

Guide to Road Safety Part 5
Road Safety for Rural and Remote Areas



Austroads



Guide to Road Safety Part 5: Road Safety for Rural and Remote Areas



Austroads

Sydney 2006

Guide to Road Safety Part 5: Road Safety for Rural and Remote Areas

First edition project manager: Bill Frith

First edition prepared by: Michael Tziotis, Philip Roper, Colin Edmonston and Prof Mary Sheehan

Abstract

Road trauma in rural and remote areas of Australia is a major national road safety problem. Although well over half of all fatal crashes occur on roads within these environments, it has not been until the past decade that road safety strategies and programs have focused on these areas. In an endeavour to provide a more comprehensive understanding of the nature and causes of crashes in rural and remote areas, and to identify measures and future directions that will result in reduced road trauma, Austroads commissioned ARRB Group to undertake a major study into safety in rural and remote areas of Australia. The study involved the analysing of crash data in these environments, a major literature review and consultation.

Keywords

road safety in rural and remote areas, ITS and road safety, road environment safety, roadside hazards, road environment safety, Indigenous people, trauma management.

Edition 1.1 published August 2018

- Format updated

Edition 1.0 published November 2006

ISBN 1 921139 77 3

Pages 55

Austroads Project No. SP1051

Austroads Publication No. AGRS05-06

© Austroads Ltd 2006

This work is copyright. Apart from any use as permitted under the *Copyright Act 1968*, no part may be reproduced by any process without the prior written permission of Austroads.

Publisher

Austroads Ltd.
Level 9, 287 Elizabeth Street
Sydney NSW 2000 Australia

Phone: +61 2 8265 3300

austroads@austroads.com.au
www.austroads.com.au



Austroads

About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Roads and Maritime Services New South Wales
- Roads Corporation Victoria
- Queensland Department of Transport and Main Roads
- Main Roads Western Australia
- Department of Planning, Transport and Infrastructure South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Australian Government Department of Infrastructure and Regional Development
- Australian Local Government Association
- New Zealand Transport Agency.

Acknowledgements

Due acknowledgement is given to significant contributions provided by:

- Dr Nick Mabbott (ARRB Group)
- Dr Tanya Styles (ARRB Group)
- Dr Jonathan Dwyer (CARRS-Q)

This Guide is produced by Austroads as a general guide. Its application is discretionary. Road authorities may vary their practice according to local circumstances and policies. Austroads believes this publication to be correct at the time of printing and does not accept responsibility for any consequences arising from the use of information herein. Readers should rely on their own skill and judgement to apply information to particular issues.

Summary

Fatal road crashes in 'rural and remote areas' of Australia and New Zealand are a major cause of road safety concern. About 60% of all fatal road crashes in Australia occur on rural roads, while for New Zealand the proportion is much higher at 70%. Annually in Australia there are approximately 893 fatal crashes per year (1999 to 2003), while in New Zealand there are about 278 fatal crashes per year (1999 – 2003).

Up until the mid-1990s in Australia there was limited attention paid to improving road safety in rural and remote areas when compared to improving safety in urban areas. In recognition of this inadequacy, the Australian Transport Council and transport ministers from all states and territories, and the federal government initiated a separate rural and remote road safety action plan (developed by the National Road Safety Strategy Implementation Task Force) in 1996.

Since the release of the *Australian Rural Road Safety Action Plan* during 1996, the Australian Transport Safety Bureau, in coordination with key stakeholder groups, developed the *National Road Safety Strategy 2001 – 2010*, which is supported by 2-year *Road Safety Action Plans* (e.g. 2001 and 2002, 2003 and 2004, and 2005 and 2006). As part of the 2001 – 2010 strategy a range of measures was proposed which focused on improving safety in rural and remote areas. It should be noted though that the measures adopted by each jurisdiction and their detail varied to reflect local conditions and priorities.

In New Zealand, rural and remote safety issues tend to be addressed by regional plans and activity arising from data analysis carried out by Land Transport New Zealand (LTNZ), often in collaboration with the local authorities concerned. Annually LTNZ produces road safety issues reports for each local authority highlighting issues that require attention, and any rural and remote safety issues would be highlighted within.

In New Zealand there is not a specific focus on rural and remote road safety in the nation's Road Safety 2010 strategy and supporting action plans. There is however, emphasis on issues such as fatigue and speeding, which often are key safety problems in rural and remote areas.

Defining 'rural and remote' areas and roads

While jurisdictions across Australasia provide a wide range of definitions of 'rural and remote' areas, the definition adopted in this publication is based on the definition used by the Australian Government's Department of Health and Ageing, i.e. the Rural, Remote and Metropolitan Areas (RRMA) classification system. This system is based on the ranking of population centres which range from categories 1 and 2 (i.e. metro areas), to categories 3 to 7 (i.e. rural and remote areas).

'Rural and remote' roads are defined as roads that traverse a road environment with little or no abutting roadside development. As such these roads are defined as non-urban roads; undivided with a speed limit of 80 km/h, which is indicative of a road with sparse roadside development, and all other roads that have a speed limit greater than 80 km/h.

Crashes on rural and remote roads

Analysis of crash data (1999 to 2003), using the above definition for 'rural and remote' roads revealed that:

- On average in Australia there have been 893 fatal crashes per year (17 fatal crashes per week), while in New Zealand there have been on average 278 fatal crashes (5 fatal crashes per week). These crashes resulted in an average of 1,025 fatalities per year (20 fatalities per week) for Australia and 336 fatalities (6 fatalities per week) for New Zealand.
- On Australian 'rural and remote' roads there have been on average 17,319 non-fatal injury crashes per year (333 non-fatal-injury crashes per week), that resulted in 22,443 non-fatal injuries per year (432 non-fatal injuries per week).

- On New Zealand 'rural and remote' roads there have been 3,110 non-fatal injury crashes (60 per week) that resulted in 5,277 non-fatal injuries (101 non-fatal injuries per week).
- Off-path and same direction (i.e. side-swipe, rear-end and lane change types of crashes) are the predominating types of crashes on rural and remote roads.

At-risk groups

Groups found to be most at-risk of being involved in a crash include:

- local residents
- young male drivers
- truck drivers
- indigenous people.

Vehicle crash risk factors

Vehicles that have relatively high relative crash risks include:

- motorcycles
- rigid and articulated trucks.

Environmental crash risk factors

Environmental crash risk factors include:

- road condition (e.g. shoulders, surface, alignment, etc.)
- road design (e.g. divided/undivided, number of lanes, site distance, delineation, etc.)
- roadside environment (e.g. trees, culverts, embankments)
- speed limits (i.e. inconsistent or inappropriate).

Behavioural crash risk factors

Behavioural crash risk factors include:

- driving under the influence of alcohol and other drugs
- speeding
- fatigue
- failure to wear seat belts
- failure to wear helmets.

Post crash risk factors

Key factors in the severity outcome of road crashes include:

- emergency response and retrieval times
- the level of rehabilitation services available.

Key safety actions

Summarised below are key road safety measures that may be implemented in 'rural and remote' areas, or on non-urban 'rural and remote' roads to assist to reduce the level of road trauma.

Community education

- Driver behaviours and attitude in relation to alcohol, excessive speed, seatbelt compliance and driving while fatigued need to be improved, through increased enforcement, education and promotion.
- Promoting road safety within the community.

