Submission No 45

INQUIRY INTO VULNERABLE ROAD USERS

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SUBMISSION TO THE

PARLIAMENTARY INQUIRY CONDUCTED BY

THE STAYSAFE (ROAD SAFETY) COMMITTEE

INTO VULNERABLE ROAD USERS,

WITH PARTICULAR REGARD TO MOTORCYCLE SAFETY

THE GEORGE INSTITUTE
for Global Health

INQUIRY TERMS OF REFERENCE

That the Committee inquire into and report on vulnerable road users, specifically motorcycle and bicycle safety, with particular reference to:

a) patterns of motorcycle and bicycle usage in New South Wales;

b) short and long term trends in motorcycle and bicycle injuries and fatalities across a range of settings, including on-road and off-road uses;

c) underlying factors in motorcycle and bicycle injuries and fatalities;

d) current measures and future strategies to address motorcycle and bicycle safety, including education, training and assessment programs;

e) the integration of motorcyclists and bicyclists in the planning and management of the road system in NSW;

f) motorcycle and bicycle safety issues and strategies in other jurisdictions; and

g) any other related matters.

INTRODUCTION

Strategies to reduce the crash and injury risk of motorcycles and scooters depend on the accurate identification of causes and risk patterns, including demographic and behavioral factors and exposure. Commonly used measures of exposure for motorcycles include: numbers of licensed riders, vehicle kilometers/miles travelled, and registered vehicles. Each method has different limitations as they are drawn from databases developed for other administrative purposes.

The number of licensed riders is an unreliable estimate of riders at risk because it includes those who remain licensed, but no longer ride, while not accounting for unlicensed riders and pillion passengers. For example in 2008 there were 460,997 licensed motorcycle riders in NSW but only 146,583 registered motorcycles.[1]

In Australia, distance travelled (kilometres) is extrapolated from total annual fuel sales divided by the distribution of different vehicles within the national fleet. This is considered to provide robust estimates for the larger components of the total vehicle fleets (i.e. cars for gasoline sales and trucks for diesel sales), but less accurate measures for other vehicle types such as motorcycles, which only account for a small proportion of total fuel sales.[2]

The number of registered vehicles may overestimate the number of active riders by not accounting for those who own more than one vehicle, but it is believed to be the best available measure in NSW.

Unless otherwise indicated, the data analysis presented in the following sections is drawn from a report prepared annually for the Motorcycle Council of NSW (MCC) and posted on their website: www.roadsafety.mccofnsw.org.au) to provide information to help riders understand and manage their risks.

A version of that report including some previously posted results as well as new results and data has been submitted for presentation to the US Transportation Research Board Annual Meeting to be held in Washington, 2011. We would like to thank the MCC and RTA for making these data available however this paper does not necessarily reflect the views of either organization.

A. Patterns of usage

In 2008 there were 146,583 registered motorcycles in NSW[1].

- The number of motorcycles in NSW has increased by 73% since 2000.
- In 2008 the average age of a rider was 43[3] and the average age of a new rider was 33[4].
- The average age of riders is increasing due both to the aging of the cohort and to increased number of older new riders.
- Novice riders are older and represent a different demographic to that of novice drivers who are predominantly teenagers. The majority of novice riders hold an unrestricted drivers licence and are in full time employment[4].
- Motorcycles are more likely to be used for recreational than commuting or general transport purposes[4-5].
- Scooters are an increasing if small proportion (5.4%) of registered machines compared to supersports (12.8%) and cruisers (7.9%). [6]

B. Short and long term trends in motorcycle injuries and fatalities in on road settings

Between 2004-2008 there were 12,257 motorcycle crashes in NSW including 305 fatal crashes[3]. In NSW, for every rider who is killed, there will be 34 who are injured. In-depth studies of motorcycle crashes in other jurisdictions suggest that up to 25% of rider casualties will have moderate to severe injuries (AIS 3-6), whereas over 70% of rider casualties will have relatively minor injuries (AIS 1-2).[7-8]

