mostly the result of recreational riding, i.e. fatalities predominantly occur on weekends, on bends, at around midday to early afternoon and on clear days. Indeed, it was noted that there were black spots at locations in winding mountainous regions where motorcycles like to enjoy their ride and apply their riding skills. Hence any countermeasures to reduce motorcycle fatalities involving road side safety barriers should be targeted at black spot roads in known recreational riding areas, e.g. the Blue Mountains, rather than spending large sums of money retrofitting all barriers for little or no return. It would be more effective to spend money on countermeasures other than roadside barriers to reduce motorcycle casualties.

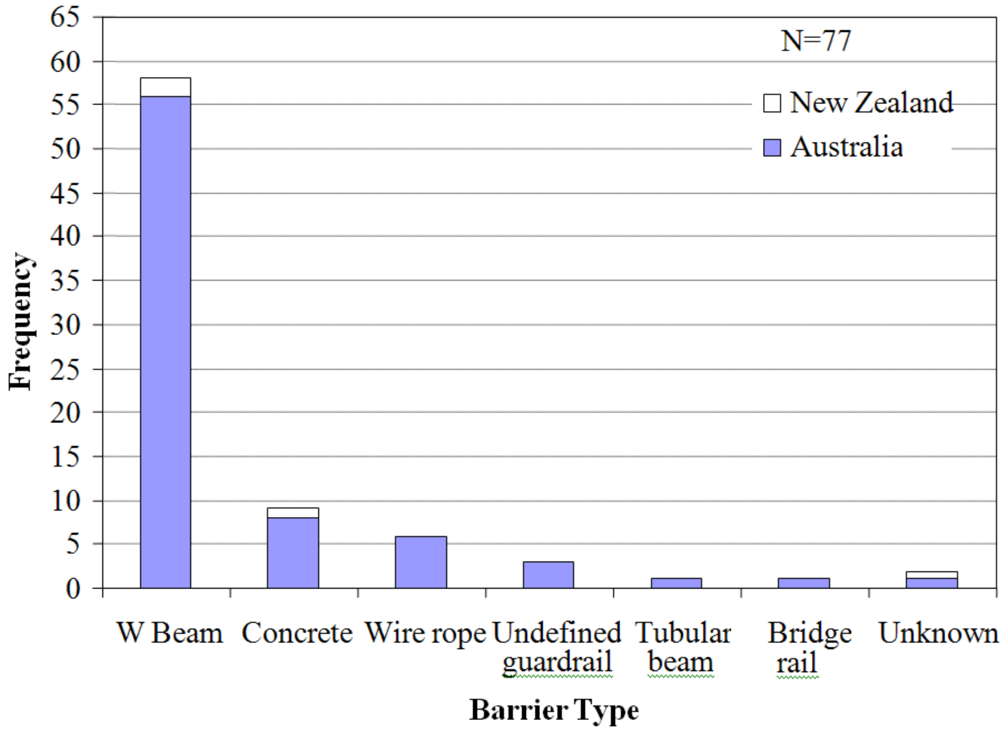

Figure 10: Roadside barrier types involved in motorcyclist fatalities in Australia and New Zealand (2000 to 2006)

[23] Daniello A. and Gabler C. (2009), Fatality risk in motorcycle collisions with roadside objects in the United States Accident Analysis & Prevention Volume 43, Issue 3, May 2011, Pages 1167-1170.