Enforcement and deployment styles

- While education, advertising and community change strategies are integral road safety interventions, traffic legislation and ongoing police enforcement need to be core components of all rural and remote road safety campaigns.
- With appropriate penalty regimes and publicity, deterrence-based enforcement has been shown to consistently achieve positive long-term behavioural change in drivers and the general population. However, due to the length of the rural road network, enforcement by conventional means is not always ideal or practical.
- Rural enforcement programs need to utilise randomised scheduling or deployment methods to enable low levels of police presence to achieve more widespread coverage of vast road networks.

Intelligent Transport Systems (ITS)

ITS technologies provide a high potential to reduce road trauma on rural and remote roads by improving:

- human behaviour (e.g. fatigue monitoring devices for heavy vehicle drivers)
- the road environment (e.g. variable speed limits, advisory speed and warning signs)
- vehicle design (e.g. electronic stability control, ABS brakes, seat belt and alcohol interlock devices)
- crash notification systems to reduce the amount of time taken to provide emergency medical services (e.g. Advanced Automatic Crash Notification system and ECall mayday system).

Road safety auditing and risk assessment

- Road safety auditing is a fundamental process in maximising the safety of the road network and minimising road trauma. The audit process has the potential to identify deficiencies and associated treatments with a significantly high return on investment.
- Improved risk assessment and risk management of hazards identified through the road safety audit process will allow for the treatment of deficiencies that pose the greatest risk to road users to be given priority. Taking this approach ensures that the highest crash risk reduction may be achieved for a given budget.

Treatment of blackspots

Australian and New Zealand research has also shown that blackspot programs are able to deliver high returns for monies spent. An evaluation by the Australian Bureau of Transport Economics (2001) found that during the first three years of the Federal Blackspot Program 1996-2002, a benefit-cost ratio (BCR) of 14:1 was able to be achieved. A similar study in New Zealand (Land Transport Safety Authority 2004), using a willingness to pay approach, found that a BCR of 28:1 was attained. It should be noted that the New Zealand approach places a higher value on safety benefits that may be achieved when remedial treatments are installed contributing to a higher BCR.

Changes to road design and infrastructure improvements

Key improvements include:

- widening and sealing of road shoulders

- improving protection around bridges and drains
- improved delineation (i.e. guide posts, line markings, guide posts and chevron alignment markers)
- increased usage of tactile edge lining
- treatment of roadside hazards (e.g. trees, drains, culverts, steep embankments, etc.)
- provision of more overtaking lanes
- improved road maintenance practices
- improved road surfacing
- improving signage (i.e. advisory and hazard warning signs)
- improving sight distance at intersections.

Medical interventions and trauma management

Key improvements include:

- increased emergency medicine (paramedical) training to be given to rural nurses and GPs who are often the first to respond at rural crash scenes
- improved communication links and liaison between rural and regional medical staff and the Government to increase support for localised efforts to develop comprehensive trauma management systems (that include regular audits).

Contents

1.	Introduction.....	1
1.1	Background	1
1.2	Defining 'rural and remote' areas	1
1.3	Objectives of the guide	3
2.	Crashes on Rural and Remote Roads	4
2.1	Rural and remote fatal crash trends	4
2.2	Rural and remote casualty crash trends	4
2.3	Severity of casualty crashes on rural and remote roads	5
2.4	Rural and remote casualty crashes by type of crash	6
2.5	Rural and remote casualty crashes by time of day, day of week and month of year	6
2.6	Rural and remote casualty crashes by light and weather conditions	9
2.7	Rural and remote casualty crashes by speed zone	10
2.8	Rural and remote casualty crashes by type of location.....	11
2.9	Casualties on rural and remote roads	11
2.10	Rural and remote casualties by age and sex	12
2.11	Rural and remote casualties by restraint and helmet use	13
3.	Risk Factors	14
3.1	Behavioural crash factors	14
3.1.1	Overview of risk characteristics	14
3.1.2	Crash risk as a function of lifestyle, personality and attitudes	15
3.1.3	Crash severity as a function of seatbelt compliance	15
3.1.4	Crash risk as a function of driver fatigue	15
3.1.5	Crash risk and severity as a function of travelling speed	16
3.1.6	Crash risk as a function of alcohol consumption	17
3.1.7	Consistency of risk factors in rural regions: the Queensland experience	18
3.2	At-risk populations	19
3.2.1	Local residents	19
3.2.2	International visitors.....	19
3.2.3	Young male drivers.....	19
3.2.4	Indigenous communities.....	19
3.2.5	Truck drivers	20
3.3	Vehicle and environmental crash factors	20
3.3.1	Crash risk and severity as a function of vehicle type	21
3.3.2	Crash risk and severity as a function of vehicle safety features and design.....	21
3.3.3	High-risk modes of transport	22
3.3.4	Environmental risk factors	23
3.4	Post-crash factors.....	26
3.4.1	Crash outcome as a function of emergency response and retrieval time	26
3.4.2	Crash outcome as a function of rehabilitation services in rural areas.....	27
4.	Road Safety Countermeasures	29
4.1.1	Behavioural interventions	29
4.1.2	Vehicular interventions	34
4.1.3	Environmental safety measures	39
4.1.4	Medical interventions and trauma management	45
	References	47

Tables

Table 1.1: RRMA classification system	2
Table 2.1: Average annual casualty crash severity in rural and remote areas (1999 to 2003) - Australia and New Zealand.....	6
Table 2.2: Average annual casualty severity in rural and remote areas (1999 to 2003) - Australia and New Zealand.....	12
Table 3.1: Times of day and week (shaded) when casualty crashes are at least 10 times more likely to involve alcohol	17
Table 3.2: Urban fatalities by nature of crash, 1994-2000 per 100,000 population	18
Table 3.3: Rural fatalities by nature of crash, 1994-2000 per 100,000 population.....	18
Table 3.4: Hospital admissions for Northern Queensland 1995/6-1998/9	23
Table 3.5: Percentage dying before medical attention in urban and rural regions (not including pedestrian or two-wheeled).....	27
Table 4.1: An overview of fatigue countermeasures	30
Table 4.2: Effective behavioural interventions in rural and remote communities	34
Table 4.3: ITS applications to rural road safety	36
Table 4.4: Core elements of effective environmental safety measures	44
Table 4.5: Core elements of effective medical interventions and trauma management	46

Figures

Figure 2.1: Fatal crash trends (1999-2003) - Australia and New Zealand	4
Figure 2.2: Casualty crash trends (1999 to 2003) - Australia and New Zealand	5
Figure 2.3: Average annual casualty crashes by crash type (1999 to 2003) - Australia and New Zealand	6
Figure 2.4: Average annual casualty crashes by time of day (1999 to 2003) - Australia and New Zealand	7
Figure 2.5: Average annual casualty crashes by day of week (1999 to 2003) - Australia and New Zealand.....	8
Figure 2.6: Average annual casualty crashes by month of year (1999 to 2003) - Australia and New Zealand.....	8
Figure 2.7: Average annual casualty crashes by light condition (1999 to 2003) - Australia and New Zealand.....	9
Figure 2.8: Average annual casualty crashes by weather condition (1999 to 2003) - Australia and New Zealand.....	10
Figure 2.9: Average annual casualty crashes by speed zone (1999 to 2003) - Australia and New Zealand.....	10
Figure 2.10: Average annual casualty crashes by location type (1999 to 2003) - Australia and New Zealand.....	11
Figure 2.11: Average annual male casualties by age group (1999 to 2003) - Australia and New Zealand	12
Figure 2.12: Average annual female casualties by age group, 1999 to 2003, Australia and New Zealand	13
Figure 2.13: Average annual casualties by restraint use, 1999 to 2003, Australia and New Zealand	13
Figure 4.1: Typical intersection treatment	43
Figure 4.2: Typical curve treatment.....	43

1. Introduction

1.1 Background

Fatal road crashes in 'rural and remote' areas of Australia and New Zealand in Section 1.2, are a major cause of road safety concern. Based on road crash data 1999 to 2003 almost 60% of fatal crashes in Australia occur on rural roads, while for New Zealand the proportion is markedly higher at 70%. In Australia, on average there are about 893 fatal crashes per year (1999 to 2003), while in New Zealand there are about 278 fatal crashes per year (1999 – 2003) on rural roads.

