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FATAL MOTORCYCLE COLLISIONS IN MALAYSIA, 2007-2011

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ABSTRACT

Motorcyclists are over-represented in casualty crashes in Malaysia, accounting for approximately 60 percent of all road fatalities. In order to develop effective ways to reduce motorcyclist casualty crashes, it is important to identify the extent of the problem, critical safety issues, the types of crashes that present the greatest risk to riders, and the factors commonly associated with these crashes and their causal factors. The objective of this paper was to explore current crash and injury factors for motorcyclist fatal collisions in Malaysia. Fatal motorcycle crashes occurring between 2007 and 2011 were extracted from the crash database to examine crash and injury patterns, including collision type and location, road geometry, vehicles involved, number of people involved, driver/rider error, demographic characteristics of riders, and injury outcomes. The results identified a number of key collision and rider characteristics that were associated with motorcyclist injury, including riding on rural federal and state roads, and intersections in urban environments, speeding, not wearing a helmet, and being young and a male. Children and young adults were also at risk of injury as pillion passengers. These findings have significant implications for countermeasures to address priority motorcyclist trauma issues in Malaysia including improved road design, speeds, as well as supporting educational and enforcement initiatives.

1 INTRODUCTION

Over the last 10-15 years, Malaysia, a rapidly developing middle-income country, has experienced significant economic expansion with growth in population, industrialization and motorization. Private vehicle ownership has increased dramatically and a high proportion of privately-owned vehicles are motorcycles: between 1997 and 2007 there was a significant increase in the number of registered motorcycles from 4,328,117 to 9,433,640 (Road Safety Department of Malaysia, 2008). The high number of motorcycles is also seen in neighbouring countries, for example in Thailand, Singapore, Vietnam and Taiwan.

The motorcycle is regarded as an important mode of daily transport in many nations, particularly in Asian countries, and is mainly used for commuting and running daily errands. Motorcycle ownership and use is popular in Malaysia for a number of reasons including low vehicle purchase price and insurance surcharge rates, low running costs, the ability for drivers to obtain a motorcycle licence as young as 16 years old, and ease of travel on congested roads (riders can reach their destination faster and with less cost than in a car or on public

transport). A recent survey on motorcyclists' receptiveness towards changes in various transport policies and vehicle ownership showed that many Malaysian road users still favour motorcycles as a mode of transport and, although the Government increased the motorcycle insurance premium recently, this did not discourage them from owning motorcycles (Radin Umar, 2006).

Unfortunately, Malaysia also has an associated high level of road trauma: approximately 4-5 times higher than countries with a good road safety performance (such as Sweden, the Netherlands, the United Kingdom, etc). In Australia, for example, 223 motorcyclists were killed in 2009, representing approximately 15 percent of all road deaths (Department of Infrastructure, Transport, Regional Development & Local Government, 2009). Note: motorcycles account for 4.5 percent of all vehicle registrations. In contrast, road crashes have become one of the major causes of mortality and morbidity and are the second leading cause of deaths in males between 15 to 64 years of age (Road Safety Department of Malaysia, 2008). In 2008, 6,527 people died on Malaysian roads and close to 25,800 were injured, and 3,898 (59.7%) of these deaths were motorcyclists (motorcycles make up approximately 50 percent of the vehicle fleet).

Given the high trauma associated with motorcycle-related crashes, any effort to reduce the numbers of fatal and serious injury crashes is a high priority for Malaysia. However, in order to develop and implement the most effective interventions, a good understanding of the contributing factors is required. This paper sets out to address some of the gaps in our knowledge of contributing factors to motorcycle-related fatal collisions.

2 METHODS

An analysis was conducted of all Police-reported motorcycle crashes that resulted in at least one motorcyclist death for a five year period from 2007 to 2011, inclusive.

2.1 Data

The motorcyclist crash data were obtained from the Malaysian Institute of Road Safety Research (MIROS) Road Accident Analysis and Database System (M-ROADS). The M-ROADS database is populated by Police-reported collision information and managed by MIROS.

All identified motorcyclist fatal crashes between 2007 and 2011 (inclusive) were extracted from the database and a range of data variables were selected for examination and included: driver and rider variables, site and crash characteristics, and broad injury outcome.