- Over the study period the number of motorcycle crash fatalities decreased by 10%, but the overall number of crashes increased by 17%.
- Taking account of the increased number of registered motorcycles, the fatality rate per 10,000 registered motorcycles decreased from 5.6 to 3.7. The injury rate decreased from 185.8 to 161.8 and the overall crash rate decreased from 211.0 to 180.9.
- Most crashes (69%) occur in low speed zones 60 km/h or less with 12% in 100+ km/h. A higher proportion (25%) of fatal motorcycle crashes occur in higher speed zones.
- Single vehicle crashes account for 41% of motorcycle crashes. They are equally likely to occur on straight as on curved roads.
- Road surface hazards, such as potholes, diesel or loose gravel on a sealed surface, were a contributing factor in 18% single vehicle crashes and were a contributing factor in 10% of fatal crashes on curves.
- Animals on the road were a factor in 3% of single vehicle crashes on curves and 9% of crashes on straight sections of road.
- Multi-vehicle collisions where the rider was most likely to be the key vehicle included rear-end 29% and head-on (not overtaking) crashes 12%.
- Multi-vehicle collisions where the other driver was most likely to be the key vehicle included were failure to see or give way at an intersection (48%), changing lanes (19%) and failing to give way when entering traffic (10%).

- Only 4% of crashes involve heavy vehicles but include 18% of fatal multi-vehicle motorcycle crashes.
- Only 10% of crashes involve light trucks but include 19% of fatal multi-vehicle motorcycle crashes.
- Over half (56%) of all multi-vehicle collisions occurred at intersections. motorcycles were the key vehicle in 39% of multi-vehicle crashes and 30% of intersection crashes.
- Almost one-third (30%) of all motorcycle multi-vehicle collisions occurred at T-junctions, with the other driver the key vehicle in 70%.
- It should be noted that studies in other jurisdiction linking hospital presentations and police records suggest that up to 50% of motorcycle crashes are not reported to police.[9-11]

C. Underlying risk factors in motorcycle injuries and fatalities

- Young riders were more likely to be involved in multi-vehicle (63%) than single-vehicle crashes whereas just over half (54%) of crashes for 40+ riders were multi-vehicle.
- The other driver was more likely to be the key vehicle (62%) in crashes, but young riders were more likely than older riders (42% vs. 34%) to be at-fault, particularly in intersection crashes.
- A higher proportion of motorcycle crashes involve alcohol compared to all vehicle crashes (3.2% vs 2.4%), and 16.3% vs 13.0% of fatal crash.
- Excessive speed for conditions is associated with almost half of all single vehicle crashes.
- Unlicensed (46%) and learner riders (31%) were more likely to be the key vehicle in intersection crashes than provisionally (27%) or fully-licensed (26%) riders.
- Unlicensed riders comprised 8% of all motorcycle crashes but 24% of all riders in fatal crashes.
- The majority of unlicensed riders are aged under 26 years (49%).
- Unlicensed riders also comprise a high proportion of riders involved in crashes associated with other high risk behaviours. They comprised 26.0% of all riders with illegal BAC and 45% of all unhelmeted riders.
- Compared to licensed riders, crashes involving unlicensed riders were more likely to be at fault (37% vs 21%), associated with fatigue (14% vs 6%) and excessive speed for conditions (29% vs 23%).

D. Current measures and future strategies to address motorcycle safety issues

1. In 2000, the Motorcycle Council of NSW (MCC), funded by the Motor Accidents Authority (MAA), commissioned Liz de Rome of LdeR Consulting to develop a road safety strategic plan to provide a framework and direction for their activities and for other stakeholders with an interest in motorcycle safety. The plan, called Positioned for Safety, was drawn from a review of research and safety programs from around the world. It was developed in consultation with stakeholders from Local, State and Federal government sectors as well as industry and the motorcycle community. The first edition was released in 2002 and a revised plan, was released in 2007. The recommendations of Positioned for Safety 2010 were for motorcyclists to be:

- Identified as vulnerable road users with special needs
- Included in crash research and monitoring programs
- Accommodated in the design and maintenance of the road environment
- Included in transport planning and facilities.

2. The George Institute for Global Health has a long standing reputation for research on the prevention of road traffic injuries. In keeping with a public health approach to injury prevention, our work encompasses research on a range of topics from surveillance, observational and intervention studies through to program evaluation and policy. Two research scholars in the Injury Division, including Liz de Rome, have been recipients of NRMA ACT Road Safety Trust scholarships.

The Division has a special interest in motorcycle safety as an emerging cause of increased injury in high income countries and a major cause of injuries in low and middle-income countries. Current work by researchers from the George Institute in motorcycle safety includes:

The Novice Rider Study: a cross sectional survey of over 1000 riders, recruited when they attended the compulsory NSW pre-provisional rider training course. The aim was to identify factors associated with the use and non-use of protective clothing by novice motorcycle riders in order to understand how and why motorcyclists make decisions about usage of protective clothing. The survey also asked about the actual riding exposure of learner riders to validate their crash risk rate. The long-term objective was to develop an educational intervention program to increase the use of protective clothing. This survey was conducted in 2008, and the analysis of results is in process. A paper on learner riders' exposure has recently been accepted for presentation at the TRB Annual Meeting in Washington, 2010. Funding: NRMA Motoring and Services, NSW.

The GEAR Study is a one year prospective cohort study of 212 motorcyclists who crashed on public roads in the ACT. The aim is to identify the associations between usage/ non-usage of motorcycle protective clothing and injury and subsequent disability. This will be the first study worldwide to distinguish between different qualities of protective clothing and to examine the role of impact protectors in preventing injury. In order to ensure a representative sample of all riders who crash, injured riders were recruited from hospitals and uninjured riders are sourced through motorcycle crash repair services. The riders were also followed-up at six weeks and six months to monitor their recovery progress and quality of life following the crash. The study was completed early in 2010. Funding: Swann Insurance (Australia).

Motorcycle Helmet Use in Vietnam: Prevalence, Barriers to Use and Policy Implications. The aim of this study was to: estimate the prevalence of helmet use in motorcycle riders in the Hai Duong province of Vietnam; examine current policies aimed at reducing motorcycle injuries and promoting motorcycle helmet use in Vietnam; identify barriers to helmet use; and study the prevalence of risky behaviours among motorcycle drivers. A cross-sectional on-site observational survey design has been implemented in order to estimate the prevalence of helmet use based on a random sample of the road hierarchy. The estimates have been obtained adjusting for the time of day, day of week and the season (summer, winter).

Researchers from the George Institute have also conducted a number of Cochrane systematic reviews relating to motorcycle safety. The purpose is to review and synthesise evidence for interventions designed to reduce motorcycle injury and summarise the estimated reductions in risk of death and injury achieved by these interventions. Reviews conducted to date include: helmets for preventing injury in motorcycle riders (published), motorcycle rider training for preventing road traffic crashes (under review), and motorcycle helmet legislation for preventing injuries in motorcyclists (under revision).

The George Institute has also been recently contracted by VicRoads to undertake the evaluation of a large-scale trial of an on-road assisted ride program for newly licensed motorcycle riders.

Recent publications:

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E. The integration of motorcyclists in the planning and management of the road system in NSW

One of the key issues to be raised during the consultations for the development of the MCC motorcycle safety strategic plan, was the lack of recognition of motorcycles as a separate class of vehicle by regulation or within policy for road safety or for traffic management and transport planning purposes. Instead they are subsumed under the general category of motor vehicles or grouped as vulnerable road users with pedestrians and bicyclists. Neither grouping allows for recognition of motorcycles as a form of transport with specific benefits and associated safety and traffic management requirements. The unintended result affects the administrative and political context within which decisions about motorcycle safety decisions are made. Road authorities are not required to make separate provision for motorcyclists in the design of roads and facilities, nor to develop expertise in motorcycle safety engineering, behavioural risks and associated factors.

In relation to planning, the NSW Department of Planning does not treat motorcycles as a separate form of motorized transport in the data analysis for the NSW survey of household travel. As a consequence motorcycles were not mentioned in the Sydney Metropolitan Strategy.

Some years ago, VicRoads commissioned a report on the present and potential roles for motorcycles in the total transport system. The objective was to provide a basis for developing a motorcycle strategy which included a balanced coverage of the mobility and accessibility contributions, as well as the inherent operating and safety costs. The report examined motorcycles as a transport option in terms of traffic flow and capacity, and environmental and economic impacts. The author found that motorcycles were currently inadequately integrated and underused in transport policy due to a singular focus on safety issues. He argued that, with appropriate vulnerable road user policies (covering pedestrians, cyclists and motorcyclists), road space management policies and improved economic evaluation systems, motorcycles could be efficiently integrated into transport and traffic models.[12]

In 2009, Victoria published a road safety and transport strategic action plan for powered two wheelers, recognizing that these vehicles are a growing part of the transport future and must be accommodated.[13]

The United Kingdom has taken the lead in becoming the first Western government to make a commitment to mainstreaming motorcycling in transport policy (DFT, 2005). The viability of including motorcycles as a safe option in transport planning has already been demonstrated by the City of London.