Up until the mid-1990s in Australia the attention paid to improving road safety in rural and remote areas, relative to urban areas was limited. In 1996 the Australian Transport Council and transport ministers from all states and territories, and the federal government recognised the general lack of explicit road safety policies and interventions for rural and remote areas. As a result a separate rural and remote road safety action plan was developed (by the National Road Safety Strategy Implementation Task Force, 1996). The *Australian Rural Road Safety Action Plan* was designed to reduce the incidence and severity of road crashes in country areas by:

- increasing public awareness of the economic costs of rural crashes
- addressing known deficiencies in identified crash areas
- improving driver behaviour and attitudes toward alcohol, excessive speed, seatbelt compliance and driving while fatigued.

Since the release of the *Australian Rural Road Safety Action Plan* during 1996, the Australian Transport Safety Bureau, in coordination with key stakeholder groups, developed the *National Road Safety Strategy 2001 – 2010*, which is supported by 2-year *Road Safety Action Plans* (e.g. 2001 and 2002, 2003 and 2004, and 2005 and 2006). As part of the 2001 – 2010 strategy a range of measures were proposed which focused on improving safety in rural and remote areas. It should be noted, however, that the composition of the measures adopted by each jurisdiction and their detail varied to reflect local conditions and priorities.

In New Zealand, rural and remote safety issues tend to be addressed by regional plans and activity arising from data analysis carried out by Land Transport New Zealand (LTNZ), often in collaboration with the local authorities concerned. Annually LTNZ produces road safety issues reports for each local authority highlighting issues that require attention, and any rural and remote safety issues would be highlighted within.

In New Zealand there is not a specific focus on rural and remote road safety in the nation's Road Safety 2010 strategy and supporting action plans. There is however, emphasis on issues such as fatigue and speeding, which often are key safety problems in rural and remote areas.

1.2 Defining 'rural and remote' areas

Jurisdictions and government bodies across Australia and New Zealand provide a wide range of definitions of rural and remote areas. While it appears conceptually simple to differentiate between rural and urban settings, determining whether a crash had occurred in a rural and remote area, or along a rural and remote road may be unclear.

When defining a rural and remote area the key issues that arise are the characteristics of the road on which a crash may have occurred, and the level of access to emergency and medical services that can be provided to the crash victims. In the first instance, rural and remote road safety may be confined to roads that have speed limits greater than 80 km/h, while in the latter case the definition may be considered to apply in areas where population densities are such as to provide relatively low levels of access to emergency and medical services.

In an effort to develop a uniform indicator for rural, remote and urban areas, the Commonwealth Department of Health, Housing and Community Services developed the Rural and Remote Area (RaRA) classification system in 1990. Cowan (1997) describes the subsequent evolution of this framework into the Rural, Remote and Metropolitan Areas (RRaMA) classification system. This classification system reflected statistical breakdowns into zones based upon their remoteness, population and access to goods and services.

During 1994 the Australian Government Department of Health and Ageing introduced the Rural, Remote and Metropolitan Areas (RRMA) classification system as a general purpose tool to help make decisions relevant to rural and remote areas. The Department of Health and Ageing has since commenced a review of the RRMA classification system. The RRMA review, which is on-going, will be investigating reliable ways to measure need across the country using more robust and up-to-date data.

Table 1.1 provides the RRMA classification system used by the Australian Government Department of Health and Ageing to define 'metropolitan', 'rural' and 'remote' areas.

Table 1.1: RRMA classification system

RRMA category	Description of area	Examples
1 - Metro	Capital cities	Canberra ACT, Melbourne VIC, Sydney NSW, Brisbane QLD, Perth WA, Adelaide SA, Hobart TAS, Darwin NT and Wellington NZ ¹
2 - Metro	Metropolitan areas / urban with population > 100,000	Geelong VIC, Townsville and the Gold Coast QLD, Newcastle and Wollongong NSW, Auckland NZ, Christchurch NZ, Hamilton NZ and Dunedin NZ
3 - Rural	Large rural centre / urban population between 25,000 and 100,000	Mildura and Shepparton VIC, Lismore NSW, Mackay Qld, Launceston TAS, Whyalla SA, Queanbeyan NSW, Rotorua NZ and Nelson NZ
4 - Rural	Small rural centre / urban population between 10,000 and 25,000	Armidale NSW, Albany WA, Caloundra QLD, Devonport TAS, Mt Gambier SA, Whakatane NZ and Ashburton NZ
5 - Rural	Other rural area / urban population < 10,000	Swan Hill VIC, Batemans Bay NSW, Ayr Qld, St Helens TAS, Busselton WA, Port Vincent SA, Opotiki NZ and Picton NZ
6 - Remote	Remote centre / urban population > 5,000	Mt Isa QLD, Alice Springs NT, Kalgoorlie WA
7 - Remote	Other remote centre / urban population < 5,000	Kununurra WA, Birdsville QLD, Carrieton SA, Strahan TAS, Katherine NT, Murrayville VIC, Karamea NZ and Haast NZ

Source: Dept Health and Ageing Rural, Remote and Metropolitan Area (RRMA) Classification System 2005.

While the RRMA classification system meets the objective of the Department of Health and Ageing as a proxy measure for 'medical' access, based on the premise that the greater the level of 'remoteness' the poorer the access to health services, it only in part is a measure of the differentiation between urban and rural driving environments, and the responsiveness of emergency and medical services to road crash victims.

From a road safety perspective, rural and remote roads have no or sparse abutting roadside development or activity. Reducing the incidence and severity of crashes on these roads requires road and roadside improvements, police enforcement, public education, and minimising the emergency and medical response times to crashes on these roads.

¹ For the purposes of this guide New Zealand cities have been categorised within the RRMA classification system.

Consistent with the RRMA classification system and recognising that roads within the metropolitan RRMA 1 and 2 categories traverse road environments with no or sparse roadside development, the following definitions are provided:

- non-urban roads – undivided roads with a speed limit of 80 km/h², and all other roads that have speed limits greater than 80 km/h
- rural and remote cities or centres – categories RRMA 3 to RRMA 7.

These definitions specify:

- the roads upon which road and roadside improvements may be carried out, and where police may enforce
- cities where local road safety education programs may be developed and operated
- areas where emergency and medical response resources may be operated and improved.

1.3 Objectives of the guide

The purpose of this guide is to:

- quantify the road safety problem on rural and remote roads
- describe the characteristics of crashes on rural and remote roads
- identify the people who are at most risk of being involved in a crash
- identify the factors that contribute to the occurrence or increased severity of crashes
- provide measures that may be used to reduce the incidence and severity of crashes
- suggest ways in which safety initiatives may be monitored and evaluated so as to ensure that they are achieving their objectives.