2.2 Data analysis

Descriptive statistics are provided for all summary data of the selected variables. In addition, Chi-square tests were conducted to determine if there were any statistically significant differences between the data variables.

The analyses were predominantly crash-based, however, demographic, behavioural and injury outcome variables were person-based as is the conventional practice for examining these factors.

3 RESULTS

During the period 2007 to 2011 there were 17,677 fatal motorcycle collisions, with an average of 3,535 collisions each year.

3.1 Collision characteristics

A number of collision characteristics were examined, including vehicles involved in collisions, collision type, number of vehicles involved. Figure 1 presents the collision partners for all collisions involving a motorcyclist fatality and shows that the most common collision was a single-vehicle motorcycle collision (32%), followed by a collision with a passenger vehicle (car, taxi or 4WD) (27%) and with a truck, bus or van (17%). Collisions with other motorcycles also contributed to 10 percent of fatal collisions.

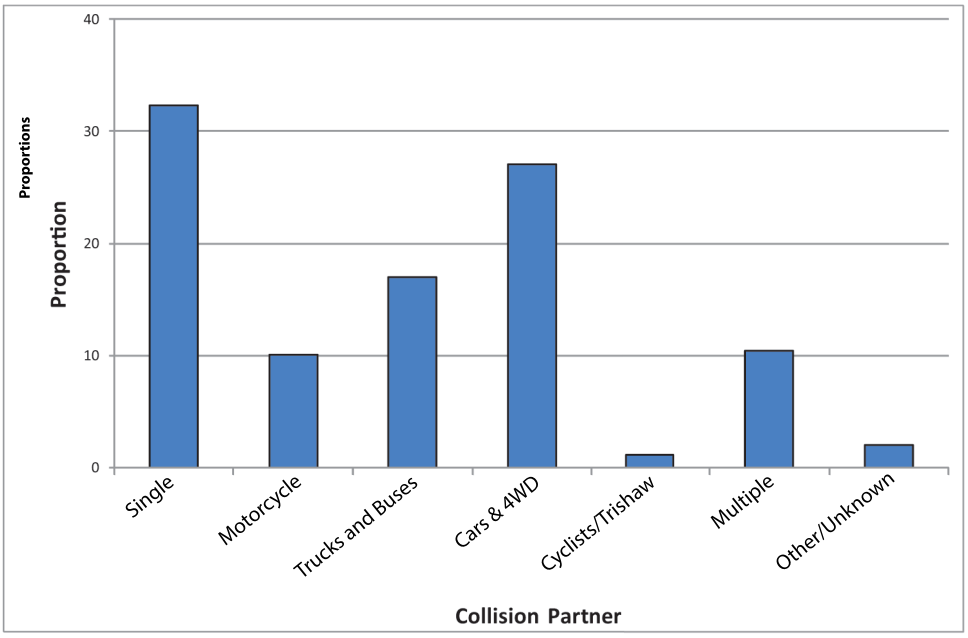

Figure 1: Type of vehicle involved in collisions

Collision partner was examined by collision type and Table 1 shows that the majority of single vehicle collisions involved loss of control, while collisions with other vehicles (other motorcycles, passenger vehicles and truck/buses) generally involved side and angle impacts (approximately 50%) as well as head on collisions (approximately 25%).

Table 1: Type of vehicle involved in collisions by collision type

Collision Partner	Head On (%)	Rear End (%)	Side/ Angular (%)	Hit Object (%)	Loss of Control (%)	Other/ Unknown (%)
Single Vehicle	4.1	5.1	10.5	18.3	57.8	4.2
Motorcycle	29.7	11.1	50.8	1.8	5.5	1.1
Truck/Bus	18.4	26.1	47.2	1.8	3.2	3.3
Car/4WD	25.3	16.7	51.6	1.8	3.3	1.3

Collision Partner	Head On (%)	Rear End (%)	Side/ Angular (%)	Hit Object (%)	Loss of Control (%)	Other/ Unknown (%)
Cyclist/Trishaw	4.5	18.4	67.7	2.5	1.0	5.9
Multiple	27.5	22	41	2.2	4.3	3.0
Other/Unknown	1.5	2.2	4.0	2.5	9.3	80.2

For collisions involving multiple vehicles, the most common collision involved two vehicles only (82.6%), with 12 percent involving three vehicles. Further, 71.4 percent involved two people, 22.2 percent involved three people, and 6.4 percent involved 4 or more people. For the majority of single vehicle collisions, only one rider was involved (88.7%), and a small proportion (11.3%) involved two or more riders/pillions.