In 2000, London published a Transport Strategy and Road Safety Plan for the city, which undertook to promote the use of motorcycles as a part of the congestion reduction program. Initiatives included exempting motorcycles from the congestion tax and incentives to encourage their use as an alternative form of transport. Promotional programs included providing advance stop lines and secure parking for motorcycles, and allowing them to use bus lanes. The provision of these facilities was complemented by motorcycle safety education campaigns aimed at both riders and other drivers. Over a three-year period there was a 10–15% increase in motorcycle trips in London, but a 30% reduction in the number of motorcyclists killed and injured (Hewing, 2005).

F. Motorcycle and safety issues and strategies in other jurisdictions

National comparisons

NSW has more registered motorcycles than other states and territories See Table 1. [14-21]

Table 1 Motorcycle registrations '000s by State and Territory, 2004-2008

	NSW	Vic	Qld	WA	SA	Tas	NT	ACT	Aust
2004	108	102	89	49	29	9	3	7	396
2005	113	108	97	53	31	9	3	7	422
2006	123	114	111	60	34	10	4	8	463
2007	133	124	126	68	37	11	4	9	512
2008	147	136	139	77	39	12	5	10	565

NSW also has more motorcycle crash casualties than the other States and Territories (see figure 1).

Figure 1 Number of motorcycle casualties by State and Territory

While the number of casualties should be considered in proportion to the number of registered motorcycles, NSW still has a higher rate of casualty than most other jurisdictions (see Table 2).

In 2008, the NSW casualty rate per 10,000 registered motorcycles was higher than all other jurisdictions in Australia with the exceptions of Western Australia and Tasmania.

Table 2. Casualty rate per 10,000 registered vehicles per State and Territory.

	NSW	Vic	Qld	WA	SA	Tas	NT	ACT	Aust
2004	198.5	190.0	177.4	228.0	171.7	230.0	250.0	205.7	181.6
2005	191.4	199.8	180.7	219.8	145.8	255.6	280.0	205.7	180.0
2006	194.5	164.4	169.5	215.0	165.0	257.0	177.5	87.5	169.1
2007	175.6	168.2	149.8	185.1	163.5	121.8	207.5	82.2	154.6
2008	179.0	163.5	141.2	184.3	169.5	189.2	176.0	80.0	153.4

Conversely, NSW has a lower fatality rate than any other state except Victoria. See Table 3

Table 3 Fatality rate per 10,000 registered motorcycles by State and Territory

	NSW	Vic	Qld	WA	SA	Tas	NT	ACT	Aust
2004	5.4	3.6	5.4	4.5	7.2	7.8	0.0	2.9	4.9
2005	5.7	4.4	6.6	4.2	6.1	7.8	6.7	11.4	5.5
2006	5.4	4.1	5.2	5.3	6.5	5.0	15.0	3.8	5.2
2007	4.6	3.6	5.8	5.4	2.2	6.4	7.5	3.3	4.7
2008	3.7	3.2	5.2	4.7	4.4	6.7	20.0	4.0	4.3

Strategic approaches

Most Australian road authorities have developed motorcycle safety strategic plans over the past 10 years. The advantage of such plans is to provide a blueprint for the actions of the lead agencies but also direction and guidance and coordination of efforts by other stakeholders particularly local government, the industry and motorcycle community. The most comprehensive implementation of such a strategy is illustrated by VicRoads, operating on behalf of the VMAC (Victorian Motorcycle Advisory Council), which is a Ministerial advisory council with an independent chair. A substantial program of research and innovation which has stimulated interest internationally.[22-23]

Conclusions and Implications

While motorcycle crash rates showed an encouraging decline in NSW from 2004 to 2008, overall crash and injury rates were higher but fatality rates lower than in most other Australian jurisdictions.

Risk factors associated with motorcycle crashes include youth and inexperience, unlicensed riding, excessive speed for conditions and riding while affected by alcohol. Road environment risk factors included relatively low speed urban areas, intersections, curves and road surface hazards such as potholes, diesel and loose gravel on sealed surfaces. The other driver was most likely to be at-fault in multi-vehicle crashes, particularly intersection crashes, lane changing and entering traffic from parking or driveways. Apart from their involvement in single vehicle crashes, riders were most likely to be at-fault in rear-end and head-on collisions.

These results indicate a need for further work to be undertaken to improve the safety of the road environment and the behavior of both riders and drivers.

Road safety auditing programs with a specific focus on motorcycle hazards should target high risk areas, particularly curves on high frequency motorcycle routes. Geo-mapping techniques could be applied to the crash data to identify high-risk locations.

NSW has two mandatory rider training programs in its graduated licensing system, but there is a need for more research to be undertaken to revise these programs to address the specific crash risks for novice riders. A recent review of the literature highlighted the lack of evidence for effective rider training programs and introduction or modification of any such programs should only be made in the context of careful high quality evaluation.

The high involvement of unlicensed riders, including non-use of helmets, speeding and alcohol involvement, indicates a need to target these high-risk riders who are outside of the licensing system. Effective programs for other drivers to be aware and avoid motorcycle crashes are also needed.

More needs to be done to make motorcycling safer for the increasing proportion of road users who choose this type of transport. NSW has lagged behind other States in recognizing the systemic changes required to identify and implement appropriate and effective countermeasures.

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Countermeasures to prevent cyclist crashes

This document is a summary of a review of countermeasures designed to reduce the risk of cyclist injury and death as a result of traffic crashes by modifying road environment, cyclists' behaviour and vehicle design. It is part of a research project commissioned by VicRoads and undertaken by the Injury division at the George Institute of Global Health[1].

Road Environment

1.1 Intersections

Most severe cyclist crashes reported to the police occur at intersections[1]. Roundabouts in particular have been identified as relatively high risk intersection configurations for vulnerable road users including cyclists.[2,3] A recent study of crashes with bicyclists at 90 roundabouts in Belgium showed that roundabouts with cycle lanes incorporated appear to perform significantly worse compared to other road design types, including mixed traffic and separate cycle paths.[3] A US study highlighted aspects of roundabout design that require additional care to ensure safe access for pedestrians and bicyclists.[4] In particular, emphasis needs to be placed on designing exit legs to ensure proper sight lines and low motor vehicle speeds. The junction of the circulatory lane and exit lane was observed to be the location of greatest risk for bicyclists. Multilane roundabouts may also require additional traffic control measures to ensure safe access for pedestrians. This might include the use of off carriageway routes around the roundabout, with signal control across the entry and exit.[4] However, none of the measures proposed in this study have been evaluated in terms of their impact on cyclists crash risk.

A recent review of the literature on the most effective intersection treatments designed to improve bicycle access and safety found that bike boxes, also known as advanced stop lines (ASL), that allow bicyclists to move in front of vehicles when stopped at a signalised intersection reduced the potential for conflicts with vehicle turning movements on green signal.[5] Despite complaints about some level of motorists encroachment, cyclists interviewed in the reviewed studies thought that ASLs were safer and easier to use because they allocated more road space for cyclists and made them more visible to drivers. The review also found that separate signal phases for bicyclists at intersections, which stop all vehicular traffic while permitting cyclists to proceed through the intersection in designated directions similar to vehicular traffic, reduce conflict with vehicle turning movements and has the potential to improve safety for cyclists. Other intersection treatments highlighted by the review as potentially beneficial in term of reducing conflict between cyclists and motorists include coloured bicycle lane markings through intersections and coloured bicycle crossings at the intersection approach (where only a small portion of the bike lane approaching the intersection is coloured).

1.2 Separate bicycle facilities

Separate bicycle facilities refer to improvements and provisions made by public agencies to accommodate or encourage bicycling. These facilities, which can be provided for the preferential or exclusive use of bicyclists, include separated bicycle facilities such as off-road paths or multi-use paths and on-street facilities (on-street bicycle lanes, bicycle routes, wide curb lanes, ASLs and other non-intersection specific treatments). While there is evidence that many of these facilities increase the perception of safety among cyclists and therefore increases the overall level of cycling.[6]There is conflicting evidence on their effectiveness in reducing the risk of crashes and injury. This is partly due to the fact that many studies do not specifically define the bicycle facilities being studied, group facilities that may have different injury risks, or do not specify the sections of the roads they examined.

Various studies have suggested that complete separation of cyclists and other road users, motorists in particular, is not possible and that partial separation such as through separate bicycle lanes can simply increase the risk of crashes at inevitable points of contact between cyclists and motorists, such as when the lanes cross driveways and intersections.[7,3,8,9,10,11] Nevertheless, there is mounting evidence in support of some purpose-built bicycle-specific facilities to prevent crashes and injuries among cyclists. A recent review of the literature found that on-road marked bike lanes had a positive safety effect in five studies, consistently reducing injury rates, collision frequencies or crash rates by about 50% compared to unmodified roads.[12] Bike lanes are defined as parts of the paved roadway marked with painted lines or a coloured surface to designate that it is reserved exclusively for cyclists. The review also found similar results regarding bike routes: a paved residential or local road that is signed as being a "bike route", and may have cyclist friendly crossings at major roads, such as traffic signals with push-buttons that are easily operated by cyclists. The review found less consistent evidence regarding off-road facilities.

It has been suggested that bicycle facilities, which are most likely to reduce the risk of crashes to cyclists are those that do not share the space with parked cars, are marked for cyclists and reduce the potential for conflict between cyclists and motorists at intersections. The latter can be achieved by the provision of facilities such as advanced green lights for cyclists and bicyclist activated traffic signals at key intersections.[13]

A recent NZ study has found that drivers were much less likely to encroach on bicycle lanes where the road surface was coloured than on uncoloured ones, particularly where ASLs are in place. The researchers recommended that road agencies continue colouring new and existing bicycle facilities at intersections, with preference given to ASLs and sites with wider approaches.[14]

Bicyclist features and facilities recommended by a recent report commissioned by the US Department of Transportation, [15] which examined pedestrian and bicyclist safety and mobility in Europe, include continuation of bike lanes up to intersections, bike lanes between traffic lanes, dashed bike lanes through intersections and rotated or longitudinal bicycle symbols at major driveways. The latter facility should particularly be considered as the analysis of police crash data in Victoria found vehicles striking cyclists while emerging from driveway to be the most common crash type occurring at non-intersection sections of the road. However, to our knowledge, there is no evidence of their effectiveness on crash risk and serious injury in cyclists.

Geo-mapping of where most collisions involving cyclists in NSW occur as well as a survey of mostly used cyclists routes could be used as a guide to where safe and well designed bicycle facilities should be developed.

1.3 High speed roads and rural locations

The association between higher speed limits and increased crash incidence and injury severity for cyclists has been confirmed in a range of studies both in rural and urban areas.[16,17,18,19,20]

However, whereas a higher proportion of cycle crashes occur in urban areas, those that occur in rural areas are more likely to lead to serious injury and death. The increased severity of crashes in rural areas is considered to be due not only to higher vehicle speeds, but also to a lack of separate bicycle lanes or paths as well as greater time delays for emergency services to provide medical intervention when crashes do occur.[21,22]

These findings suggest the importance of separating bicyclists from high-speed traffic, for example separate bicycle paths on roadways that have a speed limit of over 60 km/h, and lend support to a 30 km/h speed limit in residential neighborhoods with significant pedestrian and bicycle traffic.[16] Lower speed limits should also be considered on popular bicycle routes, particularly in rural areas.

2. Behaviour of cyclists

2.1 Conspicuity and night riding

Previous studies have found that intersections are where drivers are less likely to see the pedestrian or cyclist until it is too late.[23] It has been suggested that the reason for the higher proportion of bicycle-motor vehicle collisions at intersections is that drivers fail to see a cyclist approaching because they are not looking for them.[24] These "failed to see/look properly" errors may be made by either the cyclist or the driver.[17] A study of serious cyclist crashes in Britain found that 56% of cases were attributable to other road users failing to look properly for cyclists.[25] The same study also found that 43% serious cyclist crashes in Britain were also attributable to cyclists failing to look properly for other road users. This aspect should be emphasised in programs promoting safe sharing of the road among cyclists and other road users. Analysis of coroner reports from Victoria, revealed that more than 40% of crashes leading to cyclist fatalities were "rear end" and "sideswipe" type of crashes that might have occurred as a result of cyclists' low visibility [1].

Road positioning by cyclists requires riders to choose their place in the traffic to maximise drivers' awareness of their presence in addition to avoiding drivers' blind spots. A recent Queensland study found cyclists substantially overestimated the distance at which they would be first recognised by a driver compared to that estimated by drivers.[26] This suggests that cyclists may benefit from educational programs to help them appreciate the visual challenge they present to drivers, to develop effective traffic management strategies and to prevent them making inappropriate assumptions about the drivers' awareness of their presence

In addition, a number of studies indicate that while most bicycle crashes occur during daytime, those occurring at night, particularly in areas without effective street lighting, have a higher injury severity risk.[23,27,28] Visibility may be improved by a number of measures including street lighting, conspicuous clothing and road positioning by cyclists. Effective street lighting is associated with lower severity of injury, perhaps due to increasing reaction time available to motorists and cyclists.[27]

High conspicuity clothing for cyclists has been associated with reduced injury severity in some studies,[28,29] whereas other evidence is less conclusive.[23] In recent years visibility aids such as reflective garments and flashing lights have appeared in the market but are not required to be independently evaluated for their safety benefits. A systematic review of visibility aids for pedestrians and cyclists found that fluorescent materials in yellow, red and orange have been found to improve driver detection during the day; while lamps, flashing lights and retro-reflective materials in red and yellow, particularly those with a bio-motion configuration (taking advantage of the motion from a pedestrian's limbs), improved pedestrian recognition at night. However, the authors concluded that although visibility measures may help drivers see pedestrians and cyclists, more research needs to be done to determine whether the increased visibility actually does prevent collisions.[23]

2.2 Bicycle safety programs

The analysis of Victorian data shows that males aged 25-40 comprise the majority of severe cyclist casualties[1]. This is consistent with the experience in other countries. [25] However, while the majority of casualties in reported crashes had been wearing a helmet (72% of males and 80% of females), children and teenagers were less likely than adults to have been wearing a helmet, and this was least likely for those aged under 10 years with 42% wearing a helmet.

Non-usage of helmets is consistently associated with increased risk of serious and fatal injuries. Numerous studies report comparable positive findings for the protective benefits of bicycle helmets.[30,31,32,33,34] A Cochrane Review of five case controlled studies from different countries concluded that cycle helmets decrease the risk of head and brain injury by between 65% and 88% and decrease the risk of facial injury by 65%.[35] Legislation for bicycle helmet use has been shown to be effective in increasing helmet use and decreasing head injury rates.[36, 34] There is evidence that programs designed to increase the use of bicycle helmets in children are effective. This is true particularly for programs that are community based and those that involve distribution of free helmets.[37] There have been several studies, including in Australia, that have shown that school based bicycle safety programs can be effective in increasing use of bicycle helmets in children[38] although the impact of such programs on helmet use in disadvantaged populations is unclear.[37]

There is only limited evidence that bicycle safety programs for children can also be effective in increasing safety knowledge, and it is unclear whether these changes translate into crash or injury reductions.[39-41] Programs to change the safety knowledge and behaviour of children are best situated amongst a multi-strategy approach including environmental changes such as engineering interventions, legislation, parent counselling and educational programs. Given the potential for harm, these programs should be carefully evaluated prior to widespread implementation. Further detailed review of educational programs is needed but is beyond the scope of this review.

The majority of bicycle training programs target children and there are few if any evaluations of adult bicycle safety educational or skills based programs. It is recommended that consideration of educational and skills based bicycle programs be made for cyclists of all ages, but that implementation should be within the context of a broader program and carefully evaluated with rigorous research methods.

3. Vehicle design

Measures initially identified for the safety of pedestrians, should have corresponding benefits for other vulnerable road users including cyclists. These include features such as lower bumper bars and car bonnets, sensors to alert drivers and even pedestrian airbags. Other emerging vehicle design features may present hazards e.g. wider A-pillars to accommodate airbags, but which effectively obscure a portion of a driver's field of vision.[42] However, as the ride height and body positioning of a cyclists is different to that of a pedestrian, more research needs to be conducted to take account of these differences.[43]

4. Summary and recommendations

Road user behaviour measures relating to bicycle safety tend to relate to passive safety measures including helmet usage and enhanced cyclist conspicuity. Cycle safety programs to enhance the skills of riders tend to be provided to children, although the majority of cycle casualties are adults. Cycle safety

programs for adults are offered by some cycling clubs and associations. However the information provided is not necessarily evidence based. It is recommended that consideration be given to developing information for cyclists on safe cycling practices and that programs are carefully evaluated.

Road environment design measures include a range of cycle paths and lanes with varying degrees of separation from motorised traffic. While there are conflicting reports in the literature about their effectiveness, there is mounting evidence indicating that on-road marked bike lanes (marked with painted lines or a coloured surface and reserved exclusively for cyclists) reduce injury and crash rates in cyclists. Overall, a number of studies have indicated that bicycle facilities which have the potential to reduce the risk of crashes involving cyclists are those where the road surface is coloured, do not share the space with parked cars, are of appropriate width (i.e. sealed shoulders > 0.9m) and reduce the potential for conflict between cyclists and motorists at intersections through the provision of ASLs, advanced green lights for cyclists and bicyclist activated traffic signals at key intersections.

Recommendations

- Given the substantial research supporting benefits of helmet use in cyclists, more efforts need to be made to promote helmet use, particularly among riders aged less than 20 years old. Community based programs to increase helmet use in children have been shown to be effective in increasing helmet wearing rates.
- A detailed review of the effectiveness of educational programs for bicycle safety in children should be undertaken. It is recommended that educational and skills based bicycle programs for all ages should be considered, but that implementation should be within the context of a broader program of enforcement and environmental modification. The impact of these programs on crash and injury risk should be carefully evaluated.
- Education programs should also be directed at other road users to increase their knowledge about and behaviour towards cyclists sharing the road, particularly at intersections. The effect of education campaigns of other road users on cyclists' safety should also be evaluated.
- High conspicuity clothing for cyclists as well as the use of flashing lights has been shown to improve visibility and drivers detection of cyclists. Given the high proportion of crashes resulting from "failure to see cyclists", campaigns to increase conspicuity in cyclists are needed.
- The association between higher speed limits and increased crash risk and injury severity for cyclists suggests the need for the separation of bicyclists from high-speed traffic. For example, separate bicycle paths on roadways that have a speed limit of over 60 km/h and over should be considered. Serious consideration should also be given to a 30 km/h speed limit in residential neighborhoods with significant pedestrian and bicycle traffic. Consideration should also be given to lower speed limits on popular cycling training routes.
- There is mounting evidence indicating that on-road marked bike lanes reserved exclusively for cyclists reduce injury and crash rates in cyclists. Overall, bicycle facilities which have the potential to reduce the risk of crashes for cyclists are those that do not share the space with parked cars, are marked (with painted lines or a coloured surface) for bicycle use, are of appropriate width (i.e. sealed shoulders > 0.9m) and reduce the potential for conflict between cyclists and motorists at intersections.
- Effective intersection treatments that have been shown to improve bicycle access and safety, through the reduction of conflict between cyclists and other motorists, include bike boxes, also known as Advanced Stop Lines, as well as separate signal phases for bicyclists or advanced green lights for cyclists at key intersections.

- Other intersection treatments that should be considered and which have the potential to improve cyclists' safety include coloured bicycle lane markings through intersections, coloured bicycle crossings at the intersection approach, as well as off carriageway routes around large roundabouts with signal control across the entry and exit.
- Bicycle symbols at major driveways should also be considered as the analysis of police crash data in Victoria found vehicles striking cyclists while emerging from a driveway to be the most common crash type occurring at non-intersection sections of the road.
- Geo-coding of where most collisions involving cyclists occur as well as surveys of mostly used cyclists routes could be used as a guide to where well designed bicycle facilities and intersection treatments should be developed.
- Appropriate cyclist infrastructure, helmet use campaigns, as well as education campaigns to promote better sharing of the road among cyclists and other users should be extended to rural areas where there is a higher risk of injury severity among cyclists. There is little research on likely effective programs in rural areas and further research is needed to identify promising programs.

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