AP-R361/10

AUSTROADS RESEARCH REPORT

The Road Safety Consequences of Changing Travel Modes

Austroads

The Road Safety Consequences of Changing Travel Modes

The Road Safety Consequences of Changing Travel Modes

Published July 2010

The Road Safety Consequences of Changing Travel Modes

ISBN 978-1-921709-31-9

Austroads Project No. ST1418

Austroads Publication No. AP–R361/10

Project Manager

Martin Small, DTEI SA

Prepared by

Dr Peter Cairney

Published by Austroads Ltd.
Level 9, Robell House
287 Elizabeth Street
Sydney NSW 2000 Australia
Phone: +61 2 9264 7088
Fax: +61 2 9264 1657
Email: austroads@austroads.com.au
www.austroads.com.au

The Road Safety Consequences of Changing Travel Modes

Austroads

Sydney 2010

Austroads profile

Austroads' purpose is to contribute to improved Australian and New Zealand transport outcomes by:

- providing expert advice to SCOT and ATC on road and road transport issues
- facilitating collaboration between road agencies
- promoting harmonisation, consistency and uniformity in road and related operations
- undertaking strategic research on behalf of road agencies and communicating outcomes
- promoting improved and consistent practice by road agencies.

Austroads membership

Austroads membership comprises the six state and two territory road transport and traffic authorities, the Commonwealth Department of Infrastructure, Transport, Regional Development and Local Government, the Australian Local Government Association, and New Zealand Transport Agency. Austroads is governed by a Board consisting of the chief executive officer (or an alternative senior executive officer) of each of its 11 member organisations:

- Roads and Traffic Authority New South Wales
- Roads Corporation Victoria
- Department of Transport and Main Roads Queensland
- Main Roads Western Australia
- Department for Transport, Energy and Infrastructure South Australia
- Department of Infrastructure, Energy and Resources Tasmania
- Department of Lands and Planning Northern Territory
- Department of Territory and Municipal Services Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development and Local Government
- Australian Local Government Association
- New Zealand Transport Agency.

The success of Austroads is derived from the collaboration of member organisations and others in the road industry. It aims to be the Australasian leader in providing high quality information, advice and fostering research in the road sector.

CONTENTS

TABLES

FIGURES

SUMMARY

Understanding the extent of changes in modal shift and their consequences in terms of road deaths and injuries is essential if we are to fully understand progress towards the targets of the National Road Safety Strategy, and the actions that may be needed to ensure that the targets are met. For example, a shift to higher-risk modes such as cycling or motorcycling could have a detrimental effect on progress towards road safety targets unless suitable infrastructure and supporting measures are provided in time to cater for these changes. New actions in response to changed circumstances may therefore be required to keep targets on track.

The objective of the project is to provide policy makers with information about the likely consequences in terms of road casualties which would result from different levels of change in travel modes to assist with long-term planning for road safety.

Method

Data was available from a comprehensive survey carried out in 1984 across Australia which estimated travel by gender, age group, time of day and day of the week. The estimates were for car drivers, car passengers, motorcyclists, bicyclists and pedestrians. These estimates were updated by current population statistics and, for motorised travel modes, current data on vehicle use, to produce current estimates of travel. Fatalities and serious injuries were divided by the corresponding travel estimate to calculate fatality and serious injury rates.

A number of scenarios were developed to illustrate the possible consequences of modal shift in terms of road fatalities and serious injuries. These were intended to illustrate the effects of increasing use of some modes and of substituting modes to achieve the same amount of travel, assuming a 'business as usual' approach to infrastructure provision, traffic management and action to improve road user safety.

Findings

Fatality rates for all classes of road user have improved considerably since 1985; for example car driver fatality rates have fallen by 61%. Travel by car passengers is the safest mode, followed closely by travel as car drivers. Travel by motorcycle is by far the least safe mode, with fatality and serious injury rates approximately 30 times those for travel by car.

Scenarios relating to changing travel modes were investigated to identify possible areas where progress towards road safety targets may be difficult due to road users changing to higher-risk travel modes. Projections were made assuming either a power or linear relationship between travel and crash outcomes.

Under the power model, but not under the linear model:

- Substituting travel as a car driver to travel by bicycle would reduce deaths and serious injuries.
- Substituting walking for car driving would increase fatalities but reduce serious injuries.
- Substituting bus travel for car driving may result in a modest reduction in crashes.

Under both the power model and the linear model:

- Substituting travel as a car driver to travel as a car passenger would reduce deaths and injuries.

- Substituting motorcycling for car driving would increase deaths and injuries.
- Substituting any other mode for travel as a car passenger would increase deaths and fatalities.

Increases in freight movements are likely to have a major impact on deaths and serious injuries.

Fatality rates were lower in 2006 for all classes of road user than they had been in 1984, with motorcyclists showing least improvement. Bicyclists had higher ratios of injuries to fatalities than other road users, and pedestrians had lower ratios.

There is compelling data to show that as walking and cycling increase, fatality and injury rates decrease; however the relative contribution of infrastructure and other factors such as a 'safety in numbers' effect is not clear.

Recommendations for research

A better understanding of the relationship between levels of walking, cycling and motorcycling is urgently required. The issue of the relative contribution of a 'safety in numbers' effect compared to infrastructure provision and policy settings is particularly important. Useful studies would include:

- a comprehensive study to establish the benefits and costs of walking and cycling from 'a whole of community' perspective which separates rural and urban travel
- longitudinal and cross-sectional studies to establish the relationship between vulnerable road user numbers in Australia and New Zealand
- detailed studies of the relationship between the activity of different road users and crash rates at particular sites to replicate New Zealand work
- studies to assess the risk associated with different types of motorcycles and motor scooters, and the location and circumstances of motorcycle crashes during recreational and commuting times.

Recommendations for action

Road authorities, including local governments, should consider the following actions if they are not already vigorously pursuing them:

- Encouraging car-pooling and other forms of car-sharing.
- Progressively improving the provision for pedestrians accessing or leaving bus stops or train stations.
- Progressively improving provision for cyclists.
- Progressively improving measures to encourage safe motorcycling.
- Reformulating the issue of promoting or providing for walking and cycling as creating a walking and cycling infrastructure and traffic environment which will encourage high levels of walking and cycling and reduce casualty rates.

For the time being at least, until more definitive evidence is available, refrain from promoting the view that increasing the number of pedestrians or cyclists will by itself reduce the crash rate for these modes. Instead, they should promote the view that concerted policy initiatives and infrastructure provision can create an environment where walking and cycling are encouraged and are safe activities.

1 INTRODUCTION

Under Safe System principles, no road user should ever be exposed to impact forces in a traffic crash from which they are unable to recover. Major changes to roads, vehicles and the way that road users interact with one another and their environment need to occur before this visionary goal can be realised. One of the features of the current road transport system is that different types of road user have different vulnerabilities to collision impact forces and therefore experience different casualty outcomes.

This situation is likely to continue until Safe System principles are fully implemented throughout the road system at some point in the future. In the meantime, the differences in casualty outcomes associated with different travel modes are likely to persist. Changes in the proportions of travel by different modes therefore have the potential to change the casualty outcomes of the road system in a positive or negative direction, depending on the type and extent of the changes.

The sharp increases in oil prices between late 2007 and mid-2008 appear to have changed the travel patterns of large numbers of people. Future pressure on oil prices and increasing action to address greenhouse gas emissions are likely to see these trends strengthen. The most immediate effects of rapidly increasing oil prices have been a sharp increase in use of public transport in Australia and New Zealand.

Understanding the extent of these changes in modal shift and their consequences in terms of road deaths and injuries is essential if appropriate actions are to be implemented to maintain progress towards achieving the targets of the National Road Safety Strategy. For example, a shift to modes such as cycling or motorcycling could have a detrimental effect on progress towards road safety targets. Conversely, a shift toward public transport would be likely to be beneficial for road safety targets. These modal shifts may be provoked by new economic factors, so that part of the reasons why plans do not meet their targets is not due to shortcomings in the changes to the road transport system proposed under the plan. New actions in response to changed circumstances may therefore be required to keep targets on track. In the broader context, this information is important in assessing progress towards the realisation of Safe System objectives.

1.1 Objective

The objective of the present project is therefore to provide policy makers with information about the possible consequences in terms of road casualties which would result from different levels of change in travel modes to assist with long-term planning for road safety.

It is important to recognise that the report does not attempt to predict actual changes in travel behaviour. It investigates a number of scenarios which show how road deaths and serious injuries (the focal concerns of Safe System principles) would change, given a specified increase in travel by a particular mode, or specified changes in travel from one mode to another.

1.2 Literature Review

As preparation for the present project, a literature review was undertaken under another Austroads project (ST1343 Task 2). The literature review is summarised in Austroads (2009). A condensed version of that summary is also provided in the present report.

The literature review examined the issues of:

- the types of rates and different measures of exposure used to measure safety between travel modes

- deaths and hospitalisations of vulnerable road users (i.e. cyclists, pedestrians and motorcyclists)
- rates of deaths and hospitalisations of vulnerable road users
- risks, historical trends, mechanisms for change and a range of factors associated with increases and decreases in use of the different modes
- travel time budgets.

The report examines changes from use of the car to more vulnerable modes and focuses on Australia and New Zealand.

The main findings were:

- With regard to rates of casualties per distance travelled.
  - motorcycling has a much higher risk than car travel
  - cycling and walking have somewhat higher risk
  - bus travel has a lower risk.
- Casualty rate per capita is a useful measure for population level health outcomes, and for setting targets to be achieved from the combined modes of transport.
- At the time of the literature review (conducted largely in 2007), trends in travel modes were fairly static, with a small increase in cycling in some Australian cities. Predicted increases in oil prices were expected to drive decreasing use of the car and increasing engagement in the most common alternative modes: public transport, motorcycling, cycling and walking.
- The extent to which travel modes can be substituted is restricted by trip distance.
- Motorcycle registrations are increasing in both Australia and New Zealand, particularly in the very light category (60 cc capacity and less) and the very heavy category (1,000 cc and more).
- The factors that are likely to result in increased walking and cycling include:
  - feasible trip lengths and trip times that fit within travel time budgets
  - increased use of public transport (walking is a natural by-product)
  - increases in fuel prices for private motor vehicles.
- There is currently a great deal of promotion and encouragement of commuter cycling, and some cities in Australia are experiencing increases in numbers of commuter cyclists. Unfortunately, there is currently no exposure-to-risk information available to assess crash rates resulting from increases in commuter cycling at peak travel times on busy roads. All available information covers wider time-periods.
- Sources of crash data were identified and assessed. Good data is available for police recorded crashes that involve motor vehicles and result in a death or hospitalisation. However, hospitalisations are the only source of data for pedestrian-only injuries, which are sometimes misclassified, and bicycle-only injuries.
- Sources of exposure-to-risk data were also identified and assessed. Unfortunately, exposure data for non-motorised modes of transport is sparse in Australia.

The literature review concluded that safety effects of shifts from car travel to cycling, walking and motorcycling should be investigated further, particularly where governments are encouraging more vulnerable mode activities.

2 DATA SOURCES

2.1 Starting Point – the Survey of Day-to-day Travel in Australia

The starting point for the study is the day-to-day travel estimates developed in the course of the SOCIALDATA surveys on behalf of the Federal Office of Road Safety (FORS) in the 1980s.

They are valuable in that they are the only source of exposure information which:

- is Australia wide
- breaks exposure down by type of road user, by gender, and by time of day.

The reports are published as a series of FORS contractors' reports. The documents are:

- CR 51, (Socialdata Australia 1987). This report contains a comprehensive description of the survey design, field procedures and analytic methods.
- CR 68, (Intstat 1988). This report includes a quality check of the data, and weighting procedures to produce Australia wide estimates of the exposure.
- CR 70, (Anderson, Montesin & Adena 1989a). This report contains tables showing travel by state, mode, gender, age group and time of day. It also shows the corresponding fatality rates for each travel mode, with curves fitted for each gender at different times of day across the age range.
- CR 84, (Anderson, Montesin & Adena 1989b). This is a short summary report, focussing on the crash rates described in detail in Anderson et al. (1989a).

Several changes have taken place in the Australian community and road transport system since that time. Road travel has become much safer due to a combination of safer roads, safer vehicles and reductions in high-risk road user behaviour such as speeding and drink driving. The changes of most concern for the purposes of the present study are:

- reduction in fatalities by approximately half, and reduced serious injuries per population
- increases in population and vehicle ownership, leading to an increase in travel
- possible changes in mobility patterns, e.g. relatively more trips by women as drivers, a greater percentage of travel undertaken by older people.

The great value of the day-to-day travel surveys and the exposure analysis in the earlier work is the measurements of the amount of travel by different types of road user, at different times of day and on different days of the week. In the original study, this was applied to contemporary fatality data to produce crash rates for different types of road user – car drivers, car passengers, motorcyclists, bicyclists and pedestrians – broken down by gender, age, time of day and day of week.

The original work also included estimates of these rates at holiday times, which has not been pursued in the present report.

The core assumption in the present project is that, for each travel mode, the relative amounts of travel have not changed. That is to say, the relative amount of travel undertaken by men and women, by different age groups, at different times of day and on different days of the week identified in the original survey has not changed.

The original series of reports include estimates of kilometres travelled, of time spent travelling and of numbers of trips. For some purposes e.g. short trips, especially walking trips, it makes more sense to talk in terms of number of trips or time spent walking. Because non-motorised modes are slower and of shorter duration, a slightly different picture emerges when fatalities are considered per million trips or per million hours travelling than when they are considered per 10 million kilometres travel. However, because the focus in the present report is on deaths and serious injuries arising from the transport system, which are very largely an outcome of motorised travel, the present report used fatality and serious injury rates per 10 million kilometres travelled.

2.2 Sources for Updating Travel Estimates

Different amounts of overall exposure for car drivers and motorcyclists have been calculated using data from the 2004 Survey of Motor Vehicle Use (SMVU) (Australian Bureau of Statistics 2005), so there can be some confidence that the overall exposure for these modes is as accurate and up-to-date as is possible.

Updated census data from the Australian Bureau of Statistics was also used in part of the process of estimating travel by car drivers, car passengers and motorcyclists (ABS 2003). In the absence of comprehensive travel data other than the original surveys, the census data was the only source used in updating exposure for bicyclists and pedestrians.

2.3 Crash Data Sources

Crash data were compiled from data sets provided by Austroads member authorities to ARRB. Numbers of fatalities and serious injuries were averaged over the period 2002-2006.

There were two limitations on the ability to bring the data together to create a complete data set covering all crashes. Queensland uses a different set of age categories than other jurisdictions. New South Wales has a different system for classifying injuries than other jurisdictions.

It should be noted that in both the Socialdata Australia/Intstat reports and the current data set, the numbers of motorcycle, bicycle and pedestrian fatalities are small, especially when broken down by age groups. Although all recorded fatalities and serious injuries were used in the analysis, the small numbers mean that the rates may not be reliable indicators.

3 METHOD FOR ESTIMATING EXPOSURE AND CRASH RATE

The basic method was to take the travel estimates from the Socialdata Australia/Intstat series of reports and update them by recent population data. These new estimates of relative travel were then used in conjunction with recent travel and casualty data to estimate crash rates. The specific steps for the different road user classes are described in Section 3.1 to Section 3.3.

The results are presented as descriptive statistics only; no significance testing was undertaken.

3.1 Car Drivers and Motorcyclists

For car drivers and motorcyclists, the average per person travel estimates from the Socialdata Australia/Intstat reports were updated by recent population data to provide an estimate of current relative travel, broken down by gender, age, time of travel and day of travel. Current travel estimated from the SMVU was allocated to each category in each comparison according to the relevant amount of travel. The number of fatalities for each of the categories was divided by the travel estimate to provide an estimate of the number of fatalities per 10 million km travel. The number of serious injuries in each category was divided by the same travel estimate to provide an estimate of the number of serious injuries per 10 million km travel. Rates were calculated separately for each state (Appendix A). Data were combined to produce overall estimates for Australia (Section 4.1 and Section 4.3). Because Queensland uses different age categories, Queensland data had to be excluded from the tables and figures in Section 4.1 and Section 4.3. Queensland results are presented separately in Appendix B. Because NSW does not distinguish between serious injuries and other injuries in its crash database, NSW was excluded from the estimates of serious injury rates in Section 4.1 and Section 4.3.

The youngest age of the people interviewed for the Socialdata Australia/Intstat reports was nine years. This lower limit for age was also applied in the present investigation. While few individuals in these age groups feature in the crash records as drivers or motorcyclists, numbers of them do appear as car passengers, bicyclists and pedestrians. However, in the absence of travel data, it was not possible to include them in the present investigation.

3.2 Car Passengers

No direct measures of car passenger travel were available from the SMVU. To estimate current car passenger travel, the average per person travel estimates from the Socialdata Australia/Intstat reports were updated by recent population data in a similar manner to the car driver and motorcyclist data to produce an estimate of total annual travel for each of the categories in the analysis. These were multiplied by the ratio of the car ownership rates per unit population in 1984 to the rate in 2004; the products were then multiplied by the ratio of average vehicle kilometres in 1984 to the average vehicle kilometres in 2004. Vehicle numbers and average travel were obtained from the SMVU, and population was obtained from the ABS population data. This produced an adjusted estimate of the total travel by car passengers in 2004.

Fatalities and serious injuries corresponding to each of the gender, age and time of day and day of week were divided by the corresponding travel estimate to provide rates per 10 million km travel.

As was the case with the car drivers and motorcyclists, Queensland data could not be included in the analysis because of the different age categories used in the crash database. Queensland results are presented in Appendix B. NSW could not be included in the serious injury analysis as that state does not differentiate between serious and other injuries in its data base. NSW injury results are presented in Appendix A.

3.3 Bicyclists and Pedestrians

No data is available for bicyclist or pedestrian travel in the SMVU. Bicyclist and pedestrian travel were estimated by taking the average travel estimates from the Socialdata Australia/Intstat studies, multiplying them by current population numbers, then aggregating them to provide estimates of the annual travel for each of the groups in the analysis.

Fatalities and serious injuries corresponding to each of the gender, age and time of day and day of week were divided by the corresponding travel estimate to provide rates per 10 million km travel.

As was the case with other road user groups, Queensland data was not included in the analysis and NSW data was not included in the serious injury analysis due to inconsistencies in the age and injury classifications respectively.

3.4 Time Spent Travelling

An exploratory analysis was carried out in terms of time spent travelling. Estimates of time spent travelling by car drivers, disaggregated by gender, age time of day and of week, were calculated by taking the estimates of average time spent travelling in the Socialdata Australia/Intstat surveys, multiplying them by 2006 population data to produce estimates of the total annual time spent travelling for each of the categories in the analysis. Numbers of persons killed and seriously injured in each of the comparison categories were then divided by the estimated time spent travelling to calculate the fatality and serious injury rates per million hours travelling. The results are presented in Section 5.

Queensland data were excluded from this analysis due to differences in age categories, and NSW data was excluded from the serious injury analysis since NSW does not differentiate between serious injuries and other injuries (Section 2.3).

4 FATALITIES AND SERIOUS INJURIES PER KILOMETRES TRAVELLED

4.1 Fatalities and Serious Injuries per Kilometres Travelled by Age

4.1.1 Drivers

Car driver fatalities by kilometres travelled for Australia are shown in Table 4.1, and serious injury rates are shown in Table 4.2. The equivalent information is shown as graphs in Figure 4.1 and Figure 4.2 respectively.

As explained in Section 2.3, NSW does not differentiate between serious injuries and other injuries and so NSW data has been excluded from Table 4.2 and Figure 4.2. The Queensland data base makes use of different age categories, so that results are not directly comparable with those for other jurisdictions. Queensland data have therefore been excluded from both tables and both diagrams.

The NSW injury rate for car drivers is 2.82 per 10 million kilometres travel. This is the rate for all injuries, not just the serious injuries shown in Table 4.2.

For Queensland, the overall fatality rate is 0.05 per 10 million kilometres travel, and the serious injury rate is 0.96 per 10 million kilometres travel. The fatality rate is identical to the fatality rate for the rest of Australia shown in Table 4.1, but the serious injury rate is higher than the serious injury rate shown in Table 4.2.

Fatality and injury rates for different age groups are shown in Figure 4.1 and Figure 4.2 respectively. They both show a U-shaped relationship, with fatality and injury rates being higher for both younger and older drivers. The data has some interesting features:

- The serious injury rates for the youngest and oldest driver age groups are high in comparison to the rates for the middle-aged driver groups; the extent of the difference is greater than the equivalent differences for the fatality rates.
- Older women drivers have particularly high serious injury rates compared to men.
- Younger women drivers have considerably lower fatality rates than men in the same age groups, but for the 50 and over aged groups, women have similar or higher fatality rates compared to men.