3.2 Environmental characteristics

A number of environmental characteristics were examined, including road geometry, type of road, speed limit of road, day and time of collision, weather, location type, and road condition. Generally, collisions occurred during good weather conditions, on flat and straight roads, and were relatively evenly distributed across all days of the week, with slightly higher proportions occurring between Friday and Sunday compared with weekdays. Almost one-quarter (24.1%) of collisions occurred during early evening (6-9pm), with 14.5 percent occurring between 3 and 6pm and 13.6 percent during early morning hours (6-9am).

A high proportion of collisions (61.4%) occurred on rural roads, with a further 29.4 percent occurring in small cities or towns. Only 6.1 percent of collisions occurred in major cities.

The type of road that collisions occurred on was recorded, and the majority (35.8%) occurred on federal roads, with 27.7 percent occurring on state roads. An additional 20 percent occurred on city roads. Some associations between type of road and other variables were noted. For example, as shown in Figure 2, rear end and loss of control collisions were more likely to occur on highways, while head on and side/angular collisions were more likely to occur on federal, state and city roads, $\chi^2_{(65)}=6618.7$, $p<0.001$.

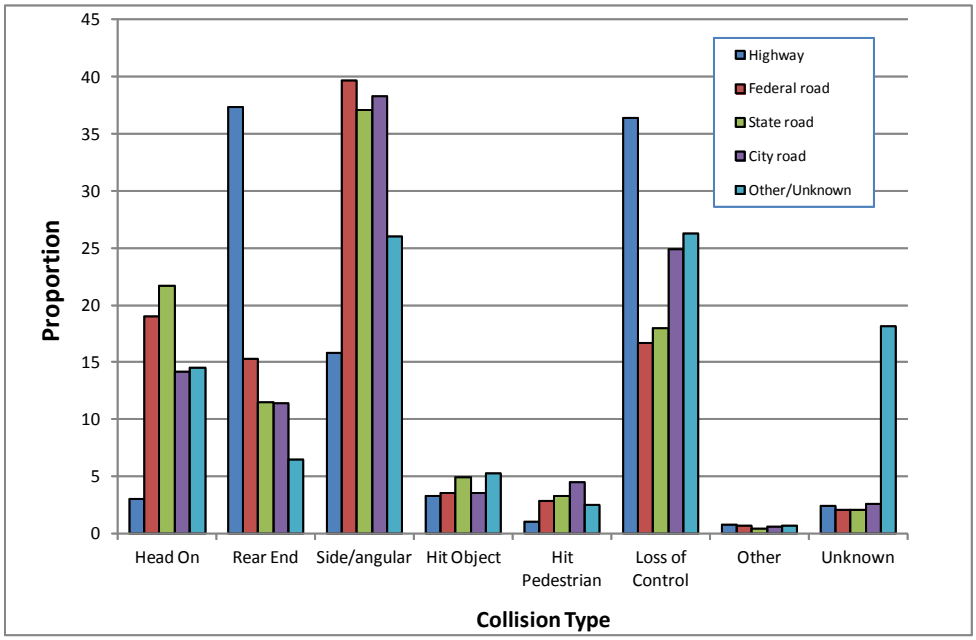

Figure 2: Collision type by road type

Further, while the majority of collisions on all road types was on a straight road (68.5%), collisions at intersections were more likely to occur on city roads compared with highways (30.2% vs 2.0%), $\chi^2_{(35)}$=8209.1, p<0.001). Substantial proportions of intersection collisions also occurred on state and federal roads (17.7%).

Almost half of the collisions occurred in relatively low speed limit zones of 50 and 70km/h (48.0%), compared with 16.7 percent in higher speed limit zones of 90 and 110km/h. In addition, and not surprisingly, speed limit was associated with road type: the majority of collisions occurring on highways were in 90-110km/h speed limit zones (78.3%), while the majority of collisions occurring on federal roads, state roads, and city roads were in 50-70km/h speed limit zones (42.0%, 56.5%, and 64.1%, respectively), $\chi^2_{(30)}$=18304.2, p<0.001.