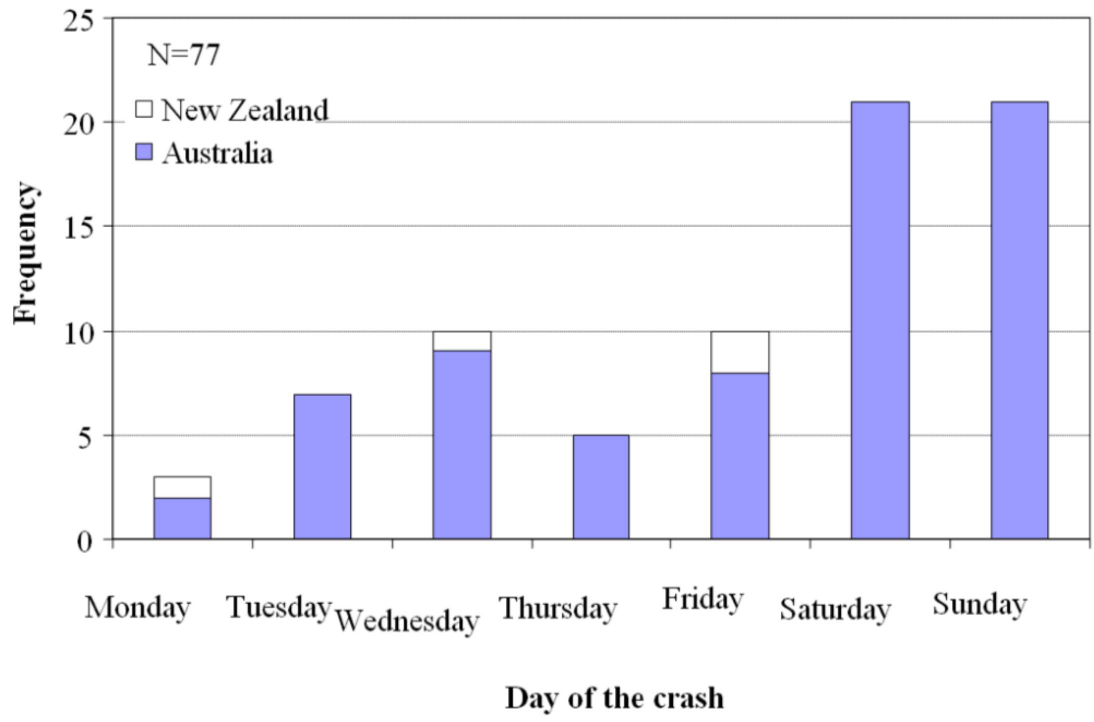

Figure 11: Day of the crash of motorcyclist fatalities involving impact into a roadside safety barrier in Australia and New Zealand (2001 to 2006)

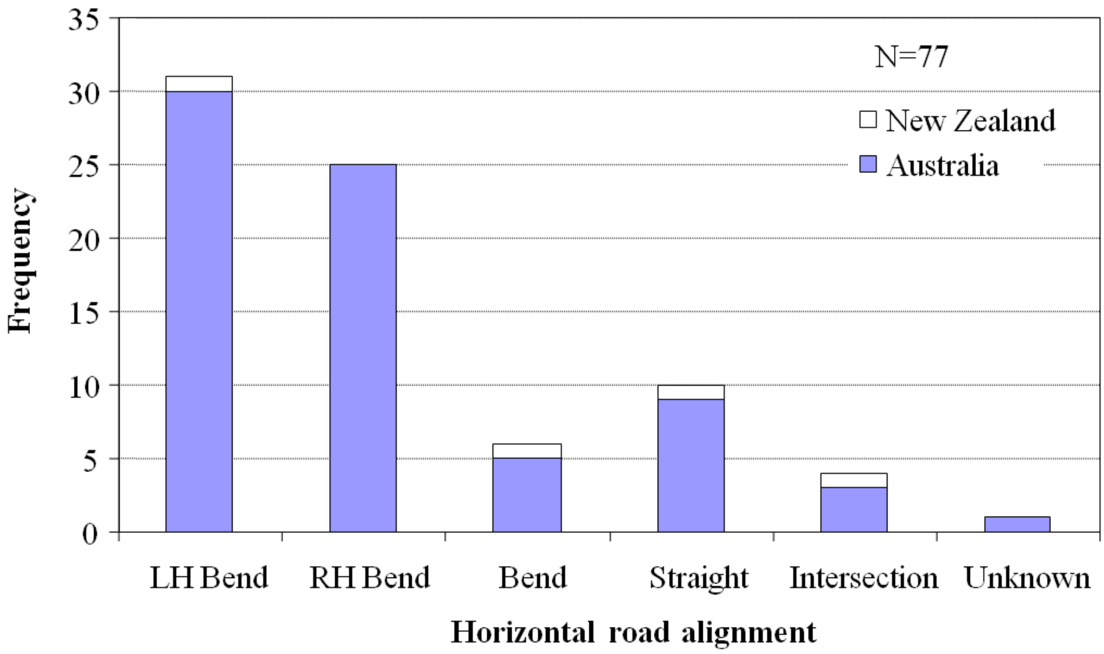

Figure 12: Horizontal alignment of roadside barrier impacted resulting in a fatality in Australia and New Zealand (2001 to 2006)