Table 4.1: Car driver fatality rates (per 10 million km travelled) by age, Australia* 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15**	7	5	12	1	3	3	0.08	0.51	0.26
16 – 20	173	342	516	18	68	86	0.11	0.20	0.17
21 – 25	374	806	1,180	17	65	82	0.05	0.08	0.07
26 – 29	350	726	1,075	8	39	47	0.02	0.05	0.04
30 – 39	1,007	1,957	2,964	22	78	100	0.02	0.04	0.03
40 – 49	842	1,979	2,821	21	54	75	0.02	0.03	0.03
50 – 59	465	1,559	2,024	19	45	64	0.04	0.03	0.03
60 – 64	97	412	509	7	15	22	0.07	0.04	0.04
65+	207	558	765	26	67	92	0.12	0.12	0.12
Total	3,523	8,343	11,866	139	434	572	0.04	0.05	0.05

* Data from Queensland is not included due to the different age categories used in the Queensland database.

** These age groups are included in the table as they were reported in the original Intstat (1988) report and could not be left out without recalculating the original results. The small numbers mean that the rates are unlikely to be reliable indicators of safety outcomes for this group, and that they will have had negligible effects on the aggregated rates for males and females, or for all drivers. The same considerations apply to all road user fatality rates in the Table 4.1 – Table 4.10.

Note: Annual fatality rates may not be an exact match to the quotient of the fatalities divided by the corresponding estimated annual travel due to rounding in the latter.

Table 4.2: Car driver serious injury rates (per 10 million km travelled) by age, Australia* 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	4	5	9	7	29	36	1.62	5.88	3.93
16 – 20	117	215	312	424	592	1,016	3.63	2.75	3.06
21 – 25	263	507	770	386	601	988	1.47	1.19	1.28
26 – 29	1,910	445	636	228	348	576	1.19	0.78	0.91
30 – 39	609	1,191	1,800	490	688	1,178	0.80	0.58	0.65
40 – 49	569	1,239	1,808	429	500	929	0.75	0.40	0.51
50 – 59	305	966	1,271	329	336	665	1.08	0.35	0.52
60 – 64	53	267	320	94	129	223	1.78	0.48	0.70
65+	138	334	473	269	374	643	1.94	1.12	1.36
Total	2,250	5,169	7,419	2,657	3,606	6,264	1.18	0.70	0.84

* Data from Queensland is not included due to the different age categories used in the Queensland database. Data from NSW has not been included due to the NSW crash data not differentiating between serious injuries and other injuries.

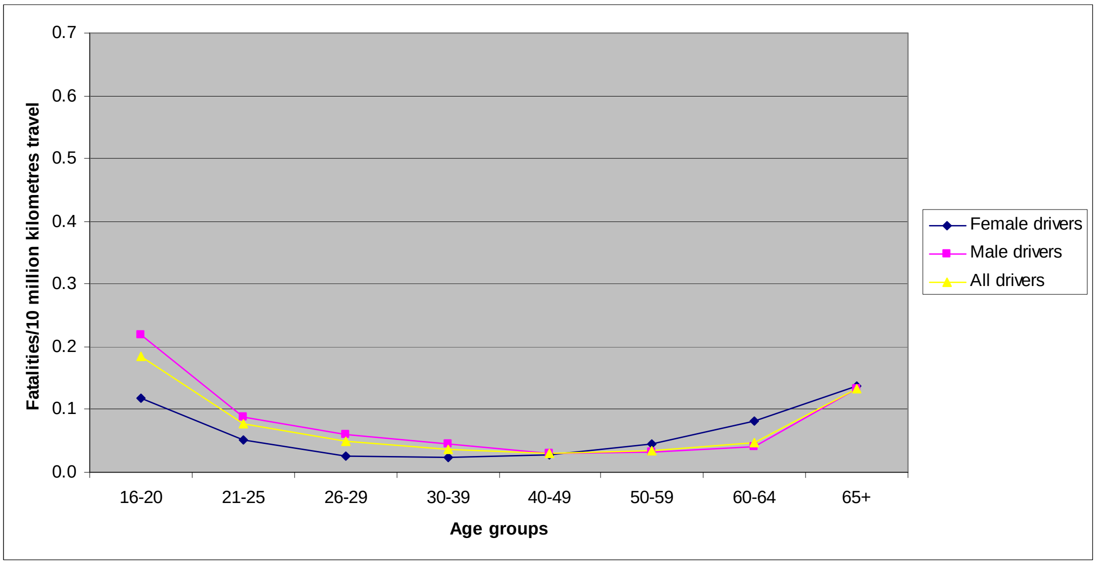

Figure 4.1: Car driver fatality rate (per 10 million km travelled) by age group, Australia 2002 – 2006

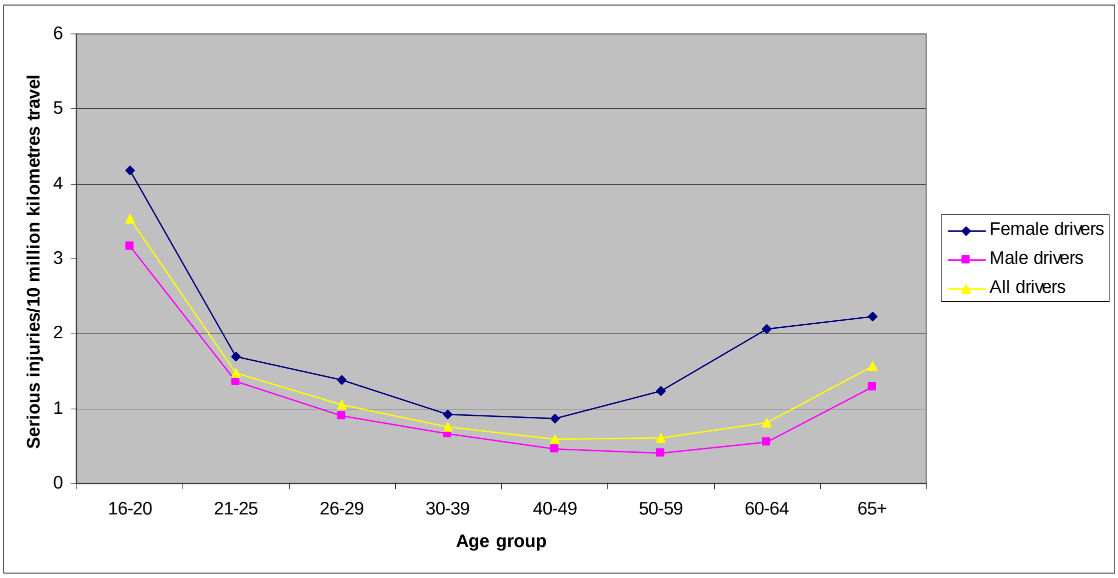

Figure 4.2: Car driver serious injury rate (per 10 million km travelled) by age group, Australia 2002 – 2006

4.1.2 Car Passengers

Car passenger fatalities by kilometres travelled for Australia are shown in Table 4.3, and serious injury rates are shown in Table 4.4. The equivalent information is shown as graphs in Figure 4.3 and Figure 4.4 respectively.

As explained in Section 2.3 and Section 4.1.1, there are differences in the crash data systems which mean that NSW injury data and all Queensland data are not directly comparable with data from other jurisdictions. NSW injury data and Queensland fatality and injury data have been excluded from the tables and figures.

The NSW injury rate for car passengers is 2.93 per 10 million kilometres travel. This is the rate for all injuries, not just the serious injuries shown in Table 4.4.

For Queensland, the overall fatality rate for car passengers is 0.04 per 10 million kilometres travel, and the serious injury rate is 0.69 per 10 million kilometres travel. The fatality rate is the same as that shown in Table 4.3 and the serious injury rate higher than the total serious injury rates in Table 4.4 The most salient feature of the passenger data is the generally higher fatality and serious injury rates for male passengers. The exceptions to this are the serious injury rates for the youngest age groups, and the serious injury and fatality rates for the older age groups.

Table 4.3: Car passenger fatality rates (per 10 million km travelled) by age, Australia 2002 – 2006

	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
Age groups	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	535	565	1,100	9	9	19	0.02	0.02	0.02
16 – 20	307	328	635	22	43	65	0.07	0.13	0.10
21 – 25	332	172	504	12	23	35	0.04	0.14	0.07
26 – 29	231	110	341	6	11	17	0.02	0.10	0.05
30 – 39	581	199	780	9	15	24	0.02	0.07	0.03
40 – 49	686	207	893	10	9	20	0.01	0.05	0.02
50 – 59	510	145	660	12	4	16	0.02	0.03	0.02
60 – 64	185	37	222	5	4	9	0.03	0.10	0.04
65+	364	114	478	33	10	43	0.09	0.09	0.09
Total	3,730	1,881	5,611	118	129	247	0.03	0.07	0.04

Table 4.4: Car passenger serious injury rates (per 10 million km travelled) by age, Australia 2002 – 2006

	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
Age groups	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	318	353	671	109	102	211	0.34	0.29	0.31
16 – 20	182	212	394	269	294	563	1.48	1.39	1.43
21 – 25	228	120	348	150	172	322	0.66	1.43	0.92
26 – 29	149	74	224	78	73	151	0.52	0.98	0.67
30 – 39	339	122	461	125	113	238	0.37	0.93	0.52
40 – 49	393	150	542	100	56	156	0.26	0.37	0.29
50 – 59	353	80	433	100	40	139	0.28	0.49	0.32
60 – 64	86	24	110	48	14	61	0.55	0.56	0.56
65+	221	67	288	164	50	215	0.74	0.75	0.75
Total	2,268	1,203	3,471	1,143	914	2,057	0.50	0.76	0.59

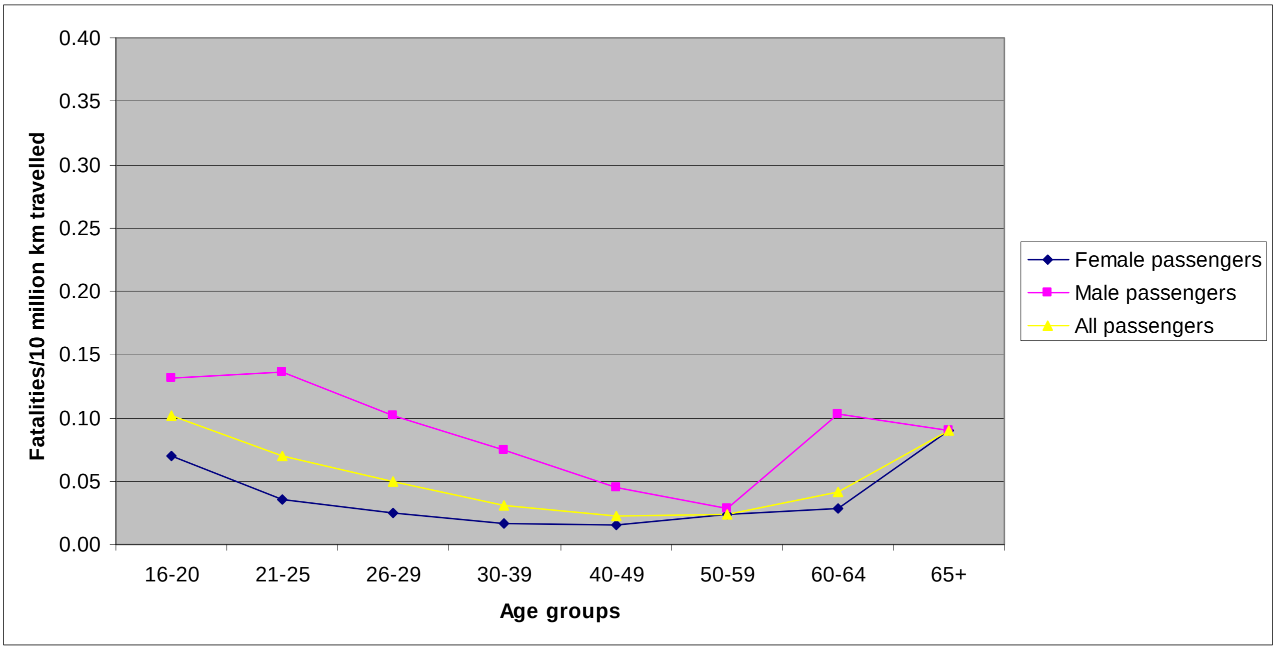

Figure 4.3: Car passenger fatality rates (per 10 million km travelled) by age, Australia 2002 – 2006

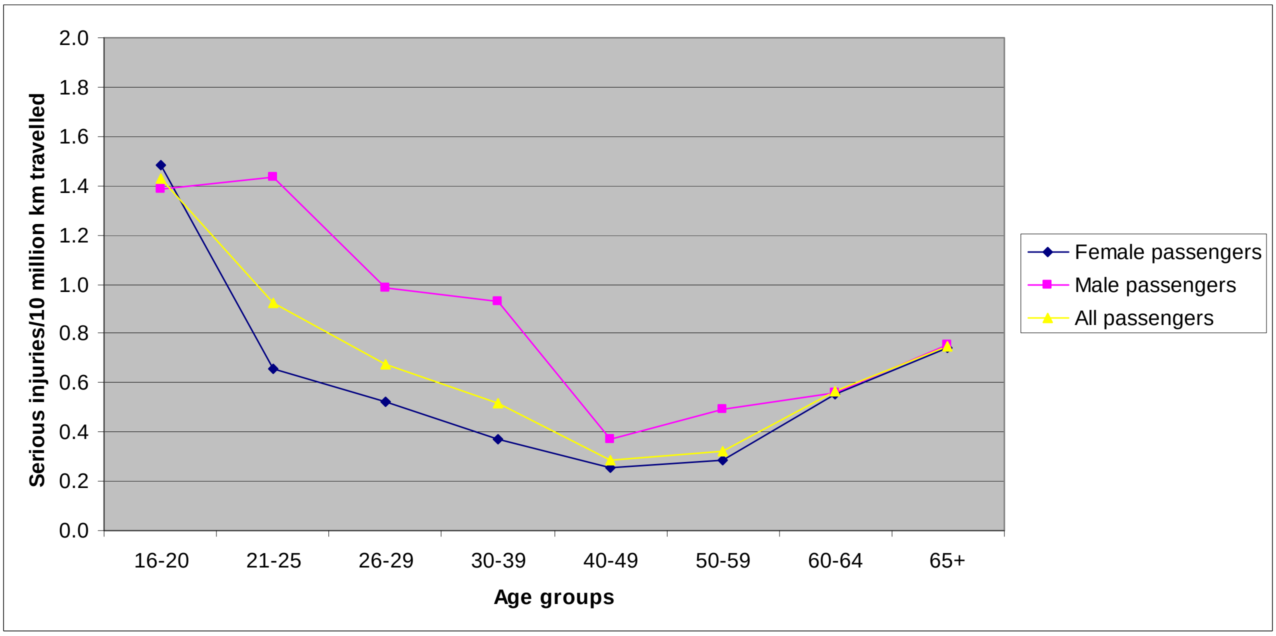

Figure 4.4: Car passenger serious injury rates (per 10 million km travelled) by age, Australia 2002 – 2006

4.1.3 Motorcyclists

Motorcyclist fatalities by kilometres travelled for Australia are shown in Table 4.5, and serious injury rates are shown in Table 4.6. The equivalent information is shown as graphs in Figure 4.5 and Figure 4.6 respectively.

As explained in Section 2.3 and Section 4.1.1, NSW injury data and Queensland fatality and injury data have been excluded from the tables and figures.

The NSW injury rate for motorcyclists is 132.39 per 10 million kilometres travel. This is the rate for all injuries, not just the serious injuries shown in Table 4.6.

For Queensland, the overall fatality rate for motorcyclists is 0.88 per 10 million kilometres travel, and the serious injury rate is 12.67 per 10 million kilometres travel. Both of these are considerably lower than the rates for all motorcyclists shown in Table 4.5 and Table 4.6.

The two outstanding features of the motorcyclist fatality and serious injury rates are:

- a pronounced spike in the rates for women riders, focussed on the 30 – 39 year olds for fatalities and the 26 – 29 and 30 – 39 year olds for serious injuries
- higher fatality and serious injury rates for male riders aged between 40 and 64.

Table 4.5: Motorcyclist fatality rates (per 10 million km travelled) by age, Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	<1	3	3	<1	1	2	4.07	0.41	0.53
16 – 20	1	16	17	<1	12	12	0.27	0.75	0.73
21 – 25	2	21	22	1	23	24	0.81	1.09	1.07
26 – 29	<1	13	13	<1	19	19	7.03	1.50	1.52
30 – 39	<1	27	27	2	30	32	12.86	1.12	1.20
40 – 49	1	6	7	2	23	25	2.47	4.02	3.83
50 – 59	1	5	6	1	12	13	1.83	2.28	2.24
60 – 64	<1	<1	<1	1	3	3	6.99	30.99	18.85
65+	<1	2	2	<1	3	3	0.00	1.89	2.00
Total	4	92	96	8	126	134	2.06	1.37	1.39

Table 4.6: Motorcyclist serious injury rates (per 10 million km travelled), Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	<1	2	2	2	12	14	17.62	5.10	5.62
16 – 20	<1	9	9	12	98	111	28.45	11.48	12.30
21 – 25	1	15	16	17	167	184	21.72	11.15	11.67
26 – 29	<1	9	10	16	117	132	1,004.57	12.35	14.00
30 – 39	<1	13	13	29	292	321	164.10	22.74	24.67
40 – 49	1	5	5	28	220	248	32.82	48.83	46.31
50 – 59	<1	4	4	12	109	121	34.27	29.35	29.79
60 – 64	<1	<1	<1	2	17	19	26.87	190.29	107.62
65+	<1	1	1	1	18	20	0.00	14.70	15.66
Total	3	58	61	120	1,051	1,171	42.84	18.22	19.36

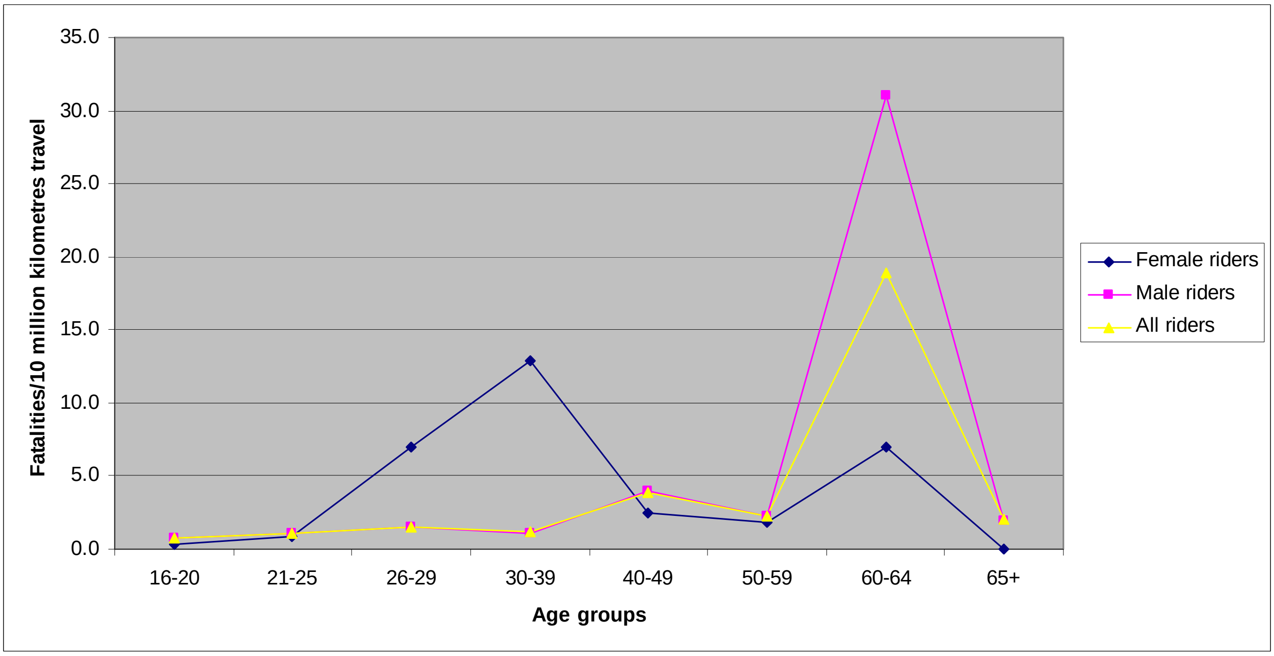

Figure 4.5: Motorcyclist fatality rates (per 10 million km travelled) by age, Australia 2002 – 2006

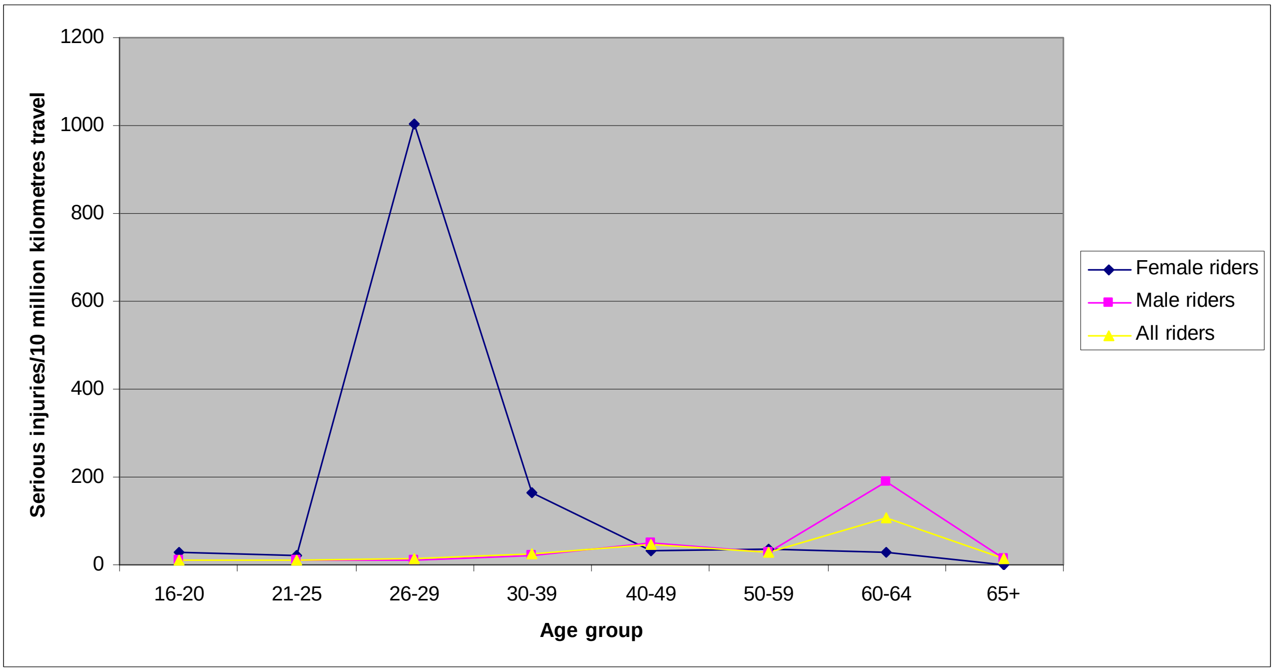

Figure 4.6: Motorcyclist serious injury rates (per 10 million km travelled), Australia 2002 – 2006

4.1.4 Bicyclists

Bicyclist fatalities by kilometres travelled for Australia are shown in Table 4.7, and serious injury rates are shown in Table 4.8. The equivalent information is shown as graphs in Figure 4.7 and Figure 4.8 respectively.

As explained in Section 2.3 and Section 4.1.1, NSW injury data and Queensland fatality and injury data have been excluded from the tables and figures.

The NSW injury rate for bicyclists is 29.8 per 10 million kilometres travel. This is the rate for all injuries, not just the serious injuries shown in Table 4.8.

For Queensland, the overall fatality rate for bicyclists is 0.16 per 10 million kilometres travel, and the serious injury rate is 5.50 per 10 million kilometres travel. The fatality rate is lower and the serious injury rate higher than the rates for all bicyclists shown in Table 4.7 and Table 4.8.

The features of the bicyclist rates are the very low fatality and serious injury rates for the youngest age group and the high fatality and serious injury rates for the oldest group of men. There is also a pronounced spike in serious injuries for 26 – 29 year old women. However, as both travel estimates and numbers of fatalities are low; these may not be reliable indications of the overall underlying pattern.

Table 4.7: Bicyclist fatality rates (per 10 million km travelled), Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	11	31	42	1	2	3	0.07	0.08	0.08
16 – 20	6	23	30	0	1	1	0.03	0.04	0.04
21 – 25	5	6	12	<1	2	2	0.00	0.25	0.14
26 – 29	1	4	6	1	1	2	0.49	0.32	0.36
30 – 39	2	10	13	<1	4	5	0.17	0.43	0.38
40 – 49	2	7	9	<1	4	5	0.19	0.63	0.53
50 – 59	2	5	7	1	3	3	0.48	0.52	0.51
60 – 64	<1	4	4	0	1	1	0.00	0.22	0.20
65+	1	2	3	0	2	2	0.00	1.56	0.93
Total	31	93	124	3	21	24	0.10	0.23	0.20

Table 4.8: Bicyclist serious injury rates (per 10 million km travelled), Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	8	22	30	9	57	65	1.05	2.60	2.18
16 – 20	4	16	20	5	24	29	1.20	1.54	1.48
21 – 25	3	5	8	14	33	48	5.76	6.53	6.27
26 – 29	1	3	4	16	36	53	22.25	11.56	13.56
30 – 39	1	8	10	3	84	87	2.14	10.29	9.16
40 – 49	2	6	8	12	67	79	5.57	11.89	10.13
50 – 59	1	4	6	7	42	49	5.21	10.27	9.02
60 – 64	<1	3	3	<1	11	11	4.85	3.94	3.96
65+	1	1	1	1	19	20	0.88	29.18	14.78
Total	21	67	88	67	373	440	3.20	5.56	5.00

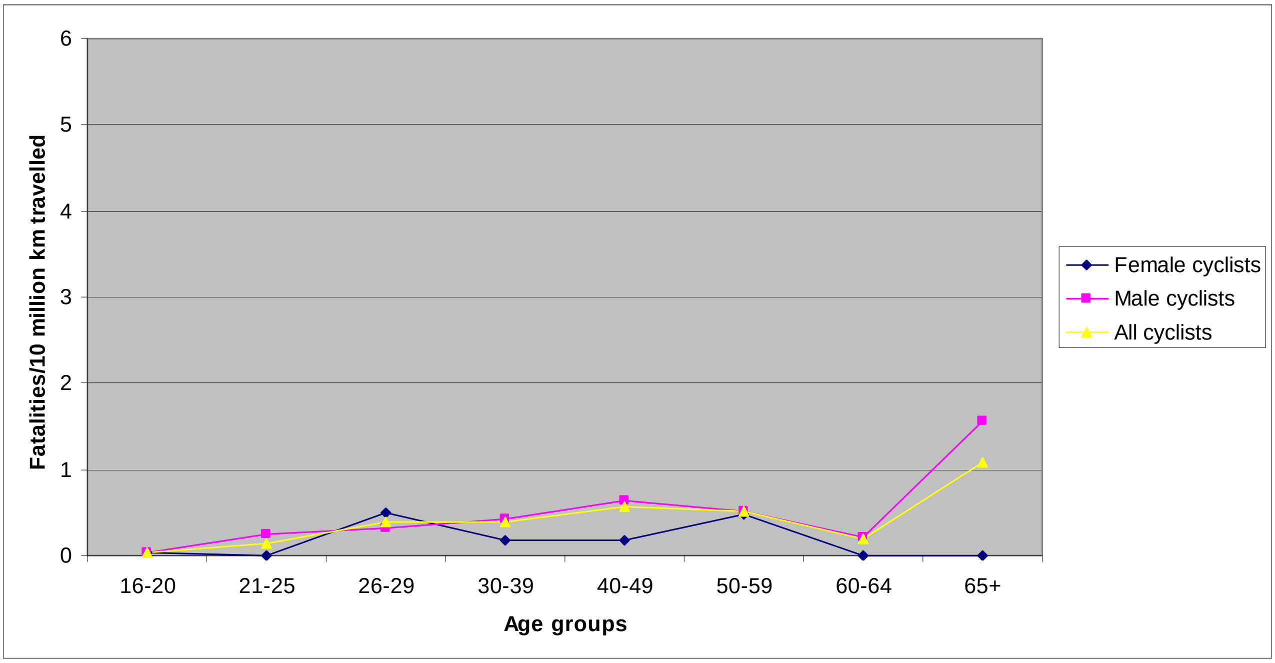

Figure 4.7: Bicyclist fatality rates (per 10 million km travelled), Australia 2002 – 2006

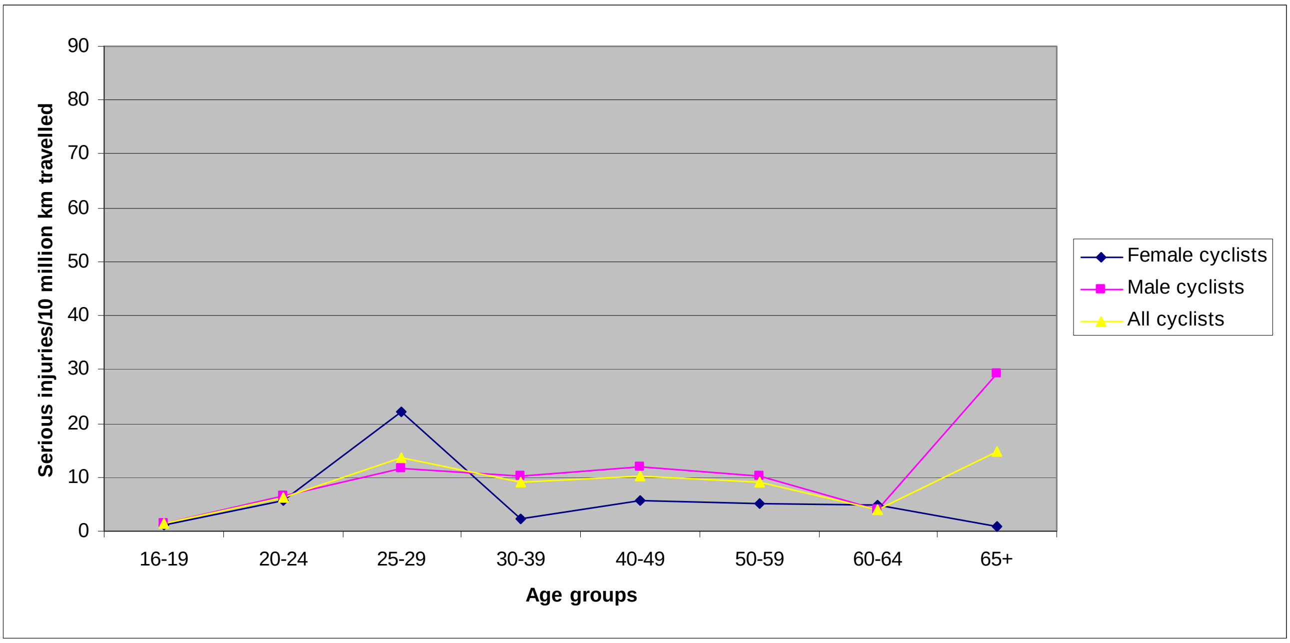

Figure 4.8: Bicyclist serious injury rates (per 10 million km travelled), Australia 2002 – 2006

4.1.5 Pedestrians

Pedestrian fatalities by kilometres travelled for Australia are shown in Table 4.9, and serious injury rates are shown in Table 4.10. The equivalent information is shown as graphs in Figure 4.9 and Figure 4.10 respectively.

As explained in Section 2.3 and Section 4.1.1, NSW injury data and Queensland fatality and injury data have been excluded from the tables and figures.

The NSW injury rate for pedestrians is 17.41 per 10 million kilometres travel. This is the rate for all injuries, not just the serious injuries shown in Table 4.10.

For Queensland, the overall fatality rate for pedestrians is 0.50 per 10 million kilometres travel, and the serious injury rate is 5.00 per 10 million kilometres travel. These rates are slightly less than the rates for all pedestrians in Table 4.9 and Table 4.10. The pedestrian fatality rates are characterised by low rates for male and female pedestrians aged 20 years or less, and high rates for male and female pedestrians aged 65 and over. For the age groups in between, the fatality rate for male pedestrians is higher than for female pedestrians. Serious injury rates for male pedestrians are highest for the 21 – 25 year old group, and decline with age until 65 and over. Serious injury rates for female pedestrians are highest for the 26 – 29 year old group, then also decline with age until 65 and over.

Table 4.9: Pedestrian fatality rates by age (per 10 million km travelled), Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	24	27	51	2	3	5	0.10	0.11	0.11
16 – 20	17	16	32	5	7	12	0.29	0.45	0.37
21 – 25	13	9	22	3	7	10	0.22	0.87	0.48
26 – 29	8	7	15	3	7	10	0.40	0.98	0.68
30 – 39	18	19	37	9	18	27	0.47	0.98	0.73
40 – 49	17	18	34	6	16	22	0.33	0.93	0.64
50 – 59	19	13	32	3	11	14	0.17	0.79	0.43
60 – 64	6	7	13	3	5	8	0.45	0.76	0.62
65+	15	19	34	27	31	59	1.82	1.70	1.75
Total	138	133	271	61	107	168	0.44	0.80	0.62

Table 4.10: Pedestrian serious injury rate (per 10 million km travelled) by age, Australia 2002 – 2006

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	13	12	25	40	57	97	3.00	4.86	3.87
16 – 20	11	10	20	47	61	108	4.36	6.45	5.34
21 – 25	9	4	13	41	66	107	4.66	15.76	8.24
26 – 29	5	4	9	34	55	89	7.25	12.87	9.93
30 – 39	11	9	20	48	88	136	4.35	9.93	6.85
40 – 49	10	9	20	42	63	105	3.98	6.81	5.31
50 – 59	12	7	19	38	39	77	3.20	5.46	4.05
60 – 64	4	4	8	15	18	33	4.14	4.23	4.19
65+	8	11	18	98	75	173	12.76	7.00	9.41
Total	82	70	152	403	524	926	4.90	7.47	6.08

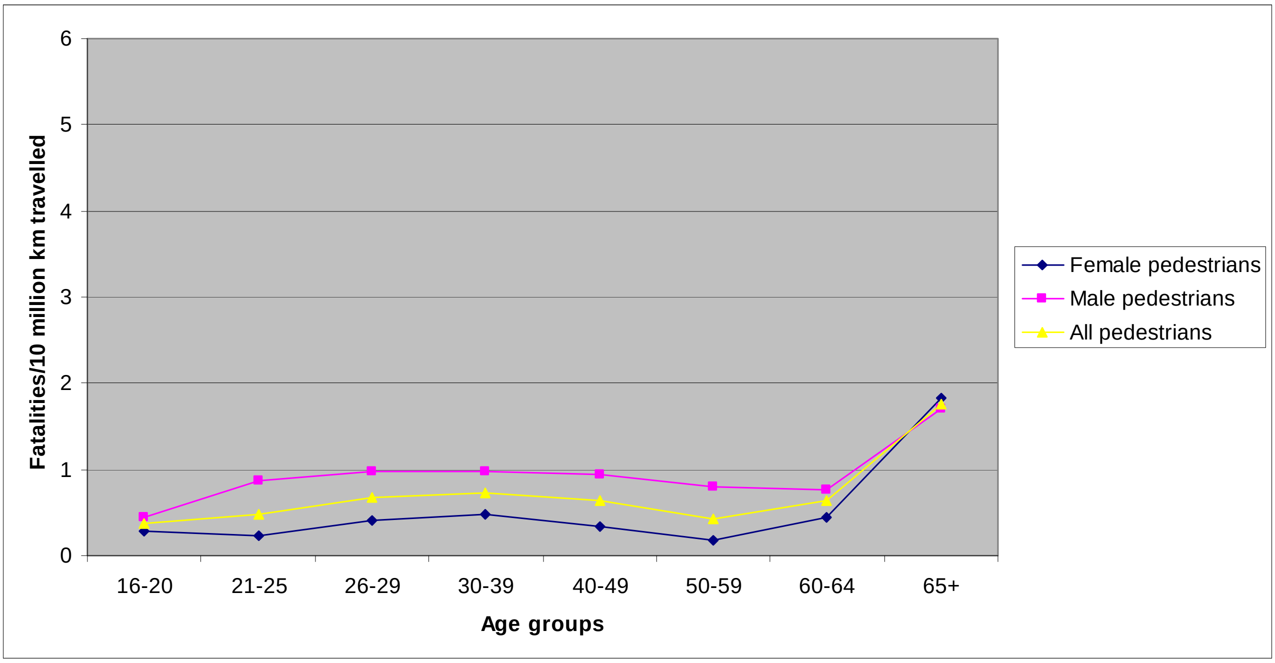

Figure 4.9: Pedestrian fatality rates (per 10 million km travelled), Australia 2002 – 2006

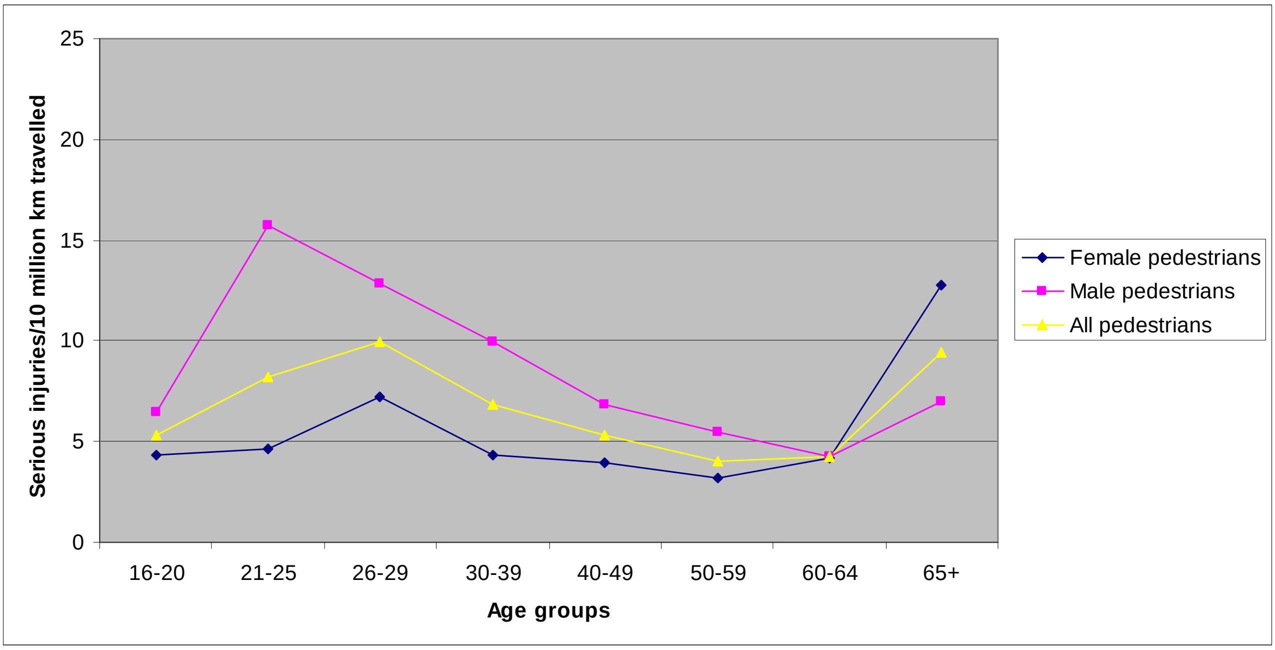

Figure 4.10: Pedestrian serious injury rates (per 10 million km travelled), Australia 2002 – 2006

4.2 Fatalities and Serious Injuries by Time of Day

Fatality and serious injury rates by time of day are presented in Section 4.2.1 to Section 4.2.5. In order to keep the report to a manageable size, the results have not been broken down by age, nor are they presented in graphical form as was the case with the analysis by kilometres travel in Section 4.1.

4.2.1 Car Drivers

Table 4.11: Driver fatality and serious injury rates (per 10 million km) by time of day, Australia 2002 – 2006

Time of travel	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
22:00 – 02:00	0.13	0.37	0.30	4.09
02:00 – 06:00	0.33	0.38	0.37	4.44
06:00 – 10:00	0.03	0.03	0.03	0.70
10:00 – 14:00	0.04	0.04	0.04	0.76
14:00 – 18:00	0.03	0.04	0.04	0.85
18:00 – 22:00	0.06	0.08	0.08	1.32

Fatality and serious injury rates are both higher at night, especially during the period 22:00 – 06:00. At their highest, fatality rates are approximately ten times as high as during the day, and serious injury rates approximately five times as high.

4.2.2 Car Passengers

Table 4.12: Passenger fatality and serious injury rates (per 10 million km) by time of day, Australia 2002 – 2006

Time of travel	Annual fatality rate			Annual serious injury rate
	Female	Female	Total	
22:00 – 02:00	0.17	0.46	0.27	3.23
02:00 – 06:00	0.17	0.55	0.33	3.60
06:00 – 10:00	0.02	0.03	0.02	0.32
10:00 – 14:00	0.03	0.04	0.03	0.41
14:00 – 18:00	0.03	0.05	0.03	0.52
18:00 – 22:00	0.03	0.08	0.05	0.77

The pattern is similar for car passengers, with a much higher fatality and injury rate at night. The pattern is even more extreme, with the fatality rates 10 to 15 times higher than they are during the day, and the serious injury rates are 8 to 10 times higher.

4.2.3 Motorcyclists

Table 4.13: Motorcyclist fatality and serious injury rates (per 10 million km) by time of day, Australia 2002 – 2006

Time of travel	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
22:00 – 02:00	–	4.33	3.66	36.34
02:00 – 06:00	–	4.69	3.29	28.84
06:00 – 10:00	1.48	0.96	0.92	11.09
10:00 – 14:00	1.70	2.77	2.47	44.18
14:00 – 18:00	4.27	1.99	1.92	28.76
18:00 – 22:00	0.89	2.87	2.59	33.67

Motorcyclists also have higher fatality rates and casualty rates at night, and these rates are higher than for car drivers or passengers. However, the difference between night time and daytime fatality and injury rates is less for motorcyclists than for car drivers or passengers. The fatality rate between 22:00 and 06:00 is approximately 8 to 9 times higher than the lowest daytime rate, while the serious injury rate is approximately 2.5 to 3 times higher. Note also that the highest injury rate occurs during the 10:00 – 14:00 period.

4.2.4 Bicyclists

Table 4.14: Bicyclist fatality and serious injury rates (per 10 million km) by time of day, Australia 2002 – 2006

Time of travel	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
22:00 – 02:00	–	0.72	0.29	10.44
02:00 – 06:00	1.50	0.67	0.39	2.57
06:00 – 10:00	0.14	0.22	0.20	7.36
10:00 – 14:00	0.18	0.32	0.24	6.97
14:00 – 18:00	0.14	0.18	0.16	6.06
18:00 – 22:00	0.13	0.41	0.33	13.72

Bicyclists show much less variation in fatality and serious injury rates across the day than do the other road users considered above. The lowest fatality rate is between 14:00 and 18:00; the highest fatality rate (02:00 – 06:00) is approximately 2.5 times the lowest rate and approximately double the fatality rate for the 06:00 – 10:00 period. The lowest serious injury rate is in the 02:00 – 06:00 period; the highest rates (in the 18:00 – 22:00 and 22:00 – 02:00 periods) are 4 to 5 times greater.

4.2.5 Pedestrians

Table 4.15: Pedestrian fatality and serious injury rates (per 10 million km) by time of day, Australia 2002 – 2006

Time of travel	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
22:00 – 02:00	16.55	9.67	8.94	61.48
02:00 – 06:00	7.87	10.14	4.27	17.59
06:00 – 10:00	0.34	0.34	0.34	3.40
10:00 – 14:00	0.22	0.37	0.28	3.69
14:00 – 18:00	0.37	0.50	0.37	4.68
18:00 – 22:00	1.63	1.94	1.78	13.65

The fatality and serious injury rates for pedestrians show the most extreme fluctuations across the day of all road users. The fatality rate in the 22:00 – 02:00 period is approximately 30 times higher than it is during the lowest periods of the day, and the serious injury rate is approximately 18 times greater.

4.3 Fatalities and Serious Injuries by Day of Week

4.3.1 Car Drivers

Fatality rates among car drivers vary little across the week, but serious injury rates tend to be higher in the period Thursday – Sunday.

Table 4.16: Car driver fatality and serious injury rates (per 10 million km) by day of week, Australia 2002 – 2006

Day of week	Annual fatality rate			Annual fatality rate
	Female	Male	Total	
Monday	0.04	0.05	0.05	0.93
Tuesday	0.04	0.05	0.04	0.88
Wednesday	0.04	0.04	0.04	0.86
Thursday	0.03	0.06	0.05	1.01
Friday	0.04	0.06	0.05	0.93
Saturday	0.07	0.07	0.07	1.10
Sunday	0.07	0.07	0.07	1.22

4.3.2 Car Passengers

Fatality rates for car passengers peak for males on Friday, and are low for females on both Saturday and Sunday. Serious injuries peak in the middle of the week, and are lowest on Saturday and Sunday.

Table 4.17: Car passenger fatality and serious injury rates (per 10 million km) by day of week, Australia 2002 – 2006

Day of week	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
Monday	0.04	0.04	0.04	0.62
Tuesday	0.07	0.06	0.06	0.89
Wednesday	0.08	0.10	0.08	1.09
Thursday	0.04	0.07	0.05	0.68
Friday	0.04	0.12	0.06	0.71
Saturday	0.02	0.07	0.04	0.51
Sunday	0.01	0.05	0.02	0.30

4.3.3 Motorcyclists

Fatalities and serious injuries peak at the weekend, especially on Saturday where the rates are many times higher than they are during the week. The rates on Sunday are also considerably higher than they are during the week.

Table 4.18: Motorcyclist fatality and serious injury rates (per 10 million km) by day of week, Australia 2002 – 2006

Day of week	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
Monday	5.29	1.37	1.23	20.40
Tuesday	0.12	0.91	0.74	14.23
Wednesday	3.16	1.44	1.38	18.06
Thursday	4.82	1.78	1.75	25.31
Friday	3.85	1.17	1.14	14.34
Saturday	2.12	10.30	7.49	105.63
Sunday	42.39	5.03	4.73	58.23

4.3.4 Bicyclists

Fatality rates and serious injury rates for both males and females are higher on weekends and on Fridays than they are for the rest of the week.

Table 4.19: Bicyclist fatality and serious injury rates (per 10 million km) by day of week, Australia 2002 – 2006

Day of week	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
Monday	0.07	0.23	0.16	4.99
Tuesday	0.07	0.20	0.16	6.02
Wednesday	0.05	0.18	0.13	6.89
Thursday	0.07	0.13	0.12	7.88
Friday	0.17	0.43	0.32	8.12
Saturday	0.87	0.34	0.41	11.79
Sunday	0.25	0.40	0.38	9.55

4.3.5 Pedestrians

Fatality rates and serious injury rates for pedestrians tend to be highest on Saturday and Sunday, especially on Saturday, than they are for the rest of the week. Note that males, but not females, also have higher fatality rates and serious injury rates on Fridays, although the rates are lower than the rates at the weekend.

Table 4.20: Pedestrian fatality and serious injury rates (per 10 million km) by day of week, Australia 2002 – 2006

Day of week	Annual fatality rate			Annual serious injury rate
	Female	Male	Total	
Monday	0.34	0.56	0.42	4.45
Tuesday	0.33	0.54	0.43	4.29
Wednesday	0.41	0.65	0.49	3.85
Thursday	0.41	0.53	0.45	4.49
Friday	0.40	1.05	0.65	6.25
Saturday	1.02	2.28	1.67	13.18
Sunday	0.92	1.09	0.98	10.22

5 FATALITIES AND SERIOUS INJURIES PER TIME TRAVELLING

Driver fatality and serious injury rates per million hours travelled are listed in Table 5.1 and Table 5.2 respectively, and shown in graphic form in Figure 5.1 and Figure 5.2. The patterns of results are similar to those found for 10 million km travel, the most salient features being:

- higher fatality and injury rates for the youngest and oldest age groups
- compared to males, females have lower fatality rates for younger people and higher fatality rates for older people, although the effect is small
- higher serious injury rates for females than for males, especially in the older age groups.

Further analysis in terms of travelling time has not been pursued as the patterns appear to be generally similar to those for kilometres travelled, and it is the latter measure which is particularly useful for the policy analysis presented later in the paper. Further results in terms of time spent travelling would complicate an already complex picture without necessarily adding further useful insights.

Table 5.1: Driver fatalities per million hours travelled by age, Australia 2002 – 2006

	Travelling time 2006 (million hours travel)			Fatalities (annual average)			Fatalities per million hours travel		
Age groups	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	2	1	3	1	3	3	0.38	2.11	1.14
16 – 20	50	88	138	18	68	86	0.37	0.77	0.62
21 – 25	96	179	274	17	65	82	0.18	0.36	0.30
26 – 29	82	154	235	8	39	47	0.10	0.26	0.20
30 – 39	270	421	691	22	78	100	0.08	0.19	0.14
40 – 49	225	432	657	21	54	75	0.09	0.13	0.11
50 – 59	128	334	463	19	45	64	0.15	0.13	0.14
60 – 64	34	113	146	7	15	22	0.21	0.13	0.15
65+	56	162	218	26	67	92	0.46	0.41	0.42
Total	942	1,883	2,825	139	434	572	0.15	0.23	0.20

Table 5.2: Driver serious injury rate (per million hours travelled) by age, Australia 2002 – 2006

	Travelling time 2006 (million hours travel)			Serious injuries (annual average)			Serious injuries per million hours travel		
Age groups	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0.9	1	2	7	29	36	7.23	24.92	17.04
16 – 20	33	54	87	424	592	1,016	12.81	10.95	11.66
21 – 25	62	107	169	386	601	988	6.20	5.62	5.83
26 – 29	48	91	139	228	348	576	4.72	3.82	4.13
30 – 39	158	244	401	490	688	1,178	3.11	2.82	2.94
40 – 49	137	239	376	429	500	929	3.13	2.09	2.47
50 – 59	82	192	273	329	336	665	4.03	1.75	2.43
60 – 64	20	62	81	94	129	223	4.76	2.10	2.74
65+	33	91	123,	269	374	643	8.20	4.13	5.21
Total	574	1,080	1,654	2,657	3,606	6,264	4.63	3.34	3.79

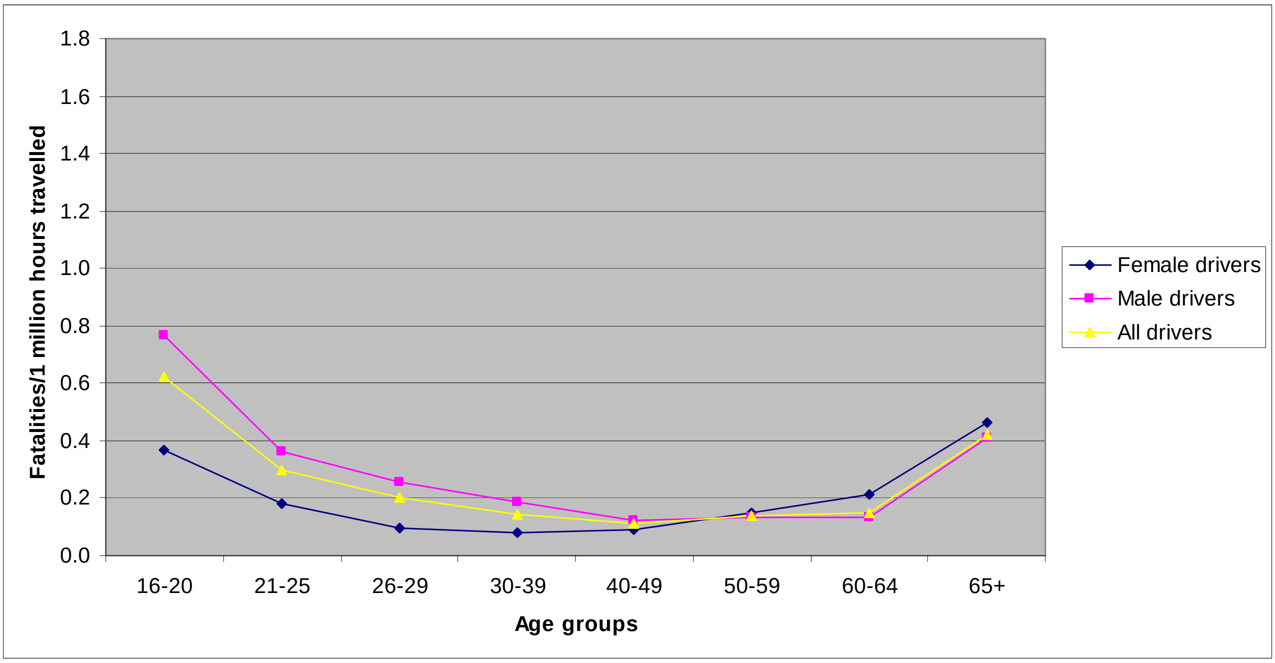

Figure 5.1: Driver fatality rate (per million hours travelled) by age, Australia 2002 – 2006

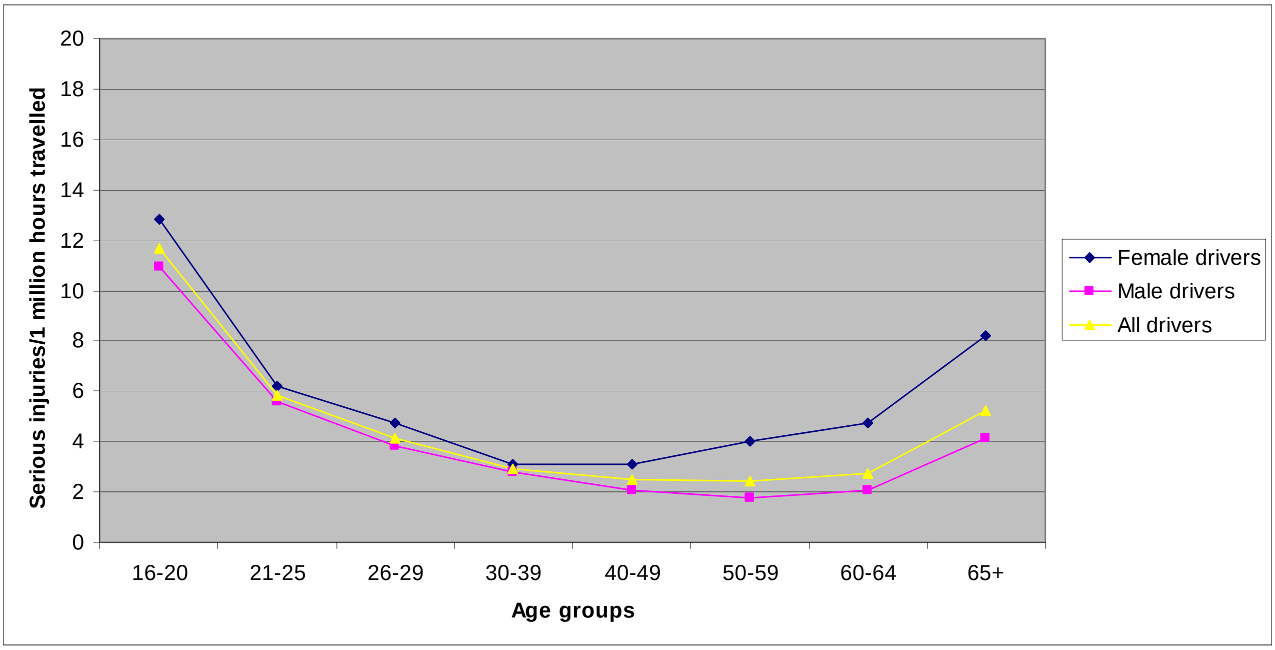

Figure 5.2: Driver serious injury rate (per million hours travelled) by age, Australia 2002 – 2006

6 SUMMARY OF EXPOSURE ESTIMATES

6.1 Accuracy of the Travel Estimates

The fatality and serious injury rates for car drivers and motorcyclists were calculated by dividing the fatalities and serious injuries derived from the road authority data bases by the amount of travel by these modes recorded in the SMVU. The overall fatality and serious injury rates are therefore as accurate as it is possible to be with the available data sources. However, the relative rates for men and women road users, although adjusted by current population data, depend on the assumption that the relative amount of travel undertaken by men and women is the same as it was in 1984. The same applies to breakdowns by road user age.

There are no population adjustments for time of travel or day of travel, so these estimates are even more dependent on the assumption of similar relative amounts of travel at different times and on different days.

Car passenger travel estimates are more dependent on the assumptions of continuity than are the driver and motorcyclist estimates as there is no contemporary estimate of travel as a car passenger from the SMVU. In this case, travel estimates for the 1984 survey were updated by the ratio of the average travel per vehicle per person in 2006 to the average travel per vehicle per person in 1984.

Non-motorised modes do not feature in the SMVU, so estimates for bicyclists and pedestrians have been updated by the population statistics, separately for both genders and each age group. Using this method, the overall amount of travel may be underestimated. For example, bicycle trips into the Melbourne CBD appear to have increased by between 5% and 18% (A. Curnow, email 21/08/2009). If trends of this order are occurring at a number of other locations, are not offset by declines in bicycle use for other sorts of trip, and have been happening over a few years, then the amount of bicycle travel could be underestimated and the casualty and serious injury rates for bicyclists lower than estimated in this project. The same email indicated that walking trips into the CBD increased by 4% between 1996 and 2006. If these changes are reflected elsewhere, then the amount of walking could be similarly underestimated.

6.2 Comparison of Rates for Different Modes, 1984 and 2006

The fatality rates by kilometres travelled for the different travel modes estimated in Section 4 are compared with the fatality rates estimated in the Intstat report (Anderson et al. 1989a). The rates for males and females are taken directly from the report. The combined rate was calculated by multiplying the rate for each gender by the proportion of persons of that gender in the Australian population in 1984 and adding the two results (Table 6.1).

Table 6.1: Fatality and serious injury rate (per 10 million km) by travel mode, 1984 and 2006

Mode	Fatalities per 10 million km travel						All serious injuries per 10 million km travel, 2006
	Female 1984	Female 2006	Male 1984	Male 2006	All 1984	All 2006	
Driver	0.10	0.04	0.15	0.05	0.13	0.05	0.84
Car passenger	0.09	0.03	0.17	0.07	0.13	0.04	0.59
Motorcyclist	1.91	2.06	2.85	1.37	2.38	1.39	19.36
Bicyclist	0.27	0.10	0.56	0.23	0.41	0.20	5.00
Pedestrian	1.26	0.44	2.36	0.80	1.81	0.62	6.08

All modes show a decline in fatality rates for 2006 compared to 1984. In most cases, the 2006 rate is between one half and one quarter of the 1984 rate. This is consistent with the large reductions in persons killed in road crashes over the period. The one exception is motorcycling, where the rate has been reduced by approximately 42%.

There are aspects of the way in which these rates were estimated that indicate caution in their interpretation and use. The safety of bicycling appears to have improved dramatically. However, there is some evidence to suggest that the nature of cycling and the persons who engage in it has changed quite markedly in recent years. There has been considerable growth in the number of commuting cyclists and, anecdotally at least, a reduction in the number of teenagers who cycle to school or for recreational purposes. The specific impact of these changes is not clear at this stage.

Table 6.2: Ratio of serious injury rates to fatality rates for different travel modes, 2006

Mode	Ratio of serious injury rate to fatality rate
Driver	16.8
Passenger	14.8
Motorcyclist	13.9
Bicyclist	25.0
Pedestrian	9.8

In Table 6.2, bicyclists stand out as having a high ratio of serious injuries to fatalities compared to other road users. This is possibly because many bicycle collisions involve collisions with motor vehicles at relatively low speeds, often as vehicles make turns in front of cyclists, so that a high proportion of crashes result in serious injury. Pedestrians, on the other hand, have a lower ratio of serious injuries to fatalities compared with other road users. Two factors seem likely to be implicated. Some pedestrian collisions involve collisions with vehicles at high speeds, which have a high probability of being fatal. Many pedestrian fatalities involve collisions with elderly persons who are less able to recover from injury; many others involve collisions with intoxicated persons whose capacity to recover may be impaired by high alcohol levels or poor general health.

7 INCREASED TRAVEL BY VULNERABLE ROAD USERS

7.1 Frequency of Cycling and Walking and Fatality and Injury Rates

The critical issue for understanding the safety implications of changing modes is the extent to which increasing the numbers travelling by a particular mode affects the safety of travel by that mode. A seminal piece of research by Jacobsen (2003) clearly shows that, for pedestrians and cyclists, the fatality rate is inversely related to the amount of travel by that mode. The data is demonstrated with fatalities associated with walking and cycling data in Californian cities, injuries associated with cycling in Denmark, and walking and cycling fatalities across European countries. All the data sets show diminishing rates of fatal and serious injury with increasing levels of walking or cycling.

Jacobsen also reinforces this picture with historical data from the Netherlands, which clearly shows a decreasing fatality rate with increasing bicycle travel, although with some erratic departures from a steady trend. He also cites historical data from the UK. There is clear evidence of increasing fatality rates as the amount of cycling declined from 1952 to 1973. After that, cycling appears to have fluctuated within a fairly narrow range and the relationship to the fatality rate is not obvious. This was a period of decreasing road casualties for a number of reasons. Despite this, the overall pattern of the relationship is clear and supported by a number of data sets.

Comparing the results from the different studies, Jacobsen suggests a relationship of the form

$$I = aE^b,$$

where I is the injury measure, E the amount of travel by the mode in question, and a and b are empirically derived. Many of the studies reviewed have a value of b close to 0.4. This means that for less vulnerable modes, the increase in traffic injuries will be much less than the increase in travel by a particular mode.

Jacobsen favours an explanation in terms of ‘safety in numbers’. He argues that increased numbers of pedestrians or cyclists are likely to result in changes to driver behaviour, for example by driving more slowly or scanning more carefully for the presence of vulnerable road users. Although Jacobsen does not mention it, there is strong theoretical support for this view from experimental psychology, which has accumulated a large body of evidence to show that people recognise and respond faster to frequent events than to infrequent ones.

There are a number of other studies which lend further support to the relationship identified by Jacobsen. Vandenbulcke et al. (2009) compared the 589 municipalities of Belgium (called ‘communes’ in the article) and found a similar pattern of results for bicyclists. The authors identified clusters based upon the proportion of commuting cyclists and the risk of a cyclist being injured.

Cyclists identified as having a low to moderate casualty risk rating tended to ride in areas where the use of bicycles for commuting was high, the infrastructure was set up for cycling and policies favoured cyclists. Vandenbulcke et al. also mentioned that many drivers in these areas were themselves cyclists. One cluster formed its own unique group as it had few cyclists, but also low levels of risk to cyclists. The authors felt that this unusual finding was due to the area’s high level of urbanisation and traffic being forced to slow down due to stopping at intersections and pedestrian crossings.

The final two groups were each comprised of two clusters. Both groups had low rates of cycling and a high risk of receiving an injury while cycling. The main difference between the two groups was the cycling environment. In one the terrain was hilly and had winding roads that were not conducive to cycling. In the other the environment was more urban, but the area acts as a commuting conduit for motorists working in Brussels, thus exposing the few cyclists to more motorised vehicles (Vandenbulcke et al. 2009).

While it is tempting to conclude that raising the number of pedestrians and cyclists will increase their level of safety, the Vandenbulcke et al. study shows that other factors can have an effect. The cluster with the lowest casualty risk rate was in an urban environment which proved to be a protective factor as intersections and pedestrian crossings slowed the traffic. The clusters with a low to moderate casualty risk were identified as having good cycling infrastructure and policies promoting cycling. Additionally high cycling rates mean that more drivers are also cyclists and are more aware of cyclists when driving a motor vehicle.

The finding of reduced crash rates with increasing numbers of road users was confirmed by a Danish study (Jensen 1998, cited in Danish Road Directorate 2000) which compared injury rates per million kilometres travel by bicycle and moped with the average kilometres travelled per day by these modes in 47 Danish towns. There was a very clear reduction in injury rates as the average amount of travel by bicycle and moped increased.

A compendium of concepts to improve cycling (Danish Road Directorate 2000) cites a study by a cycling organisation (Dansk Cyklist Forbund 2000) which found that in towns where cycling had increased, the reduction in the total number of crashes had been greater than in other towns. However, there is no information on the extent to which a greater investment in cycling facilities or traffic calming in general may have contributed to both the increased cycling and the greater crash reduction.

Elvik (2009), citing Jacobsen and a range of other authors as his empirical foundation, carried out modelling of hypothetical situations to explore the possible implications of the non-linear increase in casualties with increasing numbers. Elvik's model was of the form

$$\text{Number of crashes} = aQ_{MV}^{\ B1}Q_{PED}^{\ B2}$$

where Q_{MV} is the volume of motor vehicles and Q_{PED} is the volume of pedestrians, and B1, B2 are empirically determined exponents. The models take into account the number of motor vehicles as well as the numbers of pedestrians.

In the modelling, Elvik uses a range of situations involving different numbers of motor vehicles, pedestrians and bicyclists, under a number of different scenarios involving doubling pedestrian or bicyclist numbers, or transferring 25% or 50% of motorists to walking or bicycling. He also varies the exponents associated with all three modes.

The modelling shows that doubling the number of pedestrians or cyclists will result in small reductions in crashes where the number of pedestrians or bicyclists is large compared to the number of motor vehicles, and small increases when the number of pedestrians or cyclists is small in relation to motor vehicles. Only when motor vehicles are reduced by 25% or more are there consistent reductions in crashes. These results occurred when the exponents (B2, etc.) associated with increasing pedestrian and bicyclist numbers were smaller than the exponent associated with increasing motor vehicle numbers.

Elvik emphasises the exploratory nature of the analysis, and points out that the reductions in crashes with increasing numbers of pedestrians or bicyclists depends critically on the shape of the non-linearity (and hence the exponents which describe it). He also makes it clear that the nature of the non-linearities are not known with any certainty. Nevertheless, these findings demonstrate that a safety in numbers effect is theoretically possible.

It should be noted that Elvik does not directly address the issue of the relative contribution of behavioural change or infrastructure provision to the ‘safety in numbers’ effect. His modelling implies the effects are due to behaviour change; however, one way to interpret the different exponents in the models is to consider them as representing different types of infrastructure or traffic management regimes that deliver different safety outcomes.

7.2 Studies from Australia and New Zealand

More evidence is available closer to home. Bonham et al. (2006) undertook research in Adelaide that looked at whether there were effects of spatial scale (road, intersection, local government area (LGA)) on cyclist casualties. Cyclist count data was matched to crash records for the areas in 1999 and 2000 to 2004.

On roads into the Adelaide CBD Bonham et al. found the expected pattern of lower cyclist crash rates per trip between 2000 and 2004 when there were higher numbers of cyclists. For intersections, there was a positive correlation between cyclist numbers and casualty rates. However, after removing intersections where there had been no crashes involving cyclists from the analysis, the expected pattern occurred.

At the LGA level, increased cyclist numbers were associated with lower casualty rates, but the relationship was weaker than when analysed at the road and intersection level.

Bonham et al. (2006) concluded that research into cycling in residential areas needs to take place to identify the characteristics of different types of riders and the routes they choose. The authors suggest, for instance, that most children will cycle in residential areas and, as children are over-represented in the crash statistics, the relationship between cyclist numbers and crash rates will be atypical to the rest of the cycling population.

Robinson (2005) compared cycling casualty data from a number of Australian sources. Two points from this analysis are relevant to the present discussion. The first relevant comparison was of the fatality rates versus the amount of cycling in all Australian jurisdictions. There is a clear trend showing that fatality rate decreases as the amount of cycling increases. Robinson’s paper was one of the sources cited by Elvik in support of a non-linear relationship between increased cyclist numbers and crash rate.

The second relevant comparison showed that the number of regular bicycle riders (i.e. riders who cycle at least once per week) in Western Australia doubled between 1982 and 1989. At the same time, the rate of bicycle-related hospital admissions fell by 48% and the rate of bicycle-related deaths and serious injuries fell by 33% (per 10,000 km ridden by regular riders). This is almost exactly the percentage reduction predicted by Jacobsen’s equation discussed earlier.

In contrast to all of the above studies which are concerned with very broad comparisons, Turner, Roozenberg and Francis (2008) looked in detail at the relationship between pedestrian and cyclist numbers and crash rates at a number of sites in Christchurch, New Zealand. The sites included signalised intersections, roundabouts, and mid-block sites. Crash data from individual sites was matched with manual motor traffic, pedestrian and cyclist counts. Accident prediction models (APMs) were developed using generalised linear techniques. The APMs show decreasing crash rates with increasing traffic, pedestrian and cyclist numbers. It should be noted that different APMs are required for the three site categories identified, reflecting the complexity of the issues.

The APMs were applied to a number of modal shift scenarios, e.g. a 300% increase in cycling, with a commensurate reduction in car use. The results indicated a reduction in bicyclist crash rates of 'nearly 70%' (p.129) at signalised intersections. Judging from the figure they provide, the reduction at roundabouts for the same shift from driving to bicycling, the expected reduction in crash rates would be 63%. Although this is detailed work, arriving at these estimates does involve extrapolating well beyond the range of the available data. It should also be noted that crashes involving motor vehicles show very little change. Because bicycles are such a small part of the traffic stream, the change in overall crashes is also very small.

It is interesting that Turner et al.'s modelling, which is an extrapolation of findings based on real traffic situations, produces outcomes broadly similar to Elvik's theoretical analysis. However, the effects claimed are considerably greater than those estimated by Elvik. This reinforces Elvik's conclusions relating to the sensitivity of the analysis to the relative size of the exponents associated with the numbers/crash relationship for each mode.

7.3 'Safety in Numbers' and Safe System Principles

Thus there is a large body of evidence showing that as numbers of pedestrians or cyclists increase, crash rates for these road users decrease. Jacobsen's preferred explanation of this phenomenon is in terms of the 'safety in numbers' effect, i.e. that driver behaviour changes in response to increased numbers of pedestrians or cyclists in terms of reduced speed and increased readiness to deal with pedestrian or cyclist conflicts. Jacobsen prefers this explanation over reasons such as social change, road design changes or law change because the change is a rapid reaction to fluctuations in cycling rates whereas these other factors would take time for their effects to be felt.

Although the studies cited are consistent in showing reducing crash or injury rates with increasing bicycle travel, they all suffer from the limitation of being correlation studies. A correlation shows that there is a consistent relationship, but should not be taken on its own to imply a causal relationship between variables. A possible interpretation is that towns or parts of cities which have suitable road systems (e.g. cycle lanes or at least adequate road space for cyclists and good sight distances) are relatively safe environments for cyclists, and tend to attract more cycling. This is a different causal relationship to that suggested by Jacobsen and Vanderbulke et al. who maintain that increased numbers of cyclists result in a change in driver behaviour which leads to fewer crashes with cyclists.

In a paper with a title which begins, 'Making Cycling Irresistible', leaving no doubt about its polemic intent, Pucher and Buchler (2008) review the safety of cycling in countries which have successful policies to encourage cycling (the Netherlands, Denmark and Germany), and contrast them with the low levels of cycling and poorer safety outcomes in countries such as the USA and the UK.

They emphasise the importance of making cycling safe and convenient to encourage cycling, particularly the provision of separated cycle facilities along major routes and at major intersections, and traffic calming of residential neighbourhoods. These initiatives are complemented by ample bicycle parking facilities and well integrated with public transport. In addition there is training for both cyclists and motorists, promotional events to encourage cycling, taxes and restrictions on car ownership and use, and strict land use policies to encourage an urban structure which is conducive to bicycle travel.

Pucher and Buchler take the position that suitable physical infrastructure (and supporting policy) has to be created in order to provide opportunities for safe and convenient bicycle travel. Once that starts to happen, then cycling can be expected to increase, and to have relatively good safety outcomes.

It is of course quite possible that the ‘safety in numbers’ effect is real, and that drivers do change their driving behaviours and traffic monitoring strategies to take better account of cyclists and pedestrians in response to encountering them more frequently. However, the evidence supporting the proposition is open to other interpretations. If it is true, the question becomes how much has the ‘safety in numbers’ effect contributed to better outcomes, and how much has improved infrastructure and policy initiatives?

In the meantime, in the absence of more definitive evidence on the issue, it would be unwise to assume that a greater number of pedestrians or cyclists on its own would be likely to reduce crash rates for these road users.

One further observation in relation to the ‘safety in numbers’ effect needs to be made, and that is that it does not sit comfortably alongside Safe System principles. Safe System has been adopted as a guiding principle by all Australian road authorities. Safe System principles recognise that, despite road and law enforcement authorities’ and road users’ best efforts, collisions will still occur, but through a combination of infrastructure and vehicle design and speed management, no road user should be subject to impact forces so severe that they are killed or sustain injuries from which they cannot fully recover. While ‘safety in numbers’ in its literal form would predict safer travel for pedestrians and cyclists in proportion to their numbers, it involves increasing the numbers of unprotected road users without doing anything to protect them from lethal or disabling impacts in collisions, other than relying on an assumption that driver behaviour will change in response. Coordinated policy and infrastructure initiatives along the lines suggested by Pucher and Buchler are consistent with Safe System principles. However, like many of the other initiatives suggested by Safe System, they are likely to require substantial investment and to take time to implement.

8 SCENARIOS FOR CHANGES IN CRASH OUTCOMES

In order to demonstrate how the crash rate estimates developed in the report can be applied to projections of future changes in travel patterns, a number of scenarios were developed by the project team. This list was then circulated amongst an expert panel from Austroads members who suggested further scenarios for investigation. Due to limitations of the data set, not all of these suggestions could be addressed, or were addressed in a different manner to the main group of scenarios (Section 8.6 and Section 8.7).

The focus of the scenarios are the high-risk modes and high-risk times of travel, changes to which have the greatest impact on the overall safety performance of the road system. Motorcycling gets a lot of attention because of the high risk and relatively large number of casualties, plus the difference in crash rates between commuting times and recreational times.

Following Jacobsen (2003), discussed in Section 7, it has been assumed that crashes involving pedestrians and cyclists increase by a factor equivalent to the increase in travel by these modes raised to the power 0.4. A 100% increase in travel is assumed to increase fatalities and serious injuries by a factor of $2^{0.4}$=1.34. A 10% increase in travel would increase the fatalities and serious injuries by $1.1^{0.4}$=1.04.

It is assumed that the same relationships apply to changes in motorcycling. The relationships between deaths and injuries for car drivers and car passengers and amount of travel are assumed to be linear. Although this will tend to overestimate the casualty increases associated with increased travel, it is unlikely to have a major impact on outcomes as the scenarios relating to car travel alone relate to late night travel where single vehicle crashes predominate; where car travel is substituted for other modes, the percentage change in car travel is very small, and the crash rate is not likely to be much affected by assuming a linear relationship[1].

Most of the following tables provide two sets of estimates of changes in fatalities and serious injuries, one based on linear extrapolation of current fatality and serious injury rates, the other based on deaths and injuries increasing according to the power function suggested by Jacobsen.

The power function outcomes are probably a much better reflection of what is likely to happen with pedestrians and cyclists if the provision for travel by these modes is similar to that in the successful cycling countries described by Pucher and Buchler (2008). If provision does not match these levels, then casualty levels are likely to be higher, but unlikely to approach the outcomes predicted by the linear model.

For motorcycles, on the other hand, the outcomes of the power model are probably unduly optimistic. A high proportion of motorcycle crashes are single vehicle crashes, which are unlikely to benefit from any ‘safety in numbers’ effect, although it is possible that crashes with other vehicles might be reduced by this mechanism. Another reason is that available protective measures are unlikely to have as great an impact on motorcycle safety as available protective measures are having on walking and cycling in ‘best practice’ countries. At the same time, the outcomes predicted by the linear model are too extreme to be really credible.

[1] The changed travel is therefore very close to 1 x original travel. Since $1.0^{0.4}$=1.0, assuming the exponential relationship is unlikely to have much effect on casualty estimates.

Reductions in driver and car passenger fatalities and serious injuries were estimated by applying the rates identified in Table 4.1 to Table 4.4 to the estimated amount of travel for each scenario. Under the linear model, the changes in fatalities and serious injuries in the new transport mode were estimated by applying the appropriate rates from Table 4.5 to Table 4.10 to the travel estimate applying to the alternative mode in the scenario. The reductions in the old mode were subtracted from the changes in the new mode to provide a net estimate of the changes in fatalities and serious injuries which could be expected as a result of the changed travel mode.

Under the power model, the estimated amount of travel under the scenario was determined. This was added to the estimated total travel under that mode. The ratio of the new amount of travel to the original travel was determined. This ratio was then raised to the power 0.4 to create a fatality and serious injury reduction factor. This factor was then applied to the original number of fatalities and serious injuries occurring in the relevant travel segment to estimate the change in fatalities and serious injuries in that mode. The reductions in car driver or passenger deaths, calculated in the manner described in the previous paragraph, were then subtracted from the changes in the new mode to provide net estimates of changes in fatalities and serious injuries.

8.1 Motorcycling

Eight different motorcycling scenarios were investigated, involving travel at different times or by different age groups of motorcyclists. The increases in travel, fatalities and serious injuries associated with each scenario are shown in Table 8.1. The estimates presented in the table are for the whole of Australia.

Scenario 1 investigated the effects of a 100% increase in motorcycling at commuting times, defined as 06:00 – 10:00 and 14:00 to 18:00. Because of the way the data were analysed and reported in the original Intstat study, no more closely targeted times were possible. Weekday commuting travel was estimated by multiplying all travel at these times by 0.71. This was estimated to result in an annual increase of 89 fatalities and 1,229 serious injuries under the linear model, and 28 fatalities and 393 serious injuries under the power model.

Scenario 2 investigated the effects of a 100% increase in recreational motorcycling, defined as motorcycling at other times. Although the increase in travel was less than that under Scenario 1, the annual increases in fatalities and serious injuries were higher, at 94 fatalities and 1,317 serious injuries under the linear model and, 30 fatalities and 421 serious injuries under the power model.

Scenario 3 investigated a 100% increase in motorcycling by persons aged 40 and over. Annual increases in fatalities of 58 and serious injuries of 862 were estimated under the linear model, and of 19 and 276 under the power model.

Scenarios 4 and 5 broke the increase in motorcycling by the 40 and over group into commuting motorcycling and recreational motorcycling. The expected increase in the number of deaths was more for recreational motorcycling, but the increase in the number of injuries was greater for commuting motorcycling than recreational motorcycling. Deaths and injuries were approximately three times greater under the linear model than under the power model.

Scenario 6 examined a 100% increase in motorcycling by the under 25s. Although the increase in travel was almost double that expected for the 40 and over group, the increases in deaths and injuries were less, estimated at 16 and 198 respectively.

Scenarios 7 and 8 broke this increase in motorcycling for the under 25s into commuting and recreational motorcycling. Recreational motorcycling accounted for only 45% of the travel, but was estimated to result in an increase of approximately 1.5 times more fatalities and slightly more injuries under both the linear and power models.

Table 8.1: Fatality and serious injury outcomes from scenarios involving increased motorcycling

Scenario	Change in distance travelled due to scenario (10 million km)	Annual change			
		Linear model		Power model	
		Fatalities	Serious injuries	Fatalities	Serious injuries
1. 100% increase in motorcycling at commuting times	93.9	89	1,229	28	393
2. 100% increase in recreational motorcycling	53.9	94	1,317	30	421
3. 100% increase in motorcycling by people aged 40 and over	29.1	58	862	19	276
4. 100% increase in motorcycling at commuting times by people aged 40 and over	20.3	32	446	10	143
5. 100% increase in recreational motorcycling by people aged 40 and over	8.8	26	412	8	132
6. 100% increase in motorcycling by people aged 25 and under	56.5	50	620	16	198
7. 100% increase in motorcycling at commuting times by people aged 25 and under	31.0	20	282	6	90
8. 100% increase in recreational motorcycling by people aged 25 and under	25.5	31	339	10	108

Note:

Due to rounding errors, the annual changes in fatalities or injuries may not correspond exactly with product of distance and rate shown in the table.

8.2 Walking

Three walking scenarios were investigated. The results are shown in Table 8.2.

Table 8.2: Fatality and serious injury outcomes from scenarios involving increased walking

	Change in distance travelled due to scenario (10 million km)	Annual change			
		Linear model		Power model	
		Fatalities	Serious injuries	Fatalities	Serious injuries
1. 100% increase in walking at commuting times	202.1	72	840	23	269
2. 100% increase in walking at other times	136.0	130	1,095	42	350
3. 100% increase in walking by over 60's	6	86	443	0	3

Note:

Due to rounding errors, the annual changes in fatalities or injuries may not correspond exactly with product of distance and rate shown in the table.

Scenario 1 investigated a 100% increase in commuting walking. It was estimated to generate an additional 20 million kilometres travel, and to result in 72 additional deaths and 840 additional injuries per year under the linear model, and 23 additional deaths and 269 additional serious injuries per year under the power model.

Scenario 2 investigated a 100% increase in recreational walking. It resulted in a similar increase in kilometres travel, but an additional 130 deaths and 1,095 serious injuries under the linear model, an additional 42 fatalities and 350 serious injuries under the power model. Note that collisions involving intoxicated pedestrians may be a major factor in explaining the higher casualty outcomes compared to walking at commuting times.

Scenario 3 investigated a 100% increase in walking by the over 60s. This resulted in 60 million kilometres additional travel, 86 additional fatalities and 443 additional serious injuries under the linear model, and no additional fatalities and 3 additional injuries under the power model.

8.3 Bicycling

The four bicycling scenarios investigated are shown in Table 8.3.

Table 8.3: Fatality and serious injury outcomes from scenarios involving increased bicycling

	Change in distance travelled due to scenario (10 million km)	Annual change			
		Linear model		Power model	
		Fatalities	Serious injuries	Fatalities	Serious injuries
1. 100% increase in cycling at commuting times	95.4	17	632	5	202
2. 100% increase in cycling at other times	44.5	12	407	4	130
3. 100% increase in cycling by 9-15 year olds	44.6	4	152	1	49
4. 100% increase in cycling by over 60's	6.8	4	80	1	26

Note:

Due to rounding errors, the annual changes in fatalities or injuries may not correspond exactly with product of distance and rate shown in the table.

Scenario 1 involved a 100% increase in cycling at commuting times. It was estimated to generate an additional 954 million km travel, resulting in 17 additional deaths and 632 serious injuries under the linear model, and 5 additional deaths and 202 serious injuries under the power model.

Scenario 2 involved a 100% increase in cycling at other times. This generated approximately half as much additional travel as the increase at commuting times (445 million km), but was estimated to result in an additional 12 deaths and 407 serious injuries under the linear model, and 4 additional deaths and 130 serious injuries under the power model.

Scenario 3 involved a 100% increase in cycling by 9 – 15 year olds. It was estimated to result in an additional 446 million km travel, 4 additional fatalities and 152 serious injuries under the linear model, and 1 additional fatality and 49 additional serious injuries under the power model.

Scenario 4 involved a 100% increase in bicycle travel by the over 60s. It resulted in only an additional 68 million km travel, but was estimated to result in an additional 4 deaths and 80 serious injuries under the linear model, and 1 additional death and 26 serious injuries under the power model.

8.4 Changes in Travel at High-risk Times

The scenarios explored in this section dealt with increasing deaths and injuries arising from additional late night travel.

Scenario 1 involved a 50% increase in late night car travel, defined as travel between 22:00 hrs and 02:00 hrs. The way the results of the Socialdata Australia/Intstat surveys were reported restricted analysis to these times. It was estimated to result in an additional 59 fatalities and 768 serious injuries.

Scenario 2 modelled a 50% increase in late night car travel, but only by people aged 25 and under. It was estimated to result in an additional 23 fatalities and 327 serious injuries. Late night travel by this group would account for only a 21% increase in late night travel, but would result in 39% of the increased fatalities and 43% of the increased serious injuries.

Table 8.4: Fatality and serious injury outcomes from scenarios involving changes in travel at high risk times

	Change in distance travelled due to scenario (10 million km)	Annual change			
		Linear model		Power model	
		Fatalities	Serious injuries	Fatalities	Serious injuries
1. 50% increase in late night car driving	216.4	0.27	3.55	59	768
2. 50% increase in late night car driving by people aged 25 and under	45.8	0.50	7.14	23	327

Note:

Due to rounding errors, the annual changes in fatalities or injuries may not correspond exactly with product of distance and rate shown in the table.

8.5 Changing Modes

Seven scenarios involving changes in mode were investigated, and are summarised in Table 8.5.

Table 8.5: Fatality and serious injury outcomes from scenarios involving changing travel modes

Scenario	Change in distance travelled due to scenario (10 million km)	Annual change			
		Linear model		Power model	
		Fatalities	Serious injuries	Fatalities	Serious injuries
1. Shift of 10% of travel by car drivers to travel as car passengers	1,507	-6	-356	-15	-377
2. Shift of 10% of travel by car drivers to travel as motorcyclists	1,507	1,913	26,296	120	444
3. Shift of 10% of travel by car drivers to travel by walking	1,507	812	7,440	125	-164
4. Shift of 10% of travel by car drivers to travel by cycling	1,507	209	5,911	-42	-663
5. Shift of 10% of travel by car passengers to travel as motorcyclists	713	907	12,469	139	1,043
6.Shift of 10% of travel by car passengers to travel by walking	713	387	3,647	156	598
7. Shift of 10% of travel by car passengers to travel by cycling	713	102	2,932	0	107

Under Scenario 1, a 10% shift from travel as a car driver to travel as a car passenger, reductions in deaths and injuries are predicted under both models.

Scenario 2 involved a 10% shift from car driving to motorcycling. Under the power model, 120 additional deaths and 444 additional serious injuries would be expected. However, under the linear model, over 1,900 additional fatalities and more than 26,000 additional serious injuries would be expected. It should be borne in mind that a 10% shift from car driving to motorcycling would involve a ten-fold increase in motorcycling. While such a large increase in fatalities is simply not credible in the short term, this scenario illustrates how a change from car travel to motorcycling could adversely affect road safety outcomes. Some reductions in these estimates might be expected if most of the growth in motorcycling occurred during commuting times.

Scenario 3 involved a 10% shift from driving to walking. Under the power model, an increase in fatalities but a reduction in serious injuries was predicted. This finding reflects the low ratio of serious injuries to fatalities for pedestrians (i.e. the high proportion of fatalities for pedestrians) compared to other road users discussed in Section 6.2. Under the linear model, large increases in both deaths and injuries were predicted.

Under Scenario 4, cycling was substituted for 10% of car driving. Under the power model, reductions in both deaths and injuries were predicted. The increases in fatalities and serious injuries were large, but considerably less than for the same distance travelled by walking.

Scenarios 5 – 7 involved substituting travel by other modes for travel as a car passenger.

Substituting motorcycling for 10% of travel as car passenger (Scenario 5) was estimated to result in 139 additional fatalities and over 1,000 additional serious injuries under the power model. Predicted increases are almost an order of magnitude greater under the linear model.

Substituting walking for travel as a car passenger (Scenario 6) was estimated to result in an additional 156 fatalities and almost 600 additional serious injuries under the power model; increases under the linear model are substantially greater.

Under Scenario 7, bicycling was substituted for travel as a car passenger. Under the power model, no additional injuries were predicted, but serious injuries rose by over 100. Under the linear model, fatalities rose by over 100 and serious injuries by over 2,000.

8.6 Changing Modes Involving Additional Walking

Only a scenario involving moving from car travel to walking could be modelled as the necessary data was not available for other scenarios. Amongst the suggestions from the advisory group were to model substituting bus travel for walking and cycling and substituting train travel for car travel.

A discussion paper issued by the Australian Transport Safety Bureau (ATSB 1995) documents the fatality risk for different transport modes in Australia. It lists the outcomes of five Australian studies of the fatality risk to bus passengers. The range of outcomes as a proportion of the car occupant fatality rate is from 0.05 to 0.18. This is equivalent to 0.009 to 0.003 fatalities per 10 million kilometres travel. A rate of 0.005 fatalities per 10 million kilometres travel was therefore adopted for bus passengers.

As well as the change in kilometres travel, the number of trips this involved was also estimated from the Socialdata Australia/Intstat survey data. It was assumed that each bus trip would involve 700 metres walking, equivalent to a 350 metre walk at the beginning and end of each trip. The additional distance was calculated, and the number of additional fatalities was estimated using the fatality rate for pedestrians calculated in Table 4.5.

The results are shown in Table 8.6. A fatality rate of 0.009 per 10 million km travel was assumed for bus travel (ATSB 1995). The fatality rates for car driving, car passengers and walking (0.05, 0.04 and 0.62 per 10 million km travel) were taken from Table 4.1, Table 4.3 and Table 4.5 respectively.

Scenario 1 envisaged 10% of travel as a car driver being undertaken as a bus passenger. As Table 8.6 shows, there is a large reduction in fatalities through people not driving their cars, offset by a small increase in fatalities amongst bus passengers and a much larger increase in pedestrian fatalities. The net outcome is that fatalities are almost unchanged.

This analysis does not take into account the amount of walking done by car drivers to get to their destination. For example, most people driving into the centres of cities or regional centres would have to walk some distance from where they park their car to their place of work or other destination, so that the increase in walking is probably less than the analysis suggests. It was not possible to estimate this change within the scope of the project. It is also the case that walking by bus travellers would probably be safer than the average for all walking. The three high risk groups of pedestrians are the intoxicated, the very young and the elderly (Austroads 2000). Since these three groups are not likely to feature to any great extent among people who substitute bus travel for car travel, the walking associated with bus use is likely to be safer than average. It is therefore possible that the increase in casualties from walking is less than the modelling suggests, and that the effect of changing from car driving to bus travel may be to reduce overall casualties by a small amount.

Table 8.6: Fatality and serious injury outcomes of changing from travel by car to travel as a bus passenger

	Change in motorised travel (10 million kilometres)	Annual change in fatalities from not using a car	Annual change in fatalities from bus travel	Change in walking (10 million kilometres)	Annual change in fatalities from walking	Net annual change in fatalities
1. Shift of 10% of travel by car drivers to travel by bus	-1,477.28	-71	13	80.35	59	1
2. Shift of 10% of travel by car passengers to travel by bus	-698.58	-31	6	29.70	15	-10

Note:

Due to rounding errors, the annual changes in fatalities or injuries may not correspond exactly with product of distance and rate shown in the table. Note also that due to the small increase in overall amount of walking, the linear model has been used to predict deaths and injuries while walking to and from buses.

Scenario 2 envisaged a similar change from travel as a car passenger to travel as a bus passenger. The results were broadly similar to the results for substituting bus travel for car driving, except that the fatality reductions from not using a car are proportionately lower, since travel as a car passenger is slightly safer than travel as a car driver, giving rise to a slight increase in fatalities. As was the case with the last analysis, the analysis does not take into account walking by car passengers to get to their destination, so the increase in walking is possibly less than the analysis suggests, and the net result closer to no net change in fatalities.

Scenarios involving other forms of public transport have not been explored in this project. The ATSB comparison of safety across modes has no estimates for trams or light rail (Australian Transport Safety Bureau 1995). It does however have fatality estimates for rail passengers, which are marginally higher than the estimates for bus travel.

While many homes in major centres are within walking distance of a bus stop, only a small proportion are within walking distance of a train station. For many people, getting to and from the station may involve travel by car as a passenger or driver, or travel by walking and bus, or by bicycle, rather than simply walking. In the absence of detailed information about the relative use of these different modes to connect with rail, it was decided not to pursue this option. However, it is probably reasonable to assume that switching from car travel to travel as a train passenger has similar effects as switching from car travel to bus travel, i.e. it is essentially neutral in terms of road safety outcomes.

8.7 Freight Scenarios

The exposure data on which the rest of this project is based, reported in Anderson et al. (1989a), does not include estimates of travel by truck. Casualties arising from truck travel are a major concern for road authorities as trucks are involved in a large proportion of fatal and injury crashes, and truck travel is expected to grow considerably as a result of a projected 82% increase in freight between 2003 and 2020 (BITRE 2006). Changes in fatal and injury crashes have been estimated in this section to provide a more complete picture of the likely growth points in road casualties. It should be recognised that the estimates do not include crashes involving light trucks and vans engaged in carrying freight. As these crashes are not identified in the crash record, it is not possible to compile total crashes or estimate crash rates for these vehicles within the scope of the present project.

Total numbers of fatal and injury crashes involving trucks in all Australian jurisdictions were extracted from crash data provided by road authorities to ARRB. The years examined were 2003 to 2007, except in the case of Queensland where the last 5 years available were 2001 to 2005. Average yearly numbers of fatal and injury crashes were calculated. Although some confidence can be placed in the number of fatal crashes, the numbers of injury crashes should be regarded as approximations rather than precise estimates due to differences in reporting requirements between different jurisdictions. Crashes were separated into those involving rigid trucks and those involving articulated trucks.

Estimates of travel by rigid and articulated truck for the year 2004 (the latest available) were obtained from the Survey of Motor Vehicle Use (Australian Bureau of Statistics 2005). Crash rates per 10 million kilometres were estimated from the crash and travel data. The results are shown in Table 8.7. Since the increase in travel being modelled is 100%, the increase in fatal and serious injuries will, assuming no change in crash rates, be equivalent to the current total number of fatal and serious injury crashes.

Table 8.7: Fatality and serious injury outcomes from increased road freight movements

Rigid	763.9	156	4,927	0.21	5.63	156	4,927
Articulated	601.3	131	1,649	0.22	2.74	131	1,649

The fatal crash rate for rigid and articulated trucks is almost the same, but the injury crash rate for rigid trucks is just over double that for articulated trucks. This pattern may reflect vehicle mass and operating environment. Articulated trucks tend to have a greater mass than rigid trucks – usually a considerably greater mass. The greater energy exchange in a collision therefore makes it more likely that crashes involving articulated trucks will be fatal crashes. Estimates based on the Survey of Motor Vehicle Use show that travel in capital cities or other built-up areas accounts for 63% of rigid truck travel, but only 24% of articulated truck travel. This suggests that rigid trucks have much greater exposure to relatively congested travel at lower speeds where non-fatal crashes are more likely. This is consistent with the much higher injury crash rate for rigid trucks.

A doubling of the freight task, assuming that it would be carried without any changes to the mix of vehicles used or any safety improvements in the industry, would result in an additional 287 deaths and 6,576 serious injuries per year. The outcome of doubling the freight task would be different if a different mix of vehicles were used to carry out the task.

Table 12 of the Survey of Motor Vehicle Use shows the tonne-kilometres carried by different types of vehicle. The product of the load and the distance travelled, this is a useful indicator of the share of the freight task undertaken by different classes of vehicle.

Light commercial vehicles accounted for only 4% of the total freight task, rigid trucks 19% and articulated trucks 77%. Dividing the average tonne-kilometres travelled by different types of vehicle each year by the average kilometres travelled carrying a load provides an estimate of the average loads carried. In the case of rigid trucks it is 5 tonnes, in the case of articulated trucks it is almost 28 tonnes. If a large proportion of the growth is taken up by articulated trucks, then the increase in exposure might be considerably less than double the current level, and fatalities and injuries might be correspondingly less.

However, the extent to which large trucks can be substituted for smaller trucks depends very much on the nature of the freight task. In some cases, the amount of freight to be moved can be handled adequately and more economically by relatively small vehicles; in other cases, access considerations might rule out the use of larger vehicles.

Moving freight to rail is another possible option, although the scope for doing this and the impact it is likely to have on the road system is likely to be fairly limited for the foreseeable future. Rail has many advantages over road for long-distance freight transport, but is unlikely to be able to substitute for road transport for shorter distances.

The move towards larger trucks capable of carrying greater loads having wide access to the road network is likely to result in further reductions in exposure. Without a detailed examination of the different freight tasks likely to be entailed in a doubling of freight and some indication of how different types of vehicle are likely to be used to perform this task, it is not possible to provide more precise estimates.

9 CHALLENGES TO ACHIEVING ROAD SAFETY TARGETS

9.1 Limitations of the Study

When considering the challenges that the modal shifts explored in the study pose to the realisation of road safety targets, it is important to bear in mind the limitations imposed by the data and the assumptions which have been adopted as a consequence of these limitations. The extent to which these assumptions diverge from reality will have a bearing on the accuracy of the fatality and injury rates.

Although the amount of travel undertaken has changed from the time of the original study in 1984, current travel estimates for car drivers and motorcyclists are based on data from the SMVU and are therefore the best that can be achieved with current data sources which can be applied Australia-wide. Car passenger travel is based on vehicle ownership rates and average kilometres travelled by vehicles in a 2004 survey, combined with 2006 census data.

The critical assumption in the study is that relative amount of travel undertaken by the different sub-populations is the same in the 1984 sample as it was in the 2006 population. That is to say, the same proportion of travel was undertaken by each gender in the 1984 sample as was the case in the 2006 population, the same proportion was undertaken by each of the age groups, and the same proportion was undertaken at each time of day and on each day of the week.

In the absence of current travel data it is not possible to know by how much these relativities may have changed since the 1984 survey. However, some changes seem possible in the light of current trends in society:

- An increase in the proportion of travel as drivers and motorcyclists by women as a reflection of both their increasing independence and the consolidation of schools, services and other facilities in fewer locations, increasing the need for car use for access. This would tend to increase their exposure and reduce the fatality and injury rates compared to the rates estimated in the present report. As a result, the amount of travel estimated for women in Table 4.1, Table 4.5 and Table 4.6 may be an underestimate, which means that their fatality and serious injury rates would consequently be lower. The rates applying to men would then be higher. Note that the overall rates for car drivers and motorcyclists would not be affected.
- An increase in the proportion of travel by older people as car drivers, car passengers and motorcyclists, reflecting increasing active longevity and affluence. This would tend to increase their exposure and so reduce the fatality and injury rates.
- Growing concern for sustainability, which may influence decisions whether to travel or not, mode choice and vehicle choice, all of which may impact road safety outcomes.

For non-motorised modes, no current travel estimates were available. The travel estimates were based on adjusting the 1984 travel estimates in proportion to the population increases in each age group, assuming the same average amount of travel by individuals. Survey and census data indicates a recent surge in commuting cycling. For example, Bicycle Victoria (2009) cites census data that shows that travel to work in the City of Boroondara (an inner area of Melbourne) increased by 47% between 2001 and 2006, reinforcing this with bicycle counts at key locations during commuting times which showed an annual increases between 2008 and 2009 of 15 – 19%. On the other hand, there is widespread concern about teenage obesity and fitness, linked to reduced physical activity. Thus it may be that most cycling is safer than the estimates in this report indicate, since the casualties are spread over a greater amount of travel than indicated, while the crash rates for teenagers may be higher.

A further limitation of the study, imposed by the data sources, is that it does not differentiate between urban and rural travel and crash rates. In Australia and New Zealand, most fatalities occur on rural roads, but it is urban travel (particularly metropolitan travel) which has the greatest potential for modal change. Without data of the relative safety of urban and rural travel on all modes, it is not possible to say with any precision how this is likely to affect the estimated changes in crash outcomes.

9.2 The Challenges

On the basis of the scenarios examined, there appear to be five clear challenges to achieving road safety targets.

Any increases in motorcycling are likely to have an adverse effect on deaths and injuries. Recreational motorcycling, and motorcycling by riders aged 40 and over are likely to result in rises in deaths and serious injuries. Commuting motorcycling, and motorcycling involving riders aged less than 25, are likely to result in smaller increases in deaths and injuries.

A switch from car travel to walking is also likely to increase deaths and injuries, though by a lesser extent than a switch to motorcycling. Under the power model, an increase in fatalities but a reduction in injuries was predicted. A switch to cycling was predicted to have even better outcomes, with reductions in both fatalities and injuries predicted. Note, however, that substantial increases in deaths and injuries were predicted under the linear models.

Continued growth of the road freight task poses another challenge. How big a challenge this is will depend to some extent how this task is executed. Reduced travel by heavy vehicles through more efficient operations (probably involving the use of larger vehicles) is likely to improve the situation.

On the positive side, increasing travel as car passengers rather than drivers is likely to have a beneficial effect. The challenge is to increase vehicle-sharing arrangements.

Switching from travelling by car to travel as bus passengers is likely to have a neutral or mildly positive effect. Travelling as bus passengers rather than car travellers reduces casualties, but these would appear to be largely offset by the increased walking to and from the bus. Better protection of pedestrians accessing public transport, is therefore an important challenge.

9.3 Possible Strategies to Address the Challenges

Strategies are required to address these challenges. Possible strategies are outlined in this section, giving examples of possible countermeasures. Comprehensive strategies which give a fully considered assessment of possible policies and countermeasures require further development work.

9.3.1 Measuring Exposure by Different Modes

Since road safety outcomes are sensitive to travel mode, it is essential to monitor changing travel patterns in order to be able to understand trends in fatalities and injuries.

The most critical aspect to monitor is motorcycle use. At present, the only regular source of data available for motorcycle travel is the tri-annual ABS Survey of Motor Vehicle Use. Data on the number of motorcycles is available from another ABS publication, Motor Vehicle Census, Australia (ABS 2009). This provides data on the numbers of vehicles of different types on register in each state and territory, and also provides data on the changes in numbers of different types of vehicle registered compared to previous years.

Traffic counts collected by the road authorities and local government generally do not identify motorcycles as a distinct class of vehicles although the traffic counts do include motorcycles. The current Austroads system for vehicle classification does not include motorcycles. Traffic counts are generally carried out to gauge traffic flow for capacity reasons rather than gauging exposure to understand crash risk. Since current techniques evolved in an era where the storage of electronic recording devices was much more constrained than it is for current technology, it is understandable that a system which was limited to the essential information for the primary purpose of the counts was adopted.

For many years, contractors who carry out traffic counts for road authorities and councils have had the capacity to identify motorcycles as a separate category in the count. This is readily done on the basis of wheelbase. Traffic surveys that have been conducted over the last few years, and future surveys, could be re-analysed to produce historical motorcycle exposure data.

Keeping track of the amount of travel by car passengers, bicyclists and pedestrians presents a greater challenge. At present, the only reliable means of counting car passengers is by visual observation, although it is possible that image processing technology may enable the process to be automated in the future. Image processing technology is a viable alternative for counting pedestrian and bicyclist numbers, and other automated techniques are available, such as using infra-red detectors. However, most counting of passengers and vulnerable road users is carried out as part of the investigations for particular projects, rather than a comprehensive monitoring program.

Bus and train patronage should, in principle, be available as some electronic validation systems now in use automatically record numbers of patrons at entry and exit points to the system. However, it may be difficult to negotiate access to this information.

Some jurisdictions are actively pursuing data which will provide better data on some aspects of road user exposure. For example, VicRoads has extracted data from the 2006 census relating to motorcycling, bicycling and walking for the journey to work (Comment by J. Earnshaw included in A. Curnow’s email of 21/08/2009). Victoria is also undertaking surveys of travel (the Victorian Integrated Survey of Travel and Activity) (Department of Transport 2009). New Zealand conducts an ongoing travel survey, the New Zealand Household Travel survey, which is used to give rolling estimates of travel patterns in New Zealand (Ministry of Transport 2008). These are potentially useful data sources for better monitoring trends in travel patterns. An analysis of crash rates similar to the analysis in the present study could be undertaken using the travel data from these surveys. The travel data would be much more up-to-date, but would probably still be based on small numbers for some age groups at some travel times.

Many of the key sources accessed in this report were published in sources which are not part of ‘mainstream’ road safety, and the omission of some points which most road safety practitioners would be likely to raise is sometimes absent from the discussion in them. This points to the need for much greater contact between pedestrian and cycling researchers and road safety researchers. The former are often based in health promotion or transport policy organisations, and may have an advocacy role as well as a research role. In contrast, ‘mainstream’ road safety researchers and practitioners are often based in road authorities or organisations which are associated with them, and are focussed on reducing deaths and injury. Greater exposure to each others’ thinking, methods, findings and interpretations is likely to be of benefit to both groups.

9.3.2 Alternatives to Motorcycling

In an environment where the price of fuels increase substantially, more people are likely to choose to travel by modes other than as a car driver, and many of these are likely to chose motorcycle travel because of the low cost and convenience. As the scenarios explored in Section 8 show, even small percentages of people moving from travel by car to travel by motorcycle, even during the safer commuting travel periods, could result in large increases in deaths and injuries. It is therefore essential to ensure that affordable, convenient alternatives are available.

Amongst the policies which would assist this are:

- encouraging the early introduction and widespread availability of low-cost cars powered by alternative fuels, and of facilities for refuelling or recharging them
- encouraging car-sharing arrangements
- encouraging greater use of public transport, e.g. by improving frequency of services and improving the connectivity of services
- encouraging flexible working hours to achieve a better spread of patronage and more comfortable travelling conditions on public transport
- reducing the cost of public transport to the user; increased patronage, spread more evenly across the day, could help achieve this
- improving access to bus stops and rail lines by walkers and bicyclists.

These policies could be assisted by measures designed to discourage people from taking up motorcycling. These could include increasing the awareness of the high risk of motorcycling compared to other travel modes, and changes to motorcycle insurance premiums so that they were aligned with the true risk of motorcycling.

9.3.3 Improving the Safety of Motorcycling

If motorcycling is going to increase, then its adverse impact on road safety could possibly be reduced by promoting safer types of motorcycle, improving the safety of the road system for motorcycle riders, and improving the safety of motorcycle rider behaviour.

It is well established that larger motorcycles have higher crash rates than smaller motorcycles. Beyond that, it is not currently possible to say with any certainty whether different types of motorcycle are safer than others. It seems possible that scooters may have better safety outcomes than conventional motorcycles, but this is an issue which requires research. Dissemination of information on risk, once credible information is available, may be effective in persuading at least part of the motorcycling population to choose safer machines.

Actions to improve the road system would involve close attention to all the points relating to motorcycling covered in the Austroads *Guide to Road Safety* and the Austroads *Guide to Road Design*[2]. If numbers were to increase dramatically, it might be worth considering dedicated facilities for motorcycles on part of the road network, for example motorcycle lanes or separate motorcycle paths.

[2] Until recently, these points were consolidated in the now-superseded Austroads Guide to Traffic Engineering, Part 15.

Improving motorcycle safety is likely to require a range of initiatives. New technologies to improve motorcycling safety are becoming available, although they are currently only available for more expensive machines. Technology which delivers anti-lock braking, appropriately balanced braking forces to each wheel, and more rapid braking appear to be especially promising, although some sectors of the motorcycling community appear to be reluctant to embrace the benefits (Cairney & Ritzinger 2008).

In view of the high crash rates of older riders, perhaps the available programs for riders who return to motorcycling after an absence of some years could be more widely adopted and more vigorously promoted. Wider dissemination of the information relating to riding at different times may have a role in encouraging safer riding.

Victoria currently imposes a Motorcycle Safety Levy on injury insurance premiums for motorcycles with engine capacity of 126 cc and over, which is used to fund a range of activities to improve motorcycle safety. The priority areas for funding are:

- education
- engineering, technology and intelligent transport systems (ITS)
- enforcement
- enhanced information for decision making.

Projects funded include improving rider hazard protection and responses, treating high volume motorcycle routes, enforcement (targeted at other vehicles as well as motorcycles) at motorcycle blackspots, and better information on the characteristics of good riders. A listing can be found on the Arrive Alive website <http://www.arrivealive.vic.gov.au/>.

9.3.4 Improving the Safety of Walking and Bicycling

Increases in walking or cycling, or substitution of car travel for walking or cycling are likely to have adverse effects on safety outcomes, although they are likely to have off-setting benefits in terms of a positive contribution to community health. The extent to which this becomes a net positive contribution depends on the extent to which the safety of these modes can be improved. In addition to current programs, options which could be considered include:

- reconsideration of speed zoning with a greater focus on pedestrian and cyclist safety through rigorous application of Safe System principles to these issues
- improving the safety of locations where increases in pedestrians or cyclists are most likely by directing routes to safe crossing locations, improving crossing facilities, and providing separated bicycle lanes or paths where feasible
- encouraging the purchase of vehicles which are designed to inflict minimum injuries on pedestrians in the event of a collision.

9.3.5 Coping with the Freight Task

The possible effects of changing mode from car driving or being a car passenger are very severe, but speculative. The impacts of the projected growth in the freight task are also very severe, but have a high probability of being realised unless action is taken to improve the safety of truck travel.

Although the increases in travel by different modes, or the changes between modes, explored in Section 8.1 to Section 8.6 may not happen, or may happen to a much lesser extent than the changes in the scenarios, the increase in freight travel is based on projections of long-established trends and are driven by economic forces that show little sign of weakening at the present time.

There may be some scope to reduce the demand for freight movements through wider economic changes, such as moving towards more localised food production and changing building techniques and materials to make more efficient use of lighter materials, but these effects are likely to be small and may be offset by factors such as the increasing size of large cities and retrofitting buildings to be more energy and water efficient.

Whereas a 100% increase in motorcycling during commuting and recreational times would result in an additional 190 fatalities and almost 3,900 serious injuries per year, the predicted increase in the freight task was estimated to result in an additional 287 fatal crashes (implying in the region of 300 additional fatalities) and 6,500 serious injury crashes.

Possible actions to improve the safety of the freight task include, in addition to the programs currently being pursued by industry, road authorities and enforcement agencies:

- encouraging businesses to accommodate a wider range of pick-up and delivery times, to avoid conflict with other road users and remove pressure on schedules
- wider promotion of industry best practice, with emphasis on the profitability of good practice in relation to fuel consumption and maintenance costs
- active encouragement of new in-vehicle safety technologies such as roadway departure warning and collision avoidance
- collection and dissemination of information on the relative safety of different truck models
- better training, selection and management of drivers
- increased investment in re-engineering roads to better accommodate trucks
- restricting access of very large vehicles where their size, visibility from the driving position, or manoeuvrability has the potential to create safety problems.

9.4 The Next Steps

9.4.1 Research

Changing travel modes are likely to have a considerable influence on road safety outcomes over the next few years, yet understanding of the essential issues is relatively poor. While Jacobsen's power law possibly provides a useful theoretical starting point for such work, important questions about the robustness of the effect and the relative contribution of different factors such as improved infrastructure and 'safety in numbers' remain unanswered. Given the potential significance and scale of the problem, better answers are required.

Obtaining travel data – broken down in terms of road user characteristics, time, and location – in sufficient detail to support analyses similar to those in the present report is the key to understanding risk and the changing profiles of different travel modes as travel patterns change. One option would be to update the Socialdata Australia/Intstat studies using a similar methodology. However, this would be an expensive undertaking and, given that relatively little use of the Socialdata Australia/Intstat data appears to have been made, would be difficult to justify. It would be much more cost-effective to make use of surveys which are conducted for wider purposes, such as public transport planning, as well as assessing road safety outcomes. The New Zealand Home Travel Survey is a comprehensive survey designed for these purposes which aggregates data over a three-year period, with an on-going survey which is used to update the estimates on an annual basis. The Victorian Integrated Survey of Travel and Activity collects information about travel in the metropolitan area and major regional centres; a survey was carried out in 2007 and another one is in progress at time of writing.

Useful studies would include:

- Longitudinal studies of the relationship between crashes involving vulnerable road users and amount of travel by motorcycle, walking and bicycling. Such studies will be feasible as data from the New Zealand Home Travel Survey and the Victorian Integrated Survey of Travel and Activity become available. To ensure that these studies do happen, and that the results are available as soon as possible, these studies should be established in the near future. Disaggregation of the results by urban and rural travel, if possible, would be particularly useful.
- Cross-sectional studies to test the relationship between crash rates and amount of travel. This might require that measures of travel by different modes be collected as part of the study. A study which attempted to control for the level of infrastructure provision (e.g. by including information on the percentage of roads where bicycle facilities are present, or estimating the percentage of travel on dedicated bicycle facilities) would be particularly useful in assessing the extent of the 'safety in numbers' effect.
- Detailed studies of the relationship between the activity of different road users and crash rates to replicate the findings of Turner et al. This approach could be extended by considering activity and crash rates at different times of day, and by examining aspects of behaviour such as vehicle speeds and conflict frequency and severity in response to different numbers of vulnerable road users.
- Studies to assess the risk associated with different types of motorcycles and motor scooters, and the location and circumstances of motorcycle crashes during recreational and commuting times would give useful insights.
- A comprehensive study to establish the benefits and costs of walking and cycling from 'a whole of community' perspective. While there may be a downside to increased walking and cycling in terms of increased traffic injuries, there is likely to be a considerable upside in terms of improved health from more exercise, as well as benefits in terms of reduced congestion, reduced noxious and greenhouse gas emissions, reduced energy consumption, and increased contact between people. Such a study would be most useful if it could follow the approach attempted in the present study of disaggregating health outcomes (including traffic injuries) by gender and age; it should also disaggregate by place of residence, and urban/rural travel.

9.4.2 Action

Road authorities, including local governments, should consider the following actions if they are not already vigorously pursuing them:

- encouraging car-pooling and other forms of car-sharing
- reviewing the provision for pedestrians accessing or leaving bus stops or train stations
- reviewing provision for cyclists
- reviewing measures to encourage safe motorcycling
- if necessary, reformulating the issue of promoting or providing for walking and cycling as creating a walking and cycling infrastructure and a traffic environment which will encourage high levels of walking and cycling and which will result in casualty rates which match crash rates in countries such as the Netherlands

- for the time being at least, until more definitive evidence is available, refrain from promoting the view that increasing the number of pedestrians or cyclists will by itself reduce the crash rate for these modes; instead, promote the view that concerted policy initiatives and infrastructure provision can create an environment where walking and cycling are encouraged and are safe activities.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

The data available for the study required that a number of assumptions be adopted. The extent to which these assumptions diverge from reality will determine the accuracy of the fatality and injury rates estimated in the report. Although overall estimates of travel for motorised modes could be updated using the ABS Survey of Motor Vehicle Use, no current travel estimates were available for non-motorised modes. These were updated in proportion to the population change in each of the gender and age categories. Confidence can therefore be placed in the overall estimates for the motorised travel modes, although less confidence can be placed in the estimates for gender-specific, age-specific or time-specific rates. Less confidence applies to all aspects of the estimates for non-motorised modes.

Fatality rates per distance travelled were lower in 2006 than they were in 1984 for all classes of road user. Motorcyclists showed the least improvement. Fatality and serious injury rates vary considerably, with motorcyclists having almost 30 times the fatality and serious injury rate of car occupants.

Bicyclists stand out as having a higher ratio of serious injuries to fatalities compared to other road users, possibly due to many of their collisions occurring in relatively low-speed environments. Pedestrians have a lower ratio of serious injuries to fatalities, possibly due to a combination of impacts on high-speed roads, and capacity to survive crashes being affected by age or alcohol intoxication.

Examination of the literature on the relationship between the amount of walking and cycling and crash rates found consistent evidence from a range of sources that crash and casualty rates decrease as the amount of walking or cycling increases. A relationship which relates the change in casualties to the change in travel raised to the power 0.4 appears to give a good fit across many studies. Recently published work (Elvik 2009) shows that reduced numbers of crashes are theoretically possible when walking or bicycling is substituted for motor vehicle travel, however, the reductions are critically dependent on the shape of the curves which relate travel numbers to crash numbers for the different modes. Only if the exponents defining these functions are less for pedestrians and bicyclists than for motor vehicles will there be a reduction. At present, information about the shape of these functions is limited.

It is not clear to what extent a ‘safety in numbers’ effect (i.e. changes in behaviour on the part of vehicle drivers to take greater account of pedestrians or cyclists) of itself accounts for these changes. Communities where pedestrian and cyclist casualty rates are low have often invested heavily in infrastructure and policies to encourage walking and cycling as well as making it safer. This view is more consistent with Safe System principles than ‘safety in numbers’.

A number of scenarios relating to changing travel modes were investigated in the report. They were not intended to be forecasts of actual road casualties, but as diagnostic tools to identify possible areas where progress towards road safety targets may be made difficult due to road users changing to higher-risk travel modes for a range of reasons, including reducing travel costs, cardio-vascular health, and convenience. As there are reasons to believe the power model may produce unduly optimistic estimates of casualty outcomes, both a linear and a power model were used to investigate these scenarios; as would be expected, the difference between them was extreme. A different approach to modelling was necessary for the freight scenarios. The conclusions from the modelling were:

Under the power model, but not under the linear model:

- Substituting travel as a car driver to travel by bicycle would reduce deaths and serious injuries.
- Substituting walking for car driving would increase fatalities but reduce serious injuries.
- Substituting bus travel for car driving may possibly result in a modest reduction in crashes; reductions from reduced car travel are likely to be offset to some extent by an increase in pedestrian crashes as travellers walk to and from the bus. It is difficult to estimate the extent of this increase as little high-risk walking is likely to be associated with the shift.

Under both the power model and the linear model:

- Substituting travel as a car driver to travel as a car passenger would reduce deaths and injuries.
- Substituting motorcycling for car driving would increase deaths and injuries, even under the power model.
- Substituting any other mode for travel as a car passenger would increase deaths and fatalities, even under the power model.

Under the freight-related modelling procedure:

- The predicted increases in freight movements are likely to have a major impact on deaths and serious injuries.

A limitation of this modelling was that the data on which the study was based does not separate rural and urban travel, despite motorised rural travel having higher fatality and serious injury rates than motorised urban travel. Since there is greater scope for changing travel mode in urban settings than in rural settings, the effects of mode change on fatalities and injuries may be over-estimated.

10.2 Recommendations for Research

A better understanding of the relationship between levels of walking, cycling and motorcycling is urgently required. The issue of the relative contribution of a ‘safety in numbers’ effect compared to infrastructure provision and policy settings is particularly important. Useful studies would include:

- A comprehensive study to establish the benefits and costs of walking and cycling from ‘a whole of community’ perspective which separates rural and urban travel.
- Longitudinal and cross-sectional studies to establish the relationship between vulnerable road user numbers in Australia and New Zealand and calibrate the relationship against Jacobsen’s suggested power relationship.

- Detailed studies of the relationship between the activity of different road users and crash rates at particular sites to replicate New Zealand work. This approach could be extended to cover different times of day, and by examining road user behaviour.
- Studies to assess the risk associated with different types of motorcycles and motor scooters, and the location and circumstances of motorcycle crashes during recreational and commuting times.

10.3 Recommendations for Actions to Improve the Safety of Vulnerable Road Users

Road authorities, including local governments, should consider the following actions if they are not already vigorously pursuing them:

- Encouraging car-pooling and other forms of car-sharing.
- Progressively improving the provision for pedestrians accessing or leaving bus stops or train stations.
- Progressively improving provision for cyclists.
- Progressively improving measures to encourage safe motorcycling.
- If necessary, reformulating the issue of promoting or providing for walking and cycling as creating a walking and cycling infrastructure and traffic environment which will encourage high levels of walking and cycling will result in casualty rates which match crash rates in countries such as the Netherlands.
- For the time being at least, until more definitive evidence is available, refrain from promoting the view that increasing the number of pedestrians or cyclists will by itself reduce the crash rate for these modes. Instead, promote the view that concerted policy initiatives and infrastructure provision can create an environment where walking and cycling are encouraged and are safe activities.

REFERENCES

Anderson, PR, Montesin, HJ & Adena, MA 1989a, *Road fatalities in Australia 1984-5,* report CR 70, Federal Office of Road Safety, Canberra, ACT.

Anderson, PR, Montesin, HJ & Adena, MA 1989b, *Road fatalities in Australia 1984-5: summary report*, report CR 84, Federal Office of Road Safety, Canberra, ACT.

Australian Bureau of Statistics 2003, *Population projections, Australia, 2002 to 2101*, catalogue no. 3222.0, ABS, Canberra, ACT.

Australian Bureau of Statistics 2005, *Survey of motor vehicle use, Australia Oct 2004*, catalogue no. 9208.0, ABS, Canberra, ACT.

Australian Bureau of Statistics 2009, *Motor vehicle census, Australia, 31 Mar 2008*, catalogue no. 9390.0, ABS, Canberra, ACT.

Australian Transport Safety Bureau 1995, *Cross modal safety comparisons*, ATSB, Canberra, ACT.

Austroads 2000, *Pedestrian and cyclist safety: recent developments*, report AP-R155, Austroads, Sydney, NSW.

Bicycle Victoria 2009, *Super Tuesday bicycle commuter survey: report to the City of Booroondara*, Bicycle Victoria, Melbourne, viewed 5 March 2010, http://boroondara.vic.gov.au/freestyler/files/Boroondara_SuperTuesday_Report09%20(2).pdf

BITRE 2006, *Freight measurement and modelling in Australia*, report 112, Bureau of Infrastructure, Transport and Regional Economics, Canberra, ACT.

Bonham, J, Cathcart, S, Petkov, J & Lumb, P 2006, 'Safety in numbers: a strategy for cycling', *Australasian Transport Research Forum (ATRF), 29th, Gold Coast, Queensland*, Queensland Transport, Brisbane, Qld., vol. 29, 9 pp.

Cairney, P & Ritzinger, A 2008, 'Industry and rider views of ITS for safer motorcycling', *ARRB conference, 23rd, 2008, Adelaide, South Australia,* ARRB Group, Vermont South, Vic., 11 pp.

Danish Road Directorate 2000, *Collection of cycle concepts*, Danish Road Directorate, Copenhagen, Denmark.

Department of Transport 2009, *Victorian integrated survey of travel and activity*, Department of Transport, Melbourne, Vic, viewed 27 January 2010, <http://www.transport.vic.gov.au/vista >.

Elvik, R 2009, 'The non-linearity of risk and the promotion of environmentally sustainable transport', *Accident Analysis and Prevention*, vol. 41, no. 4, pp. 849-55.

Intstat Australia 1988, *Review of exposure data base for the survey of day to day travel in Australia 1985-86*, report CR 68, Federal Office of Road Safety, Canberra, ACT.

Jacobsen, PL 2003, 'Safety in numbers: more walkers and bicyclists, safer walking and bicycling', *Injury Prevention*, vol. 9, no. 5, pp. 205-9.

Ministry of Transport 2008, *New Zealand household travel survey*, Ministry of Transport, Wellington, NZ, viewed 27 January 2010, <http://www.transport.govt.nz/research/TravelSurvey/ >.

Pucher, J & Buchler, R 2008, 'Making cycling irresistible: lessons from the Netherlands, Denmark and Germany', *Transport Reviews*, vol. 28, no. 4, pp.1-57.

Robinson, DL 2005, 'Safety in numbers: more walkers and bicyclists, safer walking and bicycling' *Health Promotion Journal of Australia*, vol.16, no.1, pp. 47-51.

Socialdata Australia 1987, *A data base for the evaluation of road user risk in Australia,* report CR 51, Federal Office of Road Safety, Canberra, ACT.

Turner, SA, Roozenburg, AP & Francis, T 2008, *Predicting accident rates for cyclists and pedestrians*, research report 289, Land Transport New Zealand, Wellington, NZ.

Vandenbulcke, G, Thomas, I, de Geus, B, Degraeuwe, B, Torfs, R, Meeusen, R & Panis, L I 2009, 'Mapping bicycle use and the risk of accidents for commuters who cycle to work in Belgium', *Transport Policy*, vol. 16, no. 2, pp. 77-87.

APPENDIX A DRIVER FATALITIES AND SERIOUS INJURIES BY AGE BY KILOMETRES TRAVELLED BY JURISDICTION

New South Wales – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	3	<1	3	0	4	4	0.00	2.97	0.24
16 – 20	57	127	185	34	105	139	0.12	0.16	0.15
21 – 25	114	299	413	30	97	127	0.05	0.06	0.06
26 – 29	156	280	436	18	58	76	0.02	0.04	0.03
30 – 39	396	763	1,159	41	103	144	0.02	0.03	0.02
40 – 49	277	740	1,017	44	89	133	0.03	0.02	0.03
50 – 59	161	592	753	40	58	98	0.05	0.02	0.03
60 – 64	44	146	190	13	22	35	0.06	0.03	0.04
65+	70	222	292	50	141	191	0.14	0.13	0.13
Total	1,278	3,170	4,447	270	677	947	0.04	0.04	0.04

New South Wales – Injuries

Age groups	Estimated annual travel (10 million km)			Injuries (annual average)			Annual injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	3	<1	3	<1	0	<1	0.00	0.00	0.00
16 – 20	57	127	185	6	12	18	1.83	45.33	5.35
21 – 25	114	299	413	989	967	1,956	17.30	7.59	10.60
26 – 29	156	280	436	984	831	1,815	8.62	2.78	4.40
30 – 39	396	763	1,159	619	520	1,139	3.97	1.86	2.62
40 – 49	277	740	1,017	1,407	1,099	2,507	3.56	1.44	2.16
50 – 59	161	592	753	1,200	890	2,091	4.33	1.20	2.06
60 – 64	44	146	190	810	639	1,449	5.04	1.08	1.92
65+	70	222	292	221	224	444	5.04	1.53	2.34
Total	1,278	3,170	4,447	478	633	1,111	6.85	2.85	3.80

Victoria – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	3	5	8	<1	<1	<1	0.07	0.08	0.08
16 – 20	50	98	149	4	15	19	0.08	0.15	0.13
21 – 25	154	289	443	5	19	24	0.03	0.06	0.05
26 – 29	99	236	335	1	11	12	0.01	0.04	0.04
30 – 39	323	699	1,022	5	21	26	0.02	0.03	0.03
40 – 49	292	648	940	6	11	18	0.02	0.02	0.02
50 – 59	148	534	682	5	12	17	0.04	0.02	0.03
60 – 64	32	138	170	2	4	7	0.07	0.03	0.04
65+	69	199	267	8	17	26	0.12	0.09	0.10
Total	1,170	2,846	4,015	38	111	149	0.03	0.04	0.04

Victoria – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	3	5	8	3	5	8	1.09	0.97	1.02
16 – 20	50	98	149	216	279	496	4.31	2.84	3.34
21 – 25	154	289	443	229	296	525	1.48	1.02	1.18
26 – 29	99	236	335	126	167	294	1.28	0.71	0.88
30 – 39	323	699	1,022	281	319	599	0.87	0.46	0.59
40 – 49	292	648	940	252	230	481	0.86	0.35	0.51
50 – 59	148	534	682	189	164	353	1.28	0.31	0.52
60 – 64	32	138	170	58	69	127	1.82	0.50	0.75
65+	69	199	267	159	203	361	2.32	1.02	1.35
Total	1,170	2,846	4,015	1,513	1,736	3,249	1.29	0.61	0.81

South Australia – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	<1	<1	1	0	0	0	0.00	0.00	0.00
16 – 20	16	33	49	2	11	13	0.10	0.33	0.26
21 – 25	26	75	100	2	7	9	0.06	0.10	0.09
26 – 29	23	88	111	1	4	5	0.03	0.05	0.04
30 – 39	85	158	243	1	10	11	0.01	0.06	0.04
40 – 49	83	215	299	2	8	9	0.02	0.04	0.03
50 – 59	60	113	174	1	7	8	0.02	0.06	0.05
60 – 64	9	54	63	1	2	3	0.11	0.03	0.04
65+	48	51	100	3	7	10	0.06	0.14	0.10
Total	351	787	1,138	12	55	67	0.03	0.07	0.06

South Australia – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	1	0	1	0	1	1	0.00	6.76	0.93
16 – 20	16	33	49	47	80	127	2.96	2.44	2.60
21 – 25	26	75	100	33	67	100	1.29	0.89	0.99
26 – 29	23	88	111	22	32	55	0.95	0.37	0.49
30 – 39	85	158	243	46	76	123	0.55	0.48	0.51
40 – 49	83	215	299	37	51	88	0.44	0.24	0.29
50 – 59	60	113	174	30	35	65	0.50	0.31	0.37
60 – 64	9	54	63	7	13	20	0.77	0.25	0.32
65+	48	51	100	27	46	73	0.56	0.89	0.73
Total	351	787	1,138	249	401	650	0.71	0.51	0.57

Western Australia – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	0	1	2	4.84	15.95	12.39
16 – 20	38	62	99	4	16	20	0.11	0.27	0.21
21 – 25	61	105	166	3	13	16	0.05	0.13	0.10
26 – 29	36	77	113	2	10	12	0.05	0.13	0.10
30 – 39	142	232	374	5	19	24	0.04	0.08	0.06
40 – 49	130	279	408	3	13	16	0.02	0.05	0.04
50 – 59	77	199	275	3	10	12	0.03	0.05	0.04
60 – 64	9	50	59	1	4	5	0.13	0.08	0.09
65+	19	54	73	3	9	12	0.14	0.17	0.16
Total	510	1,056	1,566	23	97	120	0.05	0.09	0.08

Western Australia – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	3	20	23	72.57	230.13	179.68
16 – 20	38	62	99	135	189	324	3.60	3.07	3.27
21 – 25	61	105	166	104	194	298	1.72	1.85	1.80
26 – 29	36	77	113	64	118	182	1.80	1.53	1.61
30 – 39	142	232	374	126	244	370	0.89	1.05	0.99
40 – 49	130	279	408	113	182	294	0.87	0.65	0.72
50 – 59	77	199	275	89	115	205	1.16	0.58	0.74
60 – 64	9	50	59	22	41	63	2.47	0.82	1.07
65+	19	54	73	63	100	164	3.34	1.87	2.26
Total	510	1,056	1,566	721	1,207	1,927	1.41	1.14	1.23

Tasmania – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	<1	<1	<1	0	0	0	0.00	0.00	0.00
16 – 20	4	13	17	1	3	4	0.29	0.20	0.22
21 – 25	7	15	22	1	2	3	0.12	0.15	0.14
26 – 29	22	24	46	<1	1	1	0.01	0.05	0.03
30 – 39	23	41	64	1	3	4	0.03	0.07	0.06
40 – 49	34	46	80	1	2	3	0.02	0.04	0.03
50 – 59	10	42	52	1	3	4	0.10	0.07	0.07
60 – 64	3	8	10	0	0	0	0.00	0.00	0.00
65+	6	26	32	1	3	4	0.09	0.12	0.11
Total	108	215	323	5	17	22	0.05	0.08	0.07

Tasmania – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	<1	<1	<1	0	0	1	1.09	49.23	3.12
16 – 20	4	13	17	6	17	23	1.56	1.33	1.38
21 – 25	7	15	22	5	14	19	0.76	0.93	0.88
26 – 29	22	24	46	5	8	12	0.21	0.31	0.27
30 – 39	23	41	64	10	13	23	0.43	0.32	0.36
40 – 49	34	46	80	9	13	22	0.28	0.28	0.28
50 – 59	10	42	52	9	7	16	0.89	0.17	0.30
60 – 64	3	8	10	2	3	5	0.87	0.34	0.47
65+	6	26	32	8	15	23	1.29	0.56	0.71
Total	108	215	323	55	90	144	0.51	0.42	0.45

ACT – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	0	0	0	0.00	0.00	0.00
16 – 20	6	6	12	0	0	0	0.00	0.00	0.00
21 – 25	10	18	28	0	1	1	0.00	0.04	0.03
26 – 29	9	17	26	0	1	1	0.02	0.04	0.03
30 – 39	28	44	72	0	1	1	0.01	0.01	0.01
40 – 49	25	44	69	0	0	0	0.00	0.00	0.00
50 – 59	11	35	45	0	1	1	0.02	0.02	0.02
60 – 64	1	17	18	0	0	0	0.00	0.00	0.00
65+	2	4	6	1	1	2	0.59	0.24	0.36
Total	91	185	276	2	4	6	0.02	0.02	0.02

ACT – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	0	0	0	0.00	0.00	0.00
16 – 20	6	6	12	4	4	7	0.59	0.67	0.63
21 – 25	10	18	28	3	5	8	0.32	0.26	0.28
26 – 29	9	17	26	1	4	5	0.16	0.24	0.21
30 – 39	28	44	72	6	4	10	0.22	0.09	0.14
40 – 49	25	44	69	2	4	6	0.09	0.08	0.08
50 – 59	11	35	45	2	2	3	0.15	0.05	0.07
60 – 64	1	17	18	1	0	1	1.31	0.01	0.08
65+	2	4	6	8	5	13	4.14	1.21	2.18
Total	91	185	276	28	27	55	0.31	0.15	0.20

Northern Territory – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	0	0	0	0.00	0.00	2.26
16 – 20	1	2	3	1	1	2	0.50	0.62	0.58
21 – 25	3	6	9	1	3	4	0.25	0.52	0.43
26 – 29	2	7	9	0	1	2	0.10	0.20	0.18
30 – 39	7	16	22	1	5	6	0.15	0.31	0.26
40 – 49	5	10	15	0	2	2	0.08	0.19	0.16
50 – 59	2	33	34	1	1	2	0.41	0.03	0.05
60 – 64	0	3	3	0	1	1	0.00	0.20	0.20
65+	0	4	4	0	1	1	41.07	0.17	0.28
Total	20	81	100	4	15	19	0.22	0.19	0.19

Northern Territory – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
09 – 15	0	0	0	0	3	4	0.00	36.15	40.67
16 – 20	1	2	3	16	22	38	13.35	9.98	11.15
21 – 25	3	6	9	12	26	38	3.88	4.20	4.09
26 – 29	2	7	9	10	19	29	4.75	2.78	3.23
30 – 39	7	16	22	22	32	53	3.20	2.01	2.37
40 – 49	5	10	15	16	21	37	3.30	2.05	2.45
50 – 59	2	33	34	10	13	23	6.99	0.39	0.67
60 – 64	0	3	3	3	3	7	91.55	1.12	2.22
65+	0	4	4	3	6	9	308.03	1.77	2.61
Total	20	81	100	92	146	238	4.75	1.81	2.38

APPENDIX B CRASH RATES BY AGE AND GENDER FOR DIFFERENT TRAVEL MODES, QUEENSLAND

Car drivers – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	3	6	9	1	0	1	0.26	0.03	0.11
17 – 24	121	235	356	9	30	39	0.07	0.13	0.11
25 – 29	101	207	309	2	12	14	0.02	0.06	0.05
30 – 39	241	481	722	5	16	21	0.02	0.03	0.03
40 – 49	206	448	655	7	10	17	0.03	0.02	0.03
50 – 59	117	389	507	6	7	13	0.05	0.02	0.03
60+	72	277	349	8	20	28	0.11	0.07	0.08
Total	863	2,044	2,907	36	96	132	0.04	0.05	0.05

Car drivers – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	3	6	9	6	19	25	2.01	3.24	2.81
17 – 24	121	235	356	373	460	833	3.08	1.96	2.34
25 – 29	101	207	309	143	169	313	1.41	0.82	1.01
30 – 39	241	481	722	251	257	508	1.04	0.53	0.70
40 – 49	206	448	655	204	202	406	0.99	0.45	0.62
50 – 59	117	389	507	165	152	318	1.41	0.39	0.63
60+	72	277	349	170	228	398	2.34	0.82	1.14
Total	863	2,044	2,907	1,313	1,487	2,800	1.52	0.73	0.96

Car passengers – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	338	411	750	7	9	17	0.02	0.02	0.02
17 – 24	134	107	241	8	17	25	0.06	0.16	0.10
25 – 29	98	45	143	2	2	4	0.02	0.04	0.03
30 – 39	160	52	213	3	4	7	0.02	0.07	0.03
40 – 49	191	57	248	2	2	4	0.01	0.04	0.02
50 – 59	252	91	343	3	2	4	0.01	0.02	0.01
60+	58	11	68	7	4	11	0.11	0.37	0.16
Total	1,230	775	2,005	32	40	72	0.03	0.05	0.04

Car passengers – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	338	411	750	162	140	303	0.48	0.34	0.40
17 – 24	134	107	241	216	227	442	1.61	2.13	1.84
25 – 29	98	45	143	56	56	112	0.58	1.23	0.79
30 – 39	160	52	213	86	64	150	0.54	1.23	0.71
40 – 49	191	57	248	70	36	106	0.37	0.62	0.43
50 – 59	252	91	343	66	26	91	0.26	0.28	0.27
60+	58	11	68	135	37	172	2.35	3.45	2.52
Total	1,230	775	2,005	791	585	1,377	0.64	0.76	0.69

Motorcyclists – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	0	1	1	0	2	2	0.00	2.29	1.73
17 – 24	2	15	16	0	9	9	0.00	0.59	0.53
25 – 29	0	8	8	0	8	8	0.98	1.00	1.00
30 – 39	0	14	14	0	13	14	3.41	0.94	0.96
40 – 49	0	6	6	0	6	7	0.94	1.12	1.11
50 – 59	0	5	5	0	3	3	0.00	0.68	0.63
60+	0	0	0	0	2	3	5.38	18.57	15.62
Total	3	49	52	1	44	46	0.40	0.91	0.88

Motorcyclists – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 - 16	1	0	3	6	0	1	4.72	-	-
17 – 24	2	15	16	12	170	183	8.32	11.67	11.36
25 – 29	0	8	8	3	96	98	13.73	11.62	11.67
30 – 39	0	14	14	4	166	170	34.13	11.78	11.97
40 – 49	0	6	6	2	127	129	5.14	22.21	21.02
50 – 59	0	5	5	3	58	60	6.08	11.60	11.16
60+	0	0	0	1	8	8	16.15	60.34	50.48
Total	3	49	52	25	630	655	8.23	12.94	12.67

Bicyclists – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	8	23	30	0	2	2	-	0.11	0.08
17 – 24	2	6	9	0	1	1	-	0.12	0.09
25 – 29	1	2	3	0	1	1	-	0.29	0.21
30 – 39	1	3	3	0	1	1	-	0.39	0.31
40 – 49	1	2	2	0	1	1	-	0.50	0.38
50 – 59	1	3	3	0	1	1	0.54	0.22	0.29
60+	0	1	1	0	2	2	-	3.34	2.82
Total	13	39	51	0	8	8	0.03	0.20	0.16

Bicyclists – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 16	8	23	30	12	76	88	1.51	3.37	2.90
17 – 24	2	6	9	10	38	48	4.36	5.94	5.53
25 – 29	1	2	3	5	20	25	6.09	9.39	8.46
30 – 39	1	3	3	8	37	45	11.60	14.38	13.78
40 – 49	1	2	2	6	33	38	12.31	20.19	18.41
50 – 59	1	3	3	2	16	18	2.95	5.80	5.18
60+	0	1	1	2	19	21	20.40	40.08	37.02
Total	13	39	51	44	238	282	3.46	6.18	5.50

Pedestrians – Fatalities

Age groups	Estimated annual travel (10 million km)			Fatalities (annual average)			Annual fatality rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 15	14	17	32	3	3	6	0.18	0.19	0.18
16 – 24	6	5	11	3	6	8	0.43	1.21	0.77
25 – 29	2	2	5	0	3	3	0.17	1.29	0.70
30 – 39	5	6	10	1	3	4	0.27	0.56	0.43
40 – 49	4	4	8	1	3	5	0.29	0.83	0.56
50 – 59	8	7	15	0	4	5	0.05	0.65	0.31
60+	2	2	3	4	8	11	2.07	4.45	3.25
Total	42	42	84	12	30	42	0.29	0.71	0.50

Pedestrians – Serious injuries

Age groups	Estimated annual travel (10 million km)			Serious injuries (annual average)			Annual serious injury rate		
	Female	Male	Total	Female	Male	Total	Female	Male	Total
9 – 15	14	17	32	41	64	104	2.83	3.68	3.29
16 – 24	6	5	11	32	48	80	5.25	10.44	7.50
25 – 29	2	2	5	11	22	32	4.54	9.95	7.12
30 – 39	5	6	10	19	29	49	4.34	5.19	4.82
40 – 49	4	4	8	19	25	44	4.55	6.21	5.38
50 – 59	8	7	15	14	23	37	1.64	3.52	2.46
60+	2	2	3	36	36	72	20.58	20.97	20.78
Total	42	42	84	171	247	418	4.12	5.88	5.00

INFORMATION RETRIEVAL

Austroads, 2010, **The Road Safety Consequences of Changing Travel Modes**, Sydney, A4, 79pp, AP-R361/10

Keywords:

Modal shift, road safety, transport mode, accident rate, travel behaviour, forecast.

Abstract:

The objective of the project was to provide policy makers with information about the likely effects of changes in travel mode on road casualties. Travel estimates from an earlier travel survey were updated by applying current population and vehicle use. Although this survey is now quite old, it was the only Australia-wide data which provided breakdowns by gender, age, time of travel and travel mode. Fatalities and serious injuries for each of the cells in the analysis were divided by the travel estimates to provide fatality rates. Scenarios were developed to illustrate the consequences of modal shift on fatalities and serious injuries. Fatality rates for all classes of road user were found to have decreased since 1985. Travel as a car passenger was the safest mode, followed closely by travel as a car driver. Travel by bicycle and walking were the next safest, and motorcycling the least safe. Scenarios which involved increases in walking, bicycling or motorcycling were estimated to produce increases in fatalities and injuries, particularly the latter. Fatality rates and serious injury rates for motorcyclists during commuting times were approximately half what they were at other times. Riders aged 40 and over had almost double the fatality and serious injury rates of those aged 25 and under. Switching from travelling as a car driver to travel as a car passenger was likely to have a small beneficial effect, but switching from car driving to travel by motorcycle is likely to substantially increase deaths and injuries. Changes from car driving to other modes would also result in increases in the road toll, but by smaller amounts. Switching from travelling as a car driver to travelling as a bus passenger would have little effect, gains from safer bus travel being negated by losses due to greater pedestrian exposure. Projected increases in freight movements also present a major challenge. A doubling in the freight task from its present levels would result in approximately 290 additional deaths and 6,500 additional serious injuries per year. These estimates are sensitive to the mix of vehicles which would be used to carry out the expanded freight task. Strategies to address the threats to maintaining progress in reducing road deaths and injuries are suggested, including ongoing monitoring of exposure, ensuring low-cost alternatives to motorcycling, improving the safety of bicycling, walking and freight operations, and encouraging travel as a car passenger.