3.3 Road user characteristics

A number of road user variables were examined and a summary of these characteristics are provided in Table 2. The majority of riders were male and young, aged between 17 and 30 years of age, and only 60.1 percent were wearing their helmet. In addition, almost a quarter of killed riders were older riders aged 51 years and over, more likely to be male, and more likely to have been wearing their helmet compared with the younger group.

For pillion riders, the majority were young, with 44.3 percent aged between 17 and 30 years and almost a third were aged 16 years and under. Pillions were also more likely to be male, and a third were wearing their helmet. Interestingly, however, a substantially greater proportion of pillion riders did not wear their helmet, compared with riders (28.7% vs 14.3%). Similar characteristics were found between injured and killed pillions.

With regard to drivers involved in collisions with motorcyclists, they tended to be older than riders, less likely to be male, and only about two-thirds wore their seat-belt.

Table 2: Summary of road user characteristics

Characteristic	All Riders (%) (n=20,308)	Killed Riders (%) (n=13,062)	All Pillions (%) (n=3,157)	Killed Pillions (%) (n=1,913)	Drivers (%) (n=11,074)
Age Group:					
0-16 years	7.8	7.5	30.8	28.4	0.4
17-20 years	19.6	19.6	23.9	21.6	3.6
21-30 years	23.9	25.5	20.4	18.2	24.3
31-40 years	10.3	11.8	7.0	8.4	24.6
41-50 years	8.7	9.9	6.1	7.9	20.9
51+ years	18.6	23.9	6.1	15.4	17.2
Unknown	11.0	1.7	0.1	0.1	8.9
Gender:					
Male	83.2	92.2	63.3	59.6	79.2
Female	6.7	6.9	36.5	40.2	11.6
Unknown	10.0	0.9	0.2	0.2	9.2
Helmet wearing:					
Worn	60.8	66.1	66.6	67.6	n/a
Not worn	14.3	16.2	28.7	28.1	n/a
Not fastened	2.6	3.3	3.4	3.5	n/a
Religious cap	0.4	0.5	0.1	0.1	n/a
Unknown	22.0	14.0	1.2	0.7	n/a
Seat-belt wearing:					
Worn	n/a	n/a	n/a	n/a	64.6
Not worn	n/a	n/a	n/a	n/a	22.2
Unknown	n/a	n/a	n/a	n/a	13.2

Information regarding driver/rider errors was also examined. Overall, there was no fault attributed to the majority of collisions, by either rider or driver, with 85.1 percent of riders and 67.6 percent of drivers being deemed innocent. For those collisions where some driver/rider error was attributed, there was a range of driver and rider errors reported (Figure 3).

For riders, over a third of errors were classified as unspecified, and common errors were careless riding (14.9%), speeding (9.8%), incorrect turning (7.1%). For drivers, a different pattern of errors emerged, and frequent errors included incorrect turning (22.6%) and speeding (12.3%). Drivers were also more likely than riders to speed, cut in and tailgate.