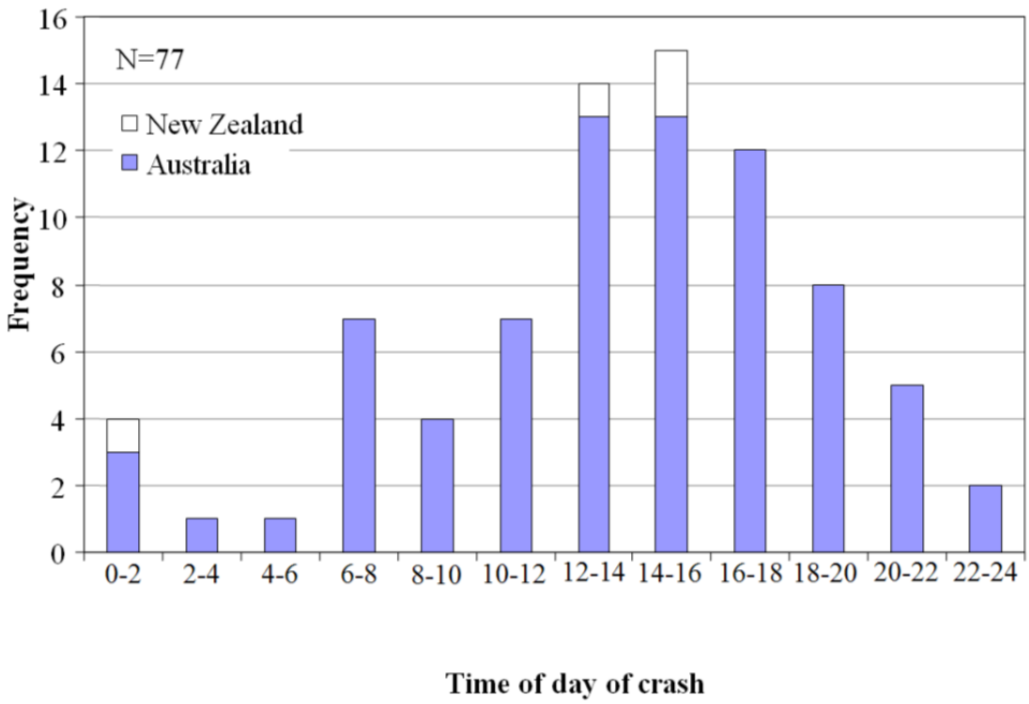

Figure 13: Time of Crash of motorcyclist fatalities involving impact into a roadside safety barrier in Australia and New Zealand (2001 to 2006)

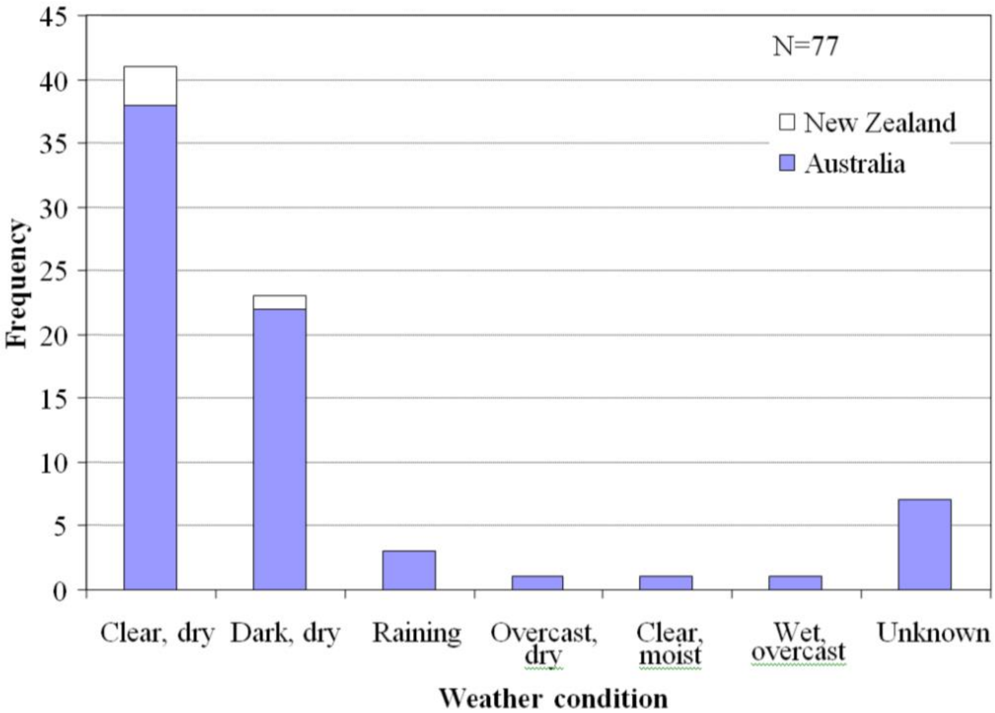

Figure 14: Weather condition at the time of a crash involving a motorcyclist fatality **and a** roadside safety barrier in Australia and New Zealand (2001 to 2006)

In regards to the issue of the effectiveness of wire-rope installations, some recent work has also been carried out in Sweden[24]. Around 1,800 km of wire-rope safety barrier systems have been installed in Sweden. A study by the Swedish National Road and Transport Research Institute (VTI) to evaluate the in-service performance of this road safety barrier type was published in January 2009. It showed that this barrier system significantly reduces road trauma. The evaluation covered 470 km of what the Swedish researchers called "collision-free" expressways of which 336 km have a speed limit of 110 km/h. These are also sometimes referred to as 2+1 roads.

Sweden's 2+1 roads are a category of three-lane road, consisting of two lanes in one direction and one lane in the other, alternating every few kilometres, and separated with a steel wire-rope barrier. Traditional roads of at least 13 metres width can be converted to 2+1 roads.

The evaluation also examined data from 1,275 km of 2+2 roads of which 400 km had a posted speed limit of 100 km/h. A 2+2 road is a specific type of dual-carriageway built in Sweden, consisting of two lanes in each direction separated by a steel wire rope barrier. These roads do not have hard shoulders.

The Swedish report[24] found that compared to normal 13 metre wide roads and expressways, 2+1 and 2+2 roads with a speed limit set at 110 km/h showed an overall reduction in fatalities and serious injuries of about 57% and 39% respectively. For the roads with a posted speed limit of 90 km/h, the fatalities and serious injuries were reduced by 62% and 63% on the 2+1 and 2+2 road types, respectively.

The Swedish study also looked into the road safety outcome of the 2+1 roads for motorcyclists. This was in response to complaints registered by motorcyclists concerning the safety of 2+1 roads. Fatal and seriously injured (FSI) motorcyclists were found to constitute 7.8% of the total FSI's for this road type being slightly lower than the Swedish nationwide proportion of 9.3%. When compared to standard 13 metre wide roads (without a wire-rope median barrier) and accounting for the mileage covered by motorcyclists, the 2+1 road type showed a 65-70% reduced number of motorcyclists killed or seriously injured. Carlson points out that even when the mileage travelled by motorcyclists was reduced significantly, the 2+1 road type still showed a reduction of 32% to 35% in the number of killed or serious injured motorcyclists.

A recent similar effective installation of wire-rope barriers was noted in New Zealand[25] on the Centennial Highway. Prior to installation of the barriers there were 12 fatalities and 4 serious injuries over a 10 year period (1996 – 2004). After installing median wire-rope barrier and reducing the speed limit from 100 km/h to 80 km/h, there have been no fatalities or serious injuries over the past five years (2005 – 2009). Other examples demonstrating the safety benefits of installing wire-rope barriers have been referenced in Grzebieta et al (2009)[7]

One of the reasons that Carlson[24] found that median wire rope reduced motorcycle injuries was that these barriers prevent barriers cross over crashes. It also prevents motorcycle riders taking unnecessary risks overtaking other vehicles at high risk locations, such as those where median double lines are painted. An example that demonstrates how median wire-rope barriers protect

[24] Carlson, A., Evaluation of 2+1 roads with cable barriers. 2009, Swedish National Road and Transportation Research Institute (VTI): Linkoping, Sweden.

[25] Marsh F and Pilgrim M., (2010) Evaluation of narrow median wire rope barrier installation on Centennial Highway, New Zealand, Journal of the Australasian College of Road Safety, November, Vol. 21 No. 2, pp. 34 – 41.

motorcyclists is evidenced by a video taken and described by Marsh and Pilgrim.[25] The sequence of images in Figure 15 shows a small truck striking the median barrier and then being redirected. The truck continued to drive and did not stop. Three and a half seconds later two motorcyclists riding close to each other drove by the point of impact. They were following by two vehicles which swerved into the emergency lane as did one of the riders. Had the barrier not been in place the motorcyclists would like have crashed with associated injuries or been killed.

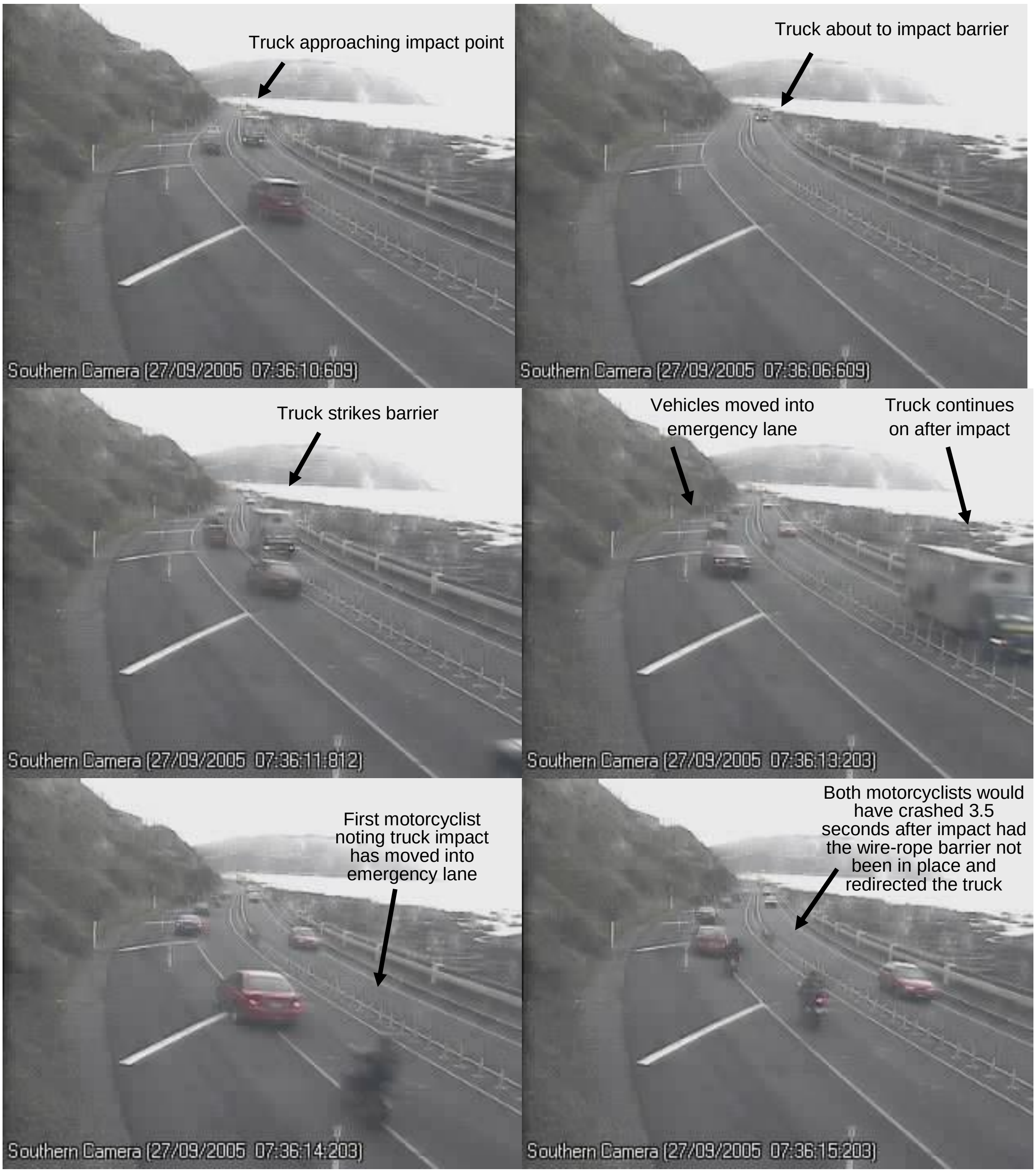

Figure 15: Sequence of photographs from Centennial Highway showing how motorcyclist were protected by a wire-rope median barrier.[25]

On the issue of rider behaviour, a bulletin from the National Road Safety Council Priority Area: Motorcycle Safety reported that "*in 70 per cent of single vehicle crashes involving the death of a motorcyclist, excessive speed (either above the limit or excessive for the conditions) was identified as* *one of the main factors in the crash."* The study focussing on motorcycle impacts into roadside barriers shows that indeed speed is an important factor.

In Australia and New Zealand between 2001 and 2006, rider behaviour played a significant role in motorcyclist into roadside barrier fatalities. Alcohol, drugs or speed, or a combination thereof, played a role in 3 out of every 4 fatal barrier crashes as shown in Figure 16. Moreover, the injury severity was found to be directly and linearly related to the pre-crash speed as shown in Figures 17 and 18.[18,19]

Fatality risk increases sharply above a 'travel' speed of about 100 km/h, while serious injury risk was greater than 20% even at the lowest travel speeds. The tool developed from fatality risk as a function of travel speed from the TARS analysis, predicts that motorcyclists travelling less than about 55 km/h could be expected to survive a collision with a fixed object. The survivability curves from our studies[19] are presented in Figure 18. These curves were modeled based on US motorcycle crashes. Sufficient detailed knowledge of crash characteristics for non-injured, injured (KSI) and killed (F), are not available from Australia. The assumption made was that the road environment (surface, barriers, lighting, rural roads, etc) closely approximates Australian conditions.

While engineering measures such as retrofitting W-beam barriers could be considered, behavioural countermeasures in these areas such as speed enforcement, random breath testing (RBT) and drug testing on weekends during midday to mid-afternoon would likely yield more effective results.

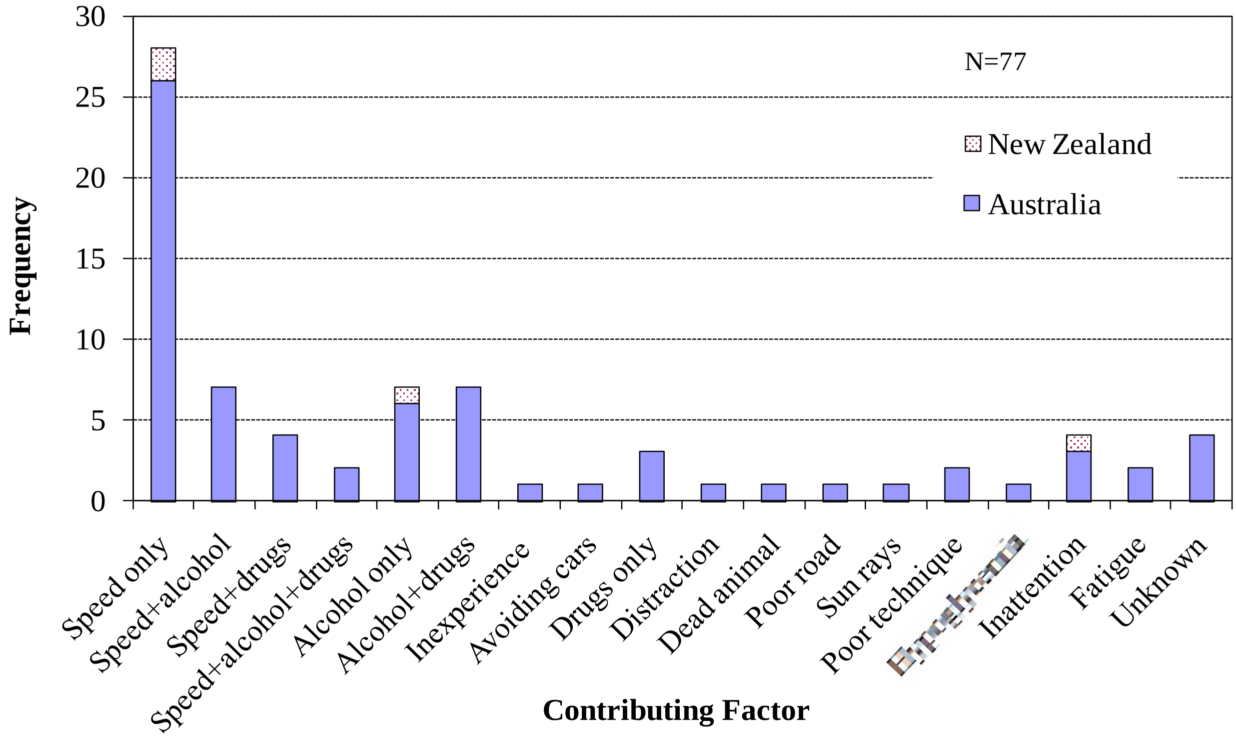

Figure 16: Crash contributory factors of motorcyclist fatalities involving a roadside safety barrier in Australia and New Zealand (2001 to 2006)

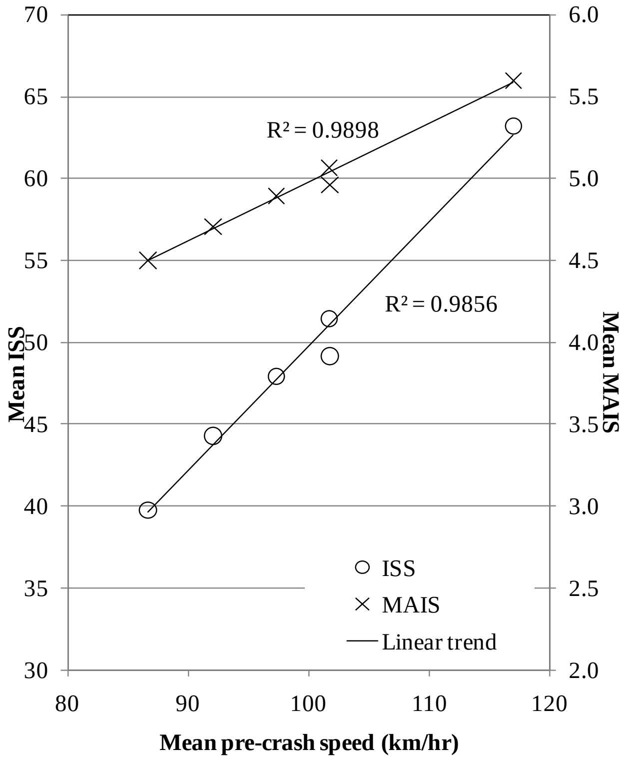

Figure 17: Mean pre-crash speeds and mean ISS (Injury Severity Score) and MAIS (Maximum Abbreviated Injury Score) [After Bambach et al, 2012][18]

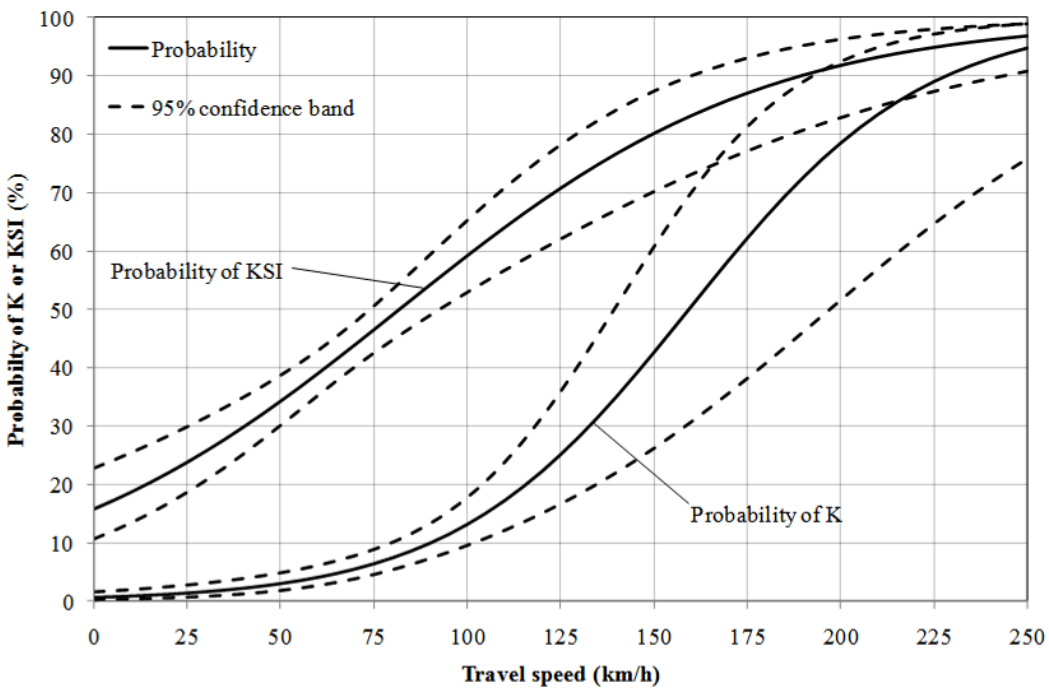

Figure 18: Probability as a function of travel speed for fixed object collisions - probability of being killed (K) and probability of being killed or seriously injured (KSI) ($n_{weighted}$ = 34,746). [After Bambach et al, 2011][19]

In summary, the TARS/IRMRC motorcycle into barrier study found that

- around 74% of fatalities were found to involve either speed, alcohol or drugs, or a combination thereof, i.e. 3 in 4 fatalities;
- there is a strong linear association between injury severity and pre-crash speed (crash severity);

- fatalities of motorcyclists involving impact with a roadside barrier predominantly involved steel W beams , half of which are sliding crashes and the other half are upright crashes into the barrier;
- wire rope barriers were found to have around half the fatality rate of W beam and concrete barriers;
- installing a road side barrier to protect road users striking trees will also reduce the risk of a motorcyclist that strikes the barrier. The risk of being killed is up to 3.6 times less than if the barrier was not present;
- Half of the fatalities involving a roadside safety barrier usually occurred on a weekend and around 60% of all barrier impact fatalities are during recreational riding and mostly in the afternoons;
- any strategies regarding retrofitting or installing 'motorcycle' friendly barriers should focus on black spot locations in areas of high activity motorcycling recreational rides, i.e. mountainous curving roads, Great Ocean Road in Victoria, etc.;
- the focus of any mitigation strategies should be on behavioural issues such as speeding, alcohol, drugs and fatigue.

Final note:

As mentioned at the start of this submission, all work carried out to date by TARS researchers can be viewed and downloaded from the following web page:
http://www.tars.unsw.edu.au/research/Current/Motorcycle-barriers/motorcycle-barrier_impacts.html