The Austroads publication, *Road Safety in Rural and Remote Areas of Australia*, AP-R273/05, forms the basis upon which this guide has been prepared.

² 80 km/h speed limit applied to undivided roads is indicative of a road within an environment with sparse roadside development.

2. Crashes on Rural and Remote Roads

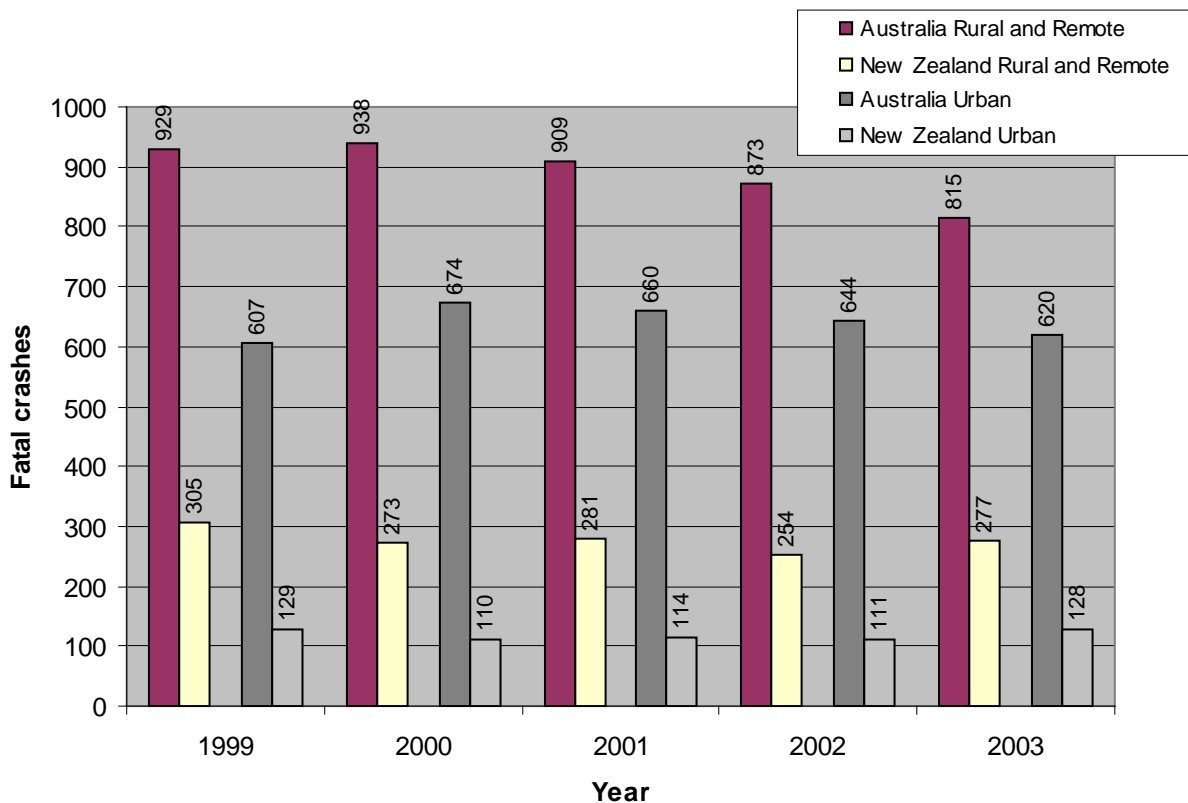
It should be noted that analysis of 'rural and remote' crash data nationally may differ from analysis by state and territory as they may define 'rural and remote' differently.

The following analysis provides crash trends and crash characteristics (1999 to 2003) on rural and remote roads in Australia and New Zealand. It should be noted, however, that the available data for Western Australia and Tasmania did not specify whether roads were divided or undivided. Therefore, all 80 km/h roads in Western Australia and Tasmania were excluded from analysis. South Australian data also did not contain casualty information for 2003, so the analysis covers only 1999 to 2002 for South Australia.

2.1 Rural and remote fatal crash trends

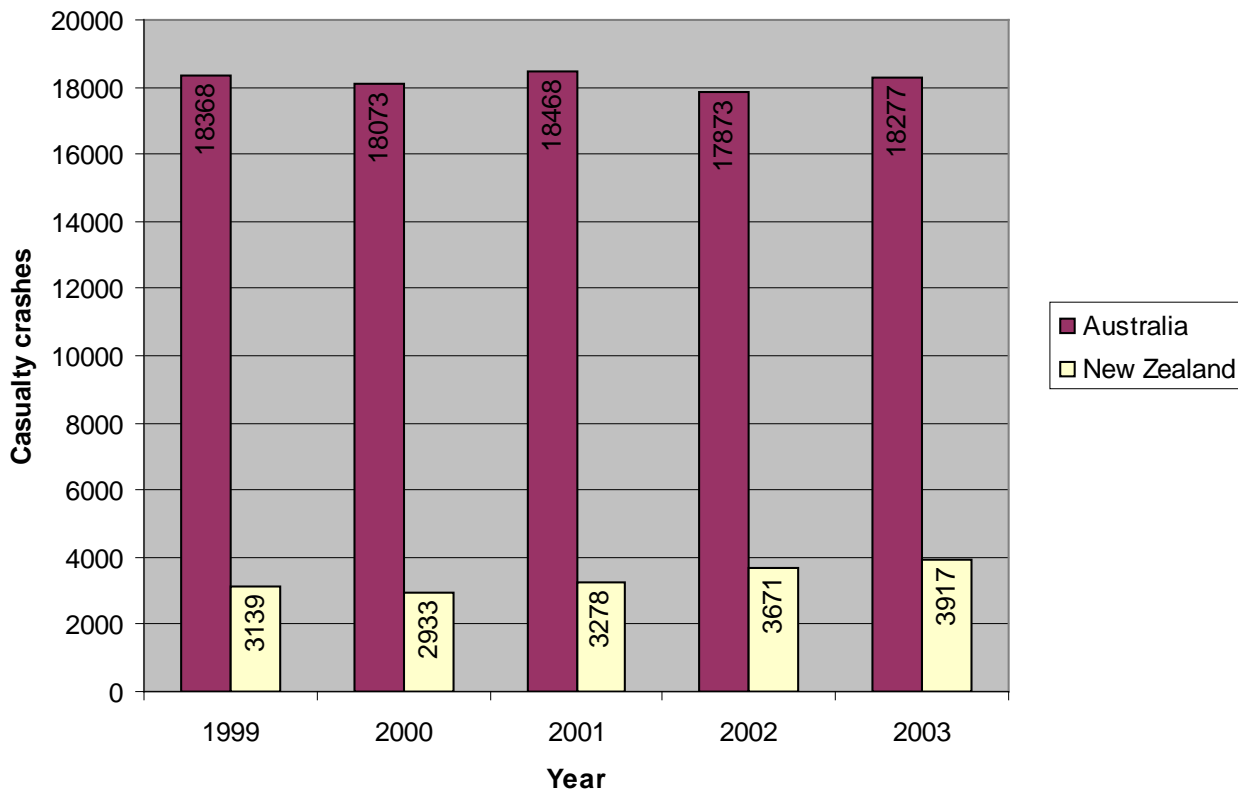
Figure 2.1 shows trends in fatal crash numbers for Australia and New Zealand. Annual rural and remote fatal crashes can be seen to fall by 114 in Australia over the five years, while in New Zealand they have remained relatively stable. Urban fatal crash numbers are also shown for comparison.