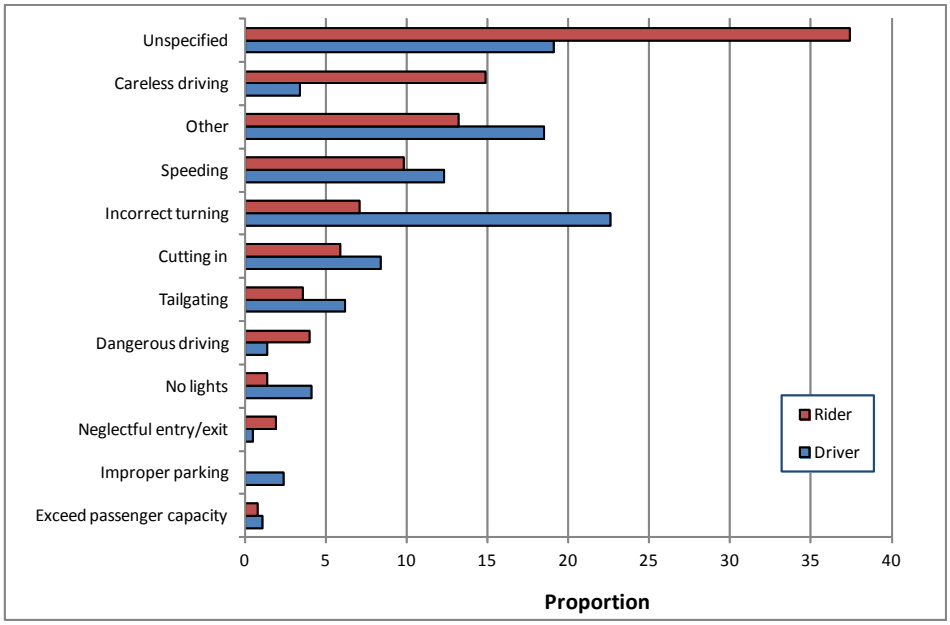

Figure 3: Proportion of errors by road user type (excluding innocent)

3.4 Injury outcome

Last, some information on injury outcome for motorcyclists (both riders and pillions) and drivers was examined. Figure 4 clearly shows injury outcome differences between motorcyclists and car occupants.

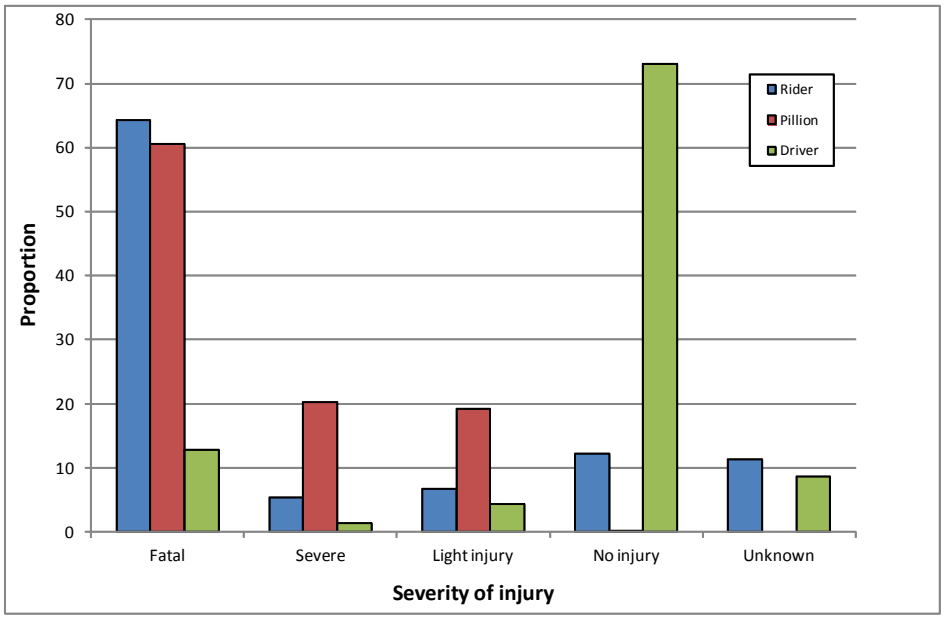

Figure 4: Severity of injury by road user group

The majority of riders and pillions involved in collisions were killed or seriously injured. In contrast, the majority of drivers sustained no injury.

With regard to body region injured, Figure 5 shows that a fatal outcome was highly associated with a head injury, with 54.2 percent of killed riders and 66 percent of killed pillions sustaining a head injury. Substantial proportions of killed riders and pillions also sustained multiple body region injuries (18.1% and 16.9%, respectively).

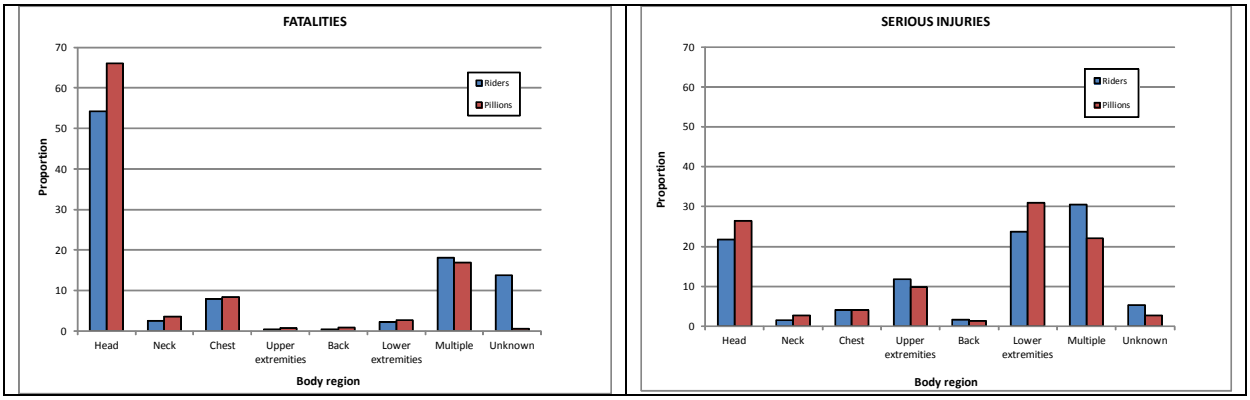

Figure 5: Body region injured by killed and seriously injured riders and pillions

In contrast, seriously injured riders and pillions were more likely to sustain lower extremity injuries and multiple injuries, although head injuries remained a relatively frequent body region injured.

Severity of injury was associated with a range of collision, behavioural and rider characteristics. A fatal or serious injury outcome was associated with collisions with other vehicles, higher speed limit zones, riding on rural roads, and not wearing a helmet, (p's <0.001).

4 DISCUSSION

Road-traffic crashes are a major public health issue worldwide, with a high proportion of these deaths and injuries (up to 90%) occurring in low and middle income countries (World Health Organisation [WHO], 2009). Use of the motorcycle as a primary mode of transportation is popular in Malaysia, however, there is an associated high level of trauma.

This paper examined collisions in which at least one motorcyclist was fatally injured and aimed to improve our understanding of the nature and extent of motorcyclist collisions by identifying contributing factors to injury collision involvement and injury outcomes. The findings of this study highlighted both expected and unexpected findings which may have implications for the development of effective measures to reduce motorcycle-related trauma in Malaysia.

The overall finding was that the high level of death and serious injury amongst riders and their pillions who are involved in a collision did not reduce significantly between 2007 and 2010. The overall numbers of motorcyclist deaths during this period was high, even compared with numbers of serious injuries. This was an unexpected finding, and contrary to the general trend in many developed countries where fatality rates/numbers are generally significantly lower than injury rates/numbers.

However, it is also noted that motorcyclists are an extremely vulnerable road user group due to their lack of protection against impacts with other vehicles, the ground and roadside objects (National Highway Traffic safety Administration [NHTSA] (2007; ETSC, 2008). For

this reason, rider injuries are often more severe than those of other road users and motorcycle riding carries a high risk of death. Per vehicle mile travelled, motorcycle riders have approximately 30 times the relative risk of death in a crash than people driving other types of motor vehicles, and they are also approximately eight times more likely to be injured (European Transport Safety Council [ETSC], 2008). A passenger car, for example, has more weight and bulk than a motorcycle. It has door beams and a roof to provide some measure of protection from impact or rollover. It has cushioning and airbags to soften impact and safety belts to hold passengers in their seats. It has windshield washers and wipers to assist visibility in the rain and snow. A car also has more stability because it is on four wheels, and because of its size, it is easier to see. A motorcycle suffers in comparison when considering vehicle characteristics that directly contribute to occupant safety.

Generally, the causes of crashes are complex and multi-factorial, and this analysis confirms this, highlighting a range of behavioural, road and environmental contributing variables. Overall, the findings suggested that young riders, particularly males, were at risk of collision while they were riding on federal or state roads, and in rural setting. It was surprising to find that, even though a high proportion of collisions were on rural roads, most collisions occurred within speed limit zones that were relatively low (between 50 and 70 km/h).

A high proportion of collisions were single-vehicle collisions and were associated with loss of control, while those involving other vehicles (either another motorcycle, bus, truck, van, or passenger vehicle) were more likely to occur at intersections and on city roads and involve a side impact. These findings support previous findings (e.g., Lin & Kraus, 2008; Pang et al., 1999).

Some important road user characteristics that may contribute to increased crash and injury risk were revealed in these analyses, particularly regarding helmet wearing behaviour and driver/rider error. With regard to helmet wearing, while close to two-thirds of riders and pillions wore their helmet, substantial proportions did not wear their helmet, particularly amongst pillion passengers. This was a surprising finding, particularly as there are numerous reports from observational and survey studies that suggest wearing rates are in the order of 80-90 percent (Kulanathan et al., 2000; Oxley et al., 2012; Oxley et al., 2011). It was of particular concern that almost one third of pillion passengers did not wear a helmet, particularly as high proportions of pillion passengers were children and young adults.

With regard to driver/rider error, the analyses revealed that there was a high proportion of ‘no-fault’ collisions and unspecific errors recorded, particularly for riders. There may be a range of reasons or explanations for this, perhaps because of the multi-factorial nature of many collisions, difficulty in determining specific behaviours, the fact that many riders were seriously injured and would not easily be able to provide information, etc., however, the most important findings were that, when error was determined, there were different patterns of errors for riders and drivers. Frequent errors were careless riding, speeding, making incorrect turns, cutting in and tailgating.

Last, analyses of injury outcomes revealed expected findings. Given the vulnerability of motorcyclists, it was not surprising that, in a collision with a vehicle, that they were more likely to sustain a fatal or serious injury while drivers were more likely to sustain no injury at all. It was also not surprising to find that head injuries were clearly the most frequent injuries with a fatal outcome, while multiple and lower extremity injuries were more common amongst motorcyclists sustaining a serious injury (Lin & Kraus, 2008). Further, severity of

injury was associated with a number of interacting characteristics, including speed, collision with another vehicle, no helmet, and riding on rural roads.

4.1 Implications of findings

The findings from this analysis have implications for where priority settings for intervention should lie, and raise a number of potential opportunities for countermeasures to address the high rate of motorcyclist fatal and serious injury trauma in Malaysia, and include road design improvements (including measures to reduce speed), and behavioural/training opportunities. The key issues that should be addressed to reduce motorcyclist deaths and serious injuries are collisions in rural setting on federal and state roads (particularly loss of control and single vehicle collisions), and at intersections to reduce side-impact collisions between motorcyclists and other vehicles.

With regard to engineering countermeasures, efforts should focus on rural roads and roads in small towns. These roads in Malaysia are often of low design, are undivided, with little or no shoulder and few barrier systems to address run-off-road collisions. Moreover, speeds are often relatively high for the environment. Engineering countermeasures have the potential to quickly and effectively create a safer and more 'crashworthy' travel environment for vulnerable road users. The improvements that may provide most benefit to motorcyclists on rural roads include: i) measures to reduce travel speeds (including lower speed zones and traffic-calming measures), and ii) improvements to roads and roadsides to provide a much higher standard of road, particularly on federal and state roads – these improvements may include improved shoulder areas, provision of clear zones, provision of barrier systems, and conversion of undivided roads to divided roads, provision (and maintenance) of separate motorcycle lanes.

Installation of barrier systems on road lengths where there is a high proportion of run-off-road or head-on collisions has been shown to be extremely effective in reducing overall casualty crashes (e.g., in Sweden, the Netherlands, and Australia). As an example, significant reductions in run-off-road and head-on serious casualty crashes between 75 and 87 percent following the introduction of flexible barrier systems in Victoria, Australia (Candappa, D'Elia, Corben & Newstead, 2009). While the debate continues regarding the types of barrier systems most protective of motorcyclists, there is the need for protection from collisions with roadside objects such as trees and poles. Current evidence points to no safety disbenefits of flexible barrier systems to motorcyclists. However, there are some points to consider in the design of barrier systems for motorcyclists including i) minimizing the number of support obstacles for barrier systems and ensuring no protruding, jagged or sharp edges, and ii) consideration of motorcyclist leaning behaviour should be incorporated in the design of barrier systems especially on bends.

Separate motorcycle lanes were first introduced in Malaysia in the late 1980s and early assessments suggested the installation of lanes led to substantial reductions in all motorcycle collisions (25% reduction in 1995; Radin Umar et al., 1995; and 39% reduction in 2000, Radin Umar et al., 2000). It is important to note that there are limitations on where motorcycle lanes can be installed, and to ensure that the design of the lanes is optimal and takes into account the speed of motorcyclists and operating space by considering placement and design of guardrails (Tung et al., 2008) and optimal width of lanes (Hussein et al., 2005).

In cities and towns, also, infrastructure and operation design features of intersections may provide benefit to motorcyclists riding in urban areas. Some examples of improvements to

intersection design include provision of well-designed roundabouts, improved signal phasing, and reduced speed limits on approaches to intersections.

There is clearly a need to focus on improvements to some rider and driver behaviours, including efforts to increase helmet wearing rates and reduction of risky driving and riding behaviours such as speeding, cutting in, turning safely and keeping adequate distances between vehicles. Provision of educational and training programs aimed at improving road user behaviour would be beneficial, as well improved licensing procedures and enhanced enforcement techniques and technologies.

4.2 Conclusions

The protection of motorcyclists is a critical area of road safety in Malaysia given their numbers on the road and the particular risks associated with motorcycle travel. Despite the many efforts the Malaysian government, industry and community organizations have made to reduce motorcycle crashes, motorcycle-related trauma remains high.

The findings from this study confirm previous studies and add some new information on current fatal and serious injury collision risk amongst motorcycle riders and pillion passengers in Malaysia. Motorcyclists appear to be at highest risk in rural areas, on major roads and are involved in single-vehicle, loss of control collisions as well as multiple collisions at intersections. Some behavioural factors also appear to play some role in crash and injury risk including helmet wearing, speeding, and risky riding behaviour. The implications for countermeasure development are presented to address these priority issues including improved road design as well as supporting education and enforcement initiatives.

REFERENCES

Candappa, N., D'Elia, A., Corben, B., & Newstead, S. (2009). Evaluation of the effectiveness of flexible barriers along Victorian roads. (Report 291). Melbourne, Monash University Accident Research Centre.

Department for Transport, Energy and Infrastructure. South Australia: South Australian Government, 2009. Road Safety: Motorcycle Facts. Viewed 15 February 2011. http://www.dtei.sa.gov.au/roadsafety/safe_road_users/motorcyclists/motorcycle_facts

European Transport Safety Council [ETSC] (2008). *Vulnerable riders: Safety implications of motorcycling in the European Union*. Brussels, ETSC.

Hussain, H., Radin Umar, R. S., Ahmad Farhan, M. S., & Dadang, M. M. (2005). Key components of a motorcycle-traffic system: A study along the motorcycle path in Malaysia. *IATSS Research, 29*(1), 50-56.

Kulanthayan, S. et al. (2000). Compliance of proper safety helmet usage in motorcyclists. *Medical Journal of Malaysia, 55*(1): 40-44

Lin, M-R.,& Kraus, J. (2008). Methodological issues in motorcycle injury epidemiology. *Accident Analysis and Prevention, 40*(5): 1653-1660.

National Highway Traffic Safety Administration [NHTSA] (2007). *Traffic safety facts 2005: Motorcycles*. Washington DC, NHTSA

Oxley, J., et al., (2011). *Keeping children safe in vehicles: an observational study in Malaysia*. MUARC Report.

Oxley, J., et al., (2012). *Case-control study of commuter crashes: an understanding of contributing factors to crash risk.* MUARC Report to Social Security Organisation [SOCSO], Malaysia.

Pang, T., Radin, U., Ashar, A., et al., (1999). Fatal injuries in Malaysian motorcyclists. *International Medical Research Journal, 3*(2), 115-119.

Radin Umar R. S. (2006). Motorcycle safety programmes in Malaysia: how effective are they? *International Journal of Injury Control and Safety Promotion*, 13(2): 71-9.

Radin Umar, R., Mackay, G. M., & Hills, B. C. (1995). Preliminary analysis on impact of motorcycle lanes along Federal Highway F02, Shah Alam, Malaysia. *IATSS Research, 19*(2), 93-98.

Radin Umar, R. S., Mackay, M., and Hills, B. (2000). Multivariate analysis of motorcycle accidents and the effects of exclusive motorcycle lanes in Malaysia. *Journal of Crash Prevention and Injury Control, 2*(1):11-17.

Road Safety Department of Malaysia. Malaysia: JKJR, 2008. *Statistics on road accident*. Viewed 15 February 2011. www.jkjr.gov.my/statistics.html

Tung, S. H., Wong, S. V., Law, T. H., and Radin Umar, R. S. (2008). Crashes with roadside objects along motorcycle lanes in Malaysia. *International Journal of Crashworthiness, 13*(2), 205-210.

World Health Organisation, *Global status report on road safety: Time for action*. 2009: Geneva, World Health Organisation.