Figure 2.1: Fatal crash trends (1999-2003) - Australia and New Zealand



2.2 Rural and remote casualty crash trends

Figure 2.2 shows the number of recorded casualty (i.e. fatal and injury) crashes occurring each year across Australia and New Zealand for the period 1999 to 2003. Annual figures for Australia appear to have hovered around 18,000 crashes for the five year period. New Zealand's crash numbers rose from about 3,100 to 3,900 during the five years.

Figure 2.2: Casualty crash trends (1999 to 2003) - Australia and New Zealand

2.3 Severity of casualty crashes on rural and remote roads

While Australia's states and territories, and New Zealand use different classifications for the severity of crashes, most can be reliably divided among the fatal, serious injury and other injury categories. The exception to this is New South Wales, where crash severities are classed as either fatal or non-fatal injury. Accordingly, a comparison is made in Table 2.1 of fatal and non-fatal crashes in rural and remote areas across Australia and New Zealand for which severity information was provided. Values represent average annual crash numbers by severity for each country, averaged over the five years (1999-2003).

There was an average of 893 fatal crashes per year (17 fatal crashes per week) in Australia and 278 per year (5 fatal crashes per week) in New Zealand over the study period. During this period there were, on average, 17,319 non-fatal injury crashes per year (333 per week) in Australia and 3,110 per year (60 per week) in New Zealand.

Five per cent of the crashes in Australia were fatal, while 8 per cent of New Zealand crashes were fatal. These proportions were based on the sums of the fatal and non-fatal averages for each country. The equivalent Australian proportions in the serious injury and other injury columns were based on the sums of the fatal, serious and other injury averages and therefore do not include New South Wales.

Table 2.1: Average annual casualty crash severity in rural and remote areas (1999 to 2003) - Australia and New Zealand

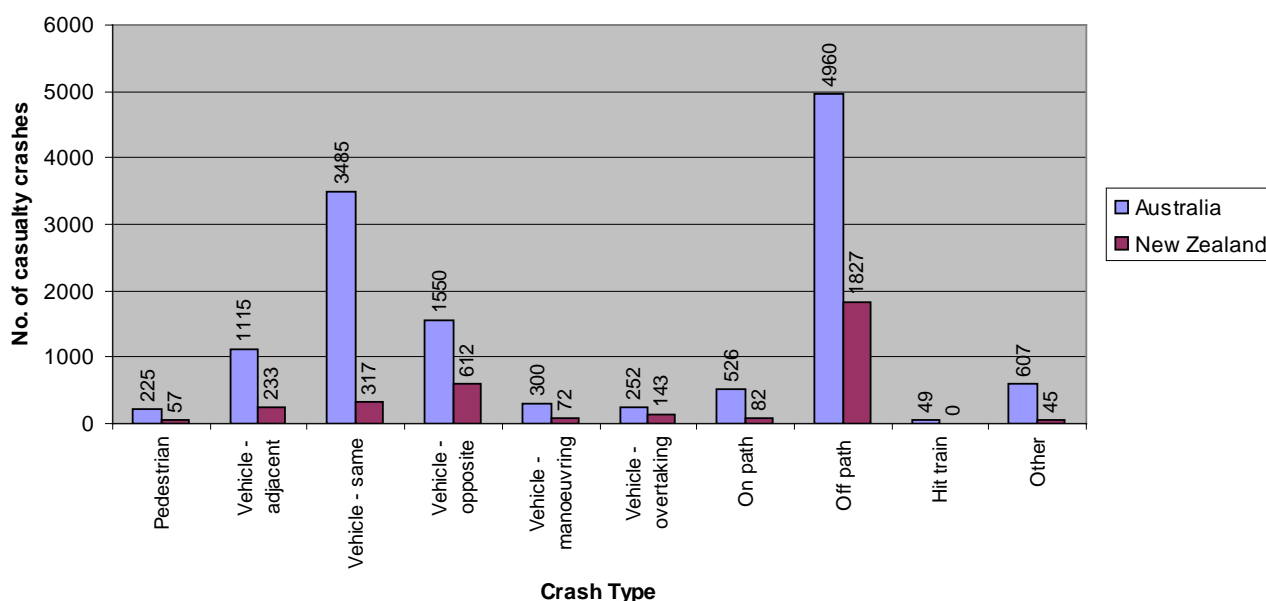
	Fatal		Non-fatal injury		Serious injury [^]		Other injury [^]		Average total fatal and non-fatal injury crashes
	crashes	%	crashes	%	crashes	%	crashes	%	
Australia	893	5	17,319	95	3,940	31	7,407	64	18,212
New Zealand	278	8	3,110	92	936	28	2,173	64	3,388

[^] Serious injury and other injury data not available for NSW; figures do not include this state. Percentages in these columns based on totals of average annual fatal, serious and other injury crashes for all states other than NSW. Non-fatal injuries, on the other hand, include NSW and so are more numerous.

2.4 Rural and remote casualty crashes by type of crash

Figure 2.3 shows average annual casualty crashes in Australia and New Zealand by crash type. Due to the variations in crash type definitions used across the jurisdictions, crashes had to be sorted into classes that were as close as possible to their actual crash types.

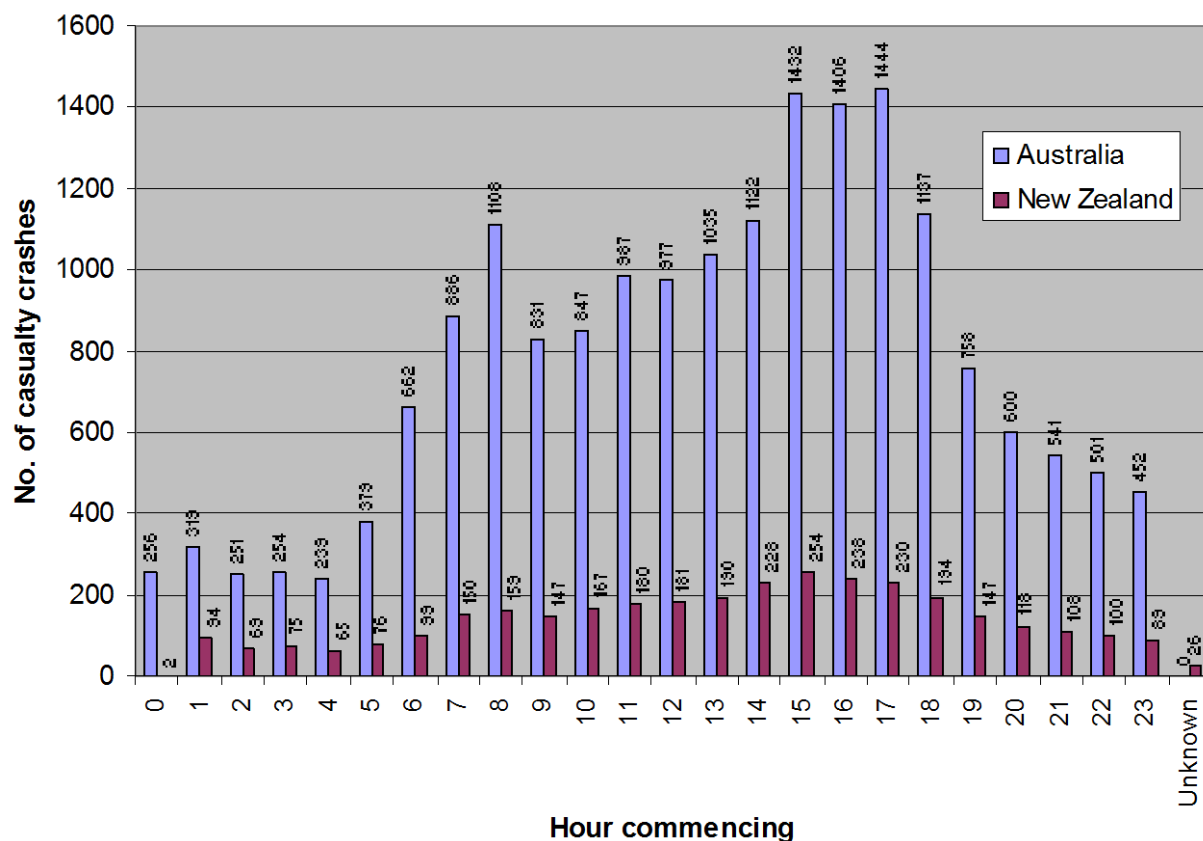
The chart reveals that off-path and same direction (i.e. rear-end, lane side swipe and lane change) crashes account for a large proportion of Australian casualty crashes. Also prominent in both countries are opposite-direction crashes (i.e. head-on crashes).

Figure 2.3: Average annual casualty crashes by crash type (1999 to 2003) - Australia and New Zealand

2.5 Rural and remote casualty crashes by time of day, day of week and month of year

Figure 2.4 depicts the distribution of average annual casualty crash numbers by time of day. A matter of concern is that after the evening peak period, crash numbers remained at nearly half the peak level until late at night. It is unlikely that traffic volumes through the night represented a similarly large proportion of daytime figures and this is an indicator that vehicles are much more likely to crash at night.

Figure 2.4: Average annual casualty crashes by time of day (1999 to 2003) - Australia and New Zealand



The spread of casualty crashes across the days of the week is shown in Figure 2.5. For Australia and New Zealand mid-week crash numbers are generally lower than Friday to Monday crash numbers. Australia recorded most crashes on Fridays while in New Zealand most crashes were recorded on Saturdays.

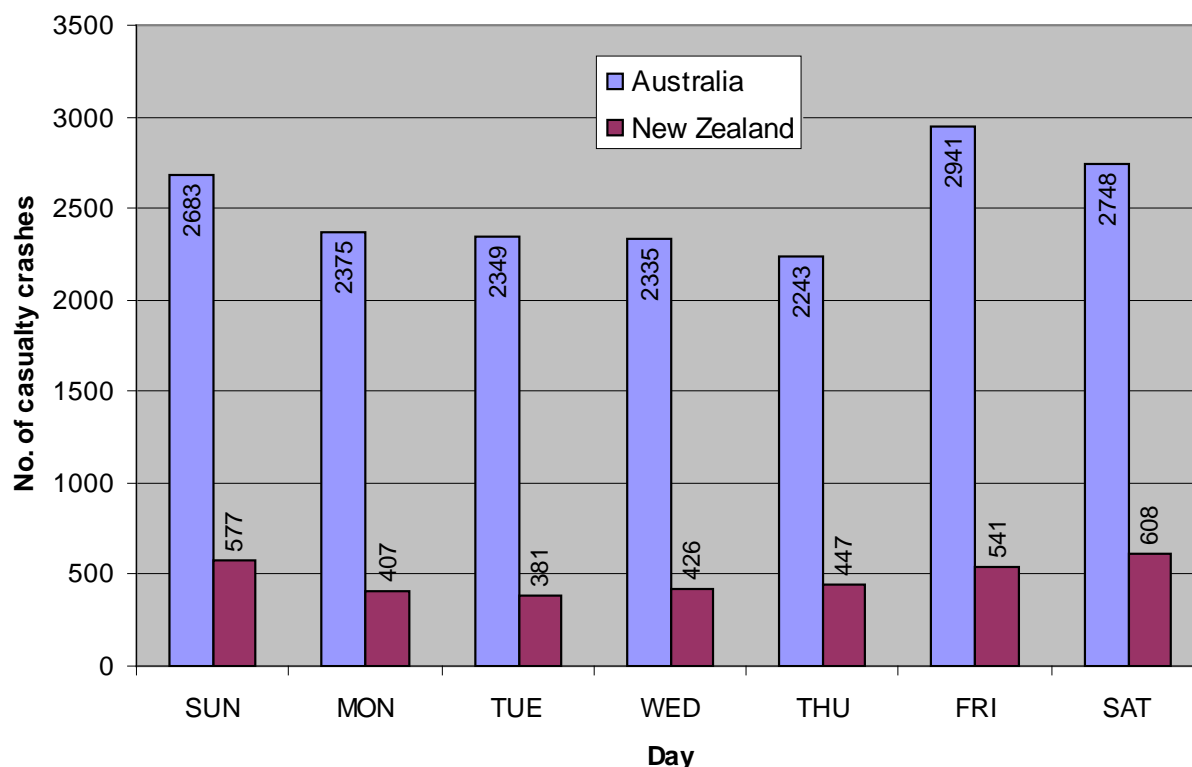
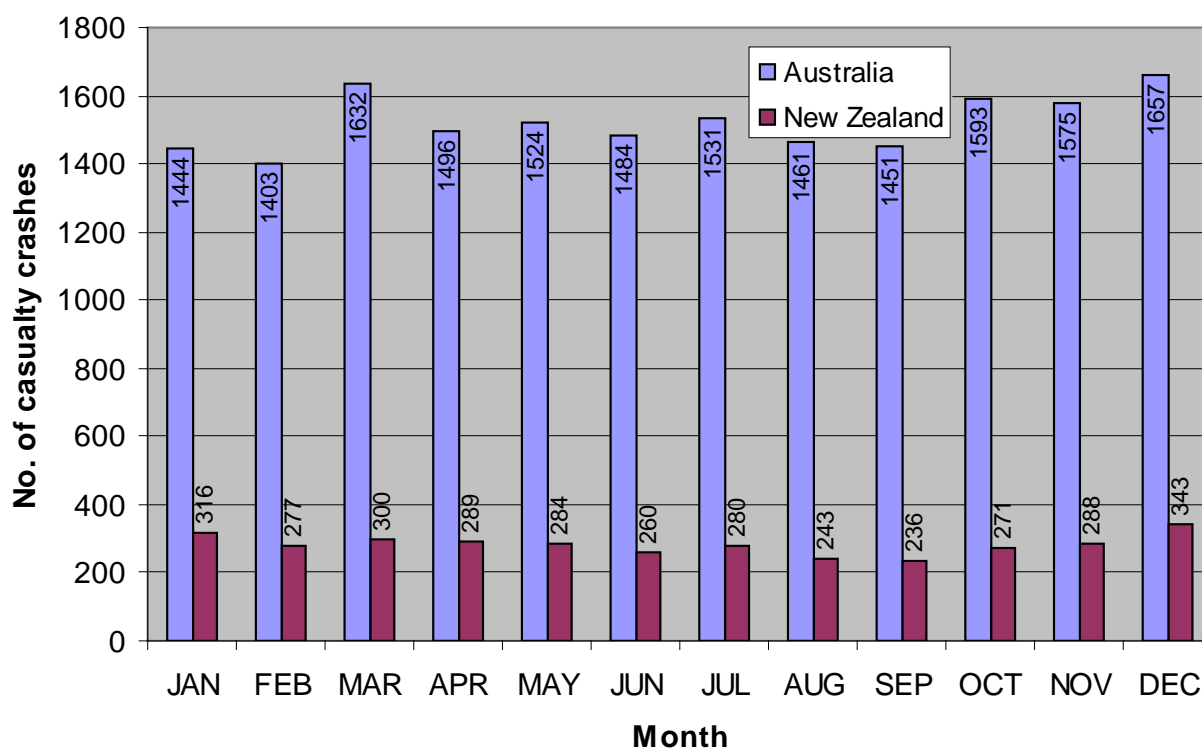
Figure 2.5: Average annual casualty crashes by day of week (1999 to 2003) - Australia and New Zealand

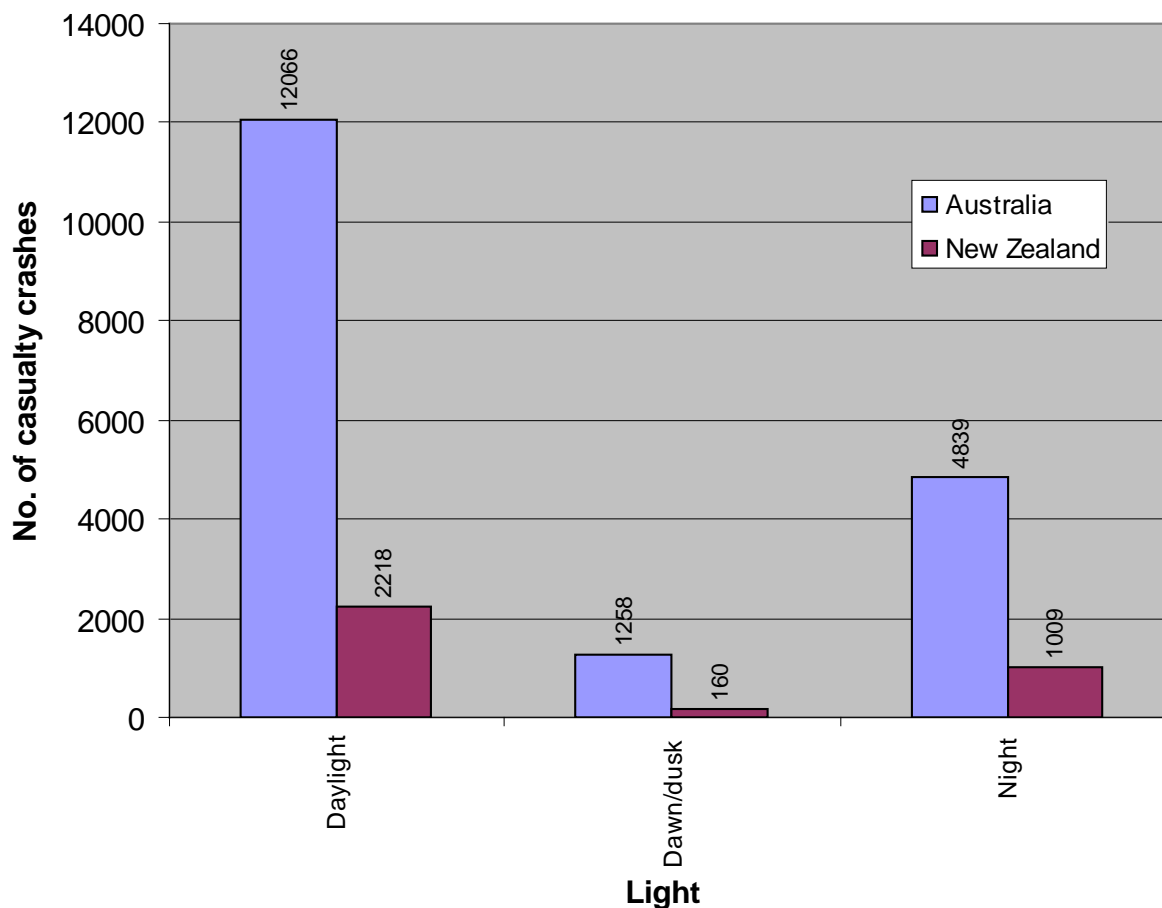
Figure 2.6 shows the average monthly casualty crash figures for each jurisdiction. The number of casualty crashes slightly increased during the summer holiday periods in both countries.

Figure 2.6: Average annual casualty crashes by month of year (1999 to 2003) - Australia and New Zealand

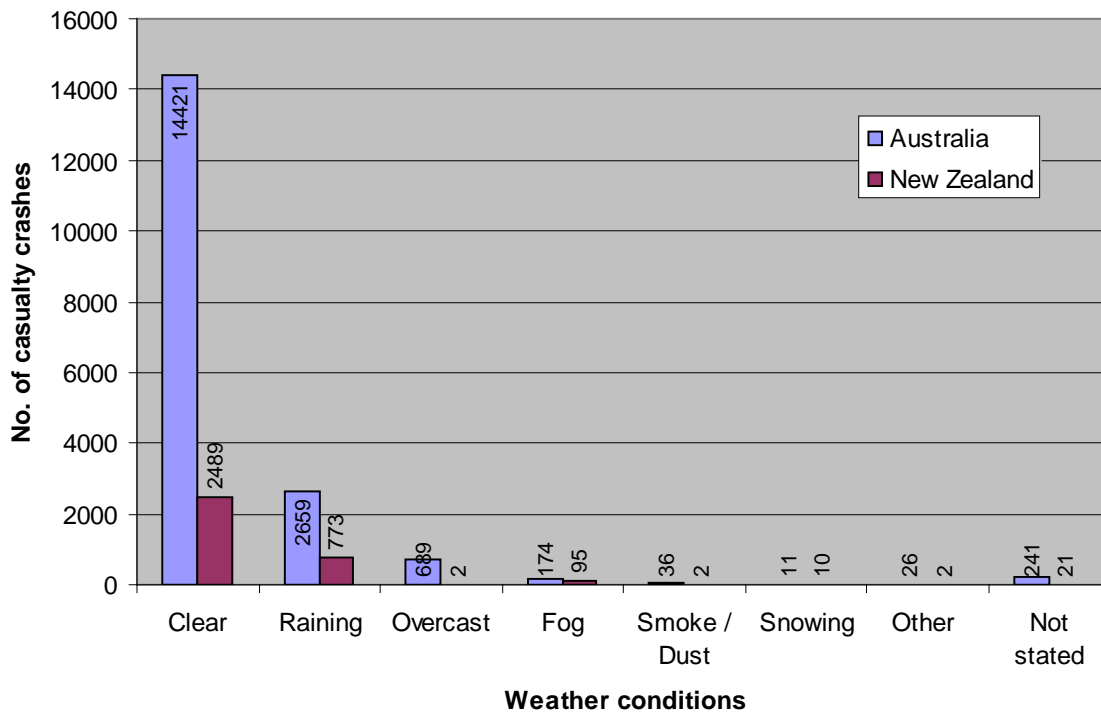
2.6 Rural and remote casualty crashes by light and weather conditions

As shown in Figure 2.7, most casualty crashes occur in daylight hours. This is to be expected because more traffic uses the roads at these times. The figure for 'night' crashes includes all night crashes in the columns to the right, regardless of street light status. This is because not all jurisdictions list presence or status of street lights, but all state whether crashes occurred at night or during the day.

Figure 2.7: Average annual casualty crashes by light condition (1999 to 2003) - Australia and New Zealand

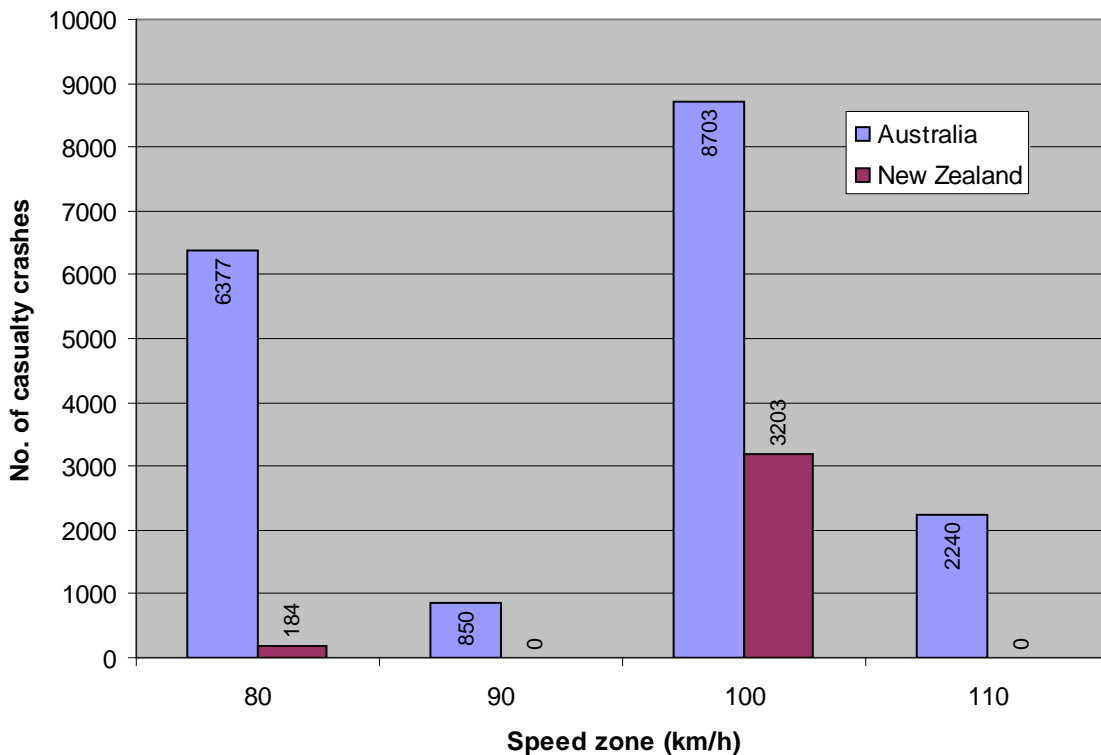


The vast majority of casualty crashes in both Australia and New Zealand occurred in clear weather conditions (Figure 2.8). Crashes during rain appear to represent a higher proportion of casualty crashes in New Zealand than in Australia.

Figure 2.8: Average annual casualty crashes by weather condition (1999 to 2003) - Australia and New Zealand

2.7 Rural and remote casualty crashes by speed zone

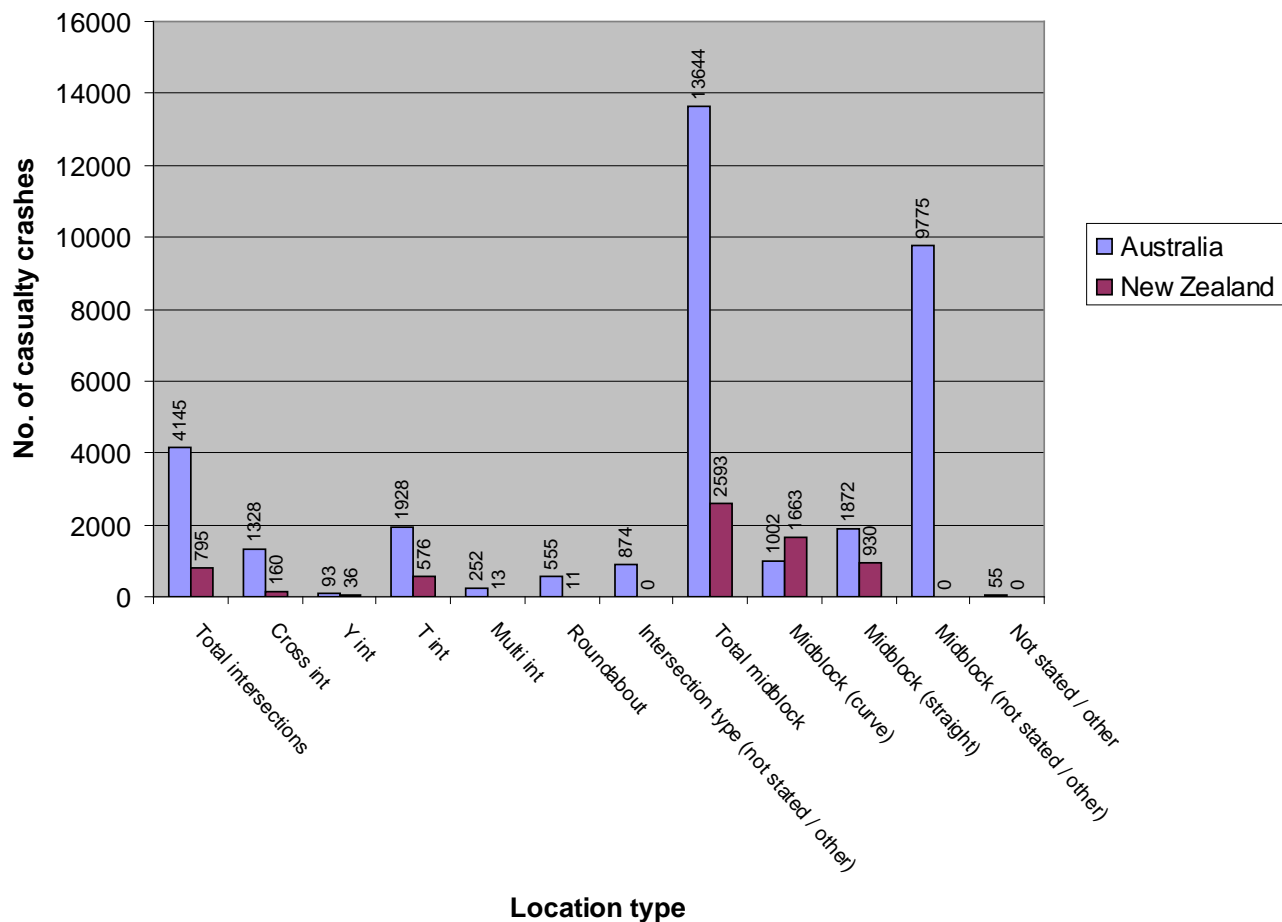
The numbers of crashes in various speed zones (Figure 2.9) appear to reflect the proportions of roads with those speed limits in rural and remote areas. Note that available Tasmanian and Western Australian data does not enable rural and remote 80 km/h roads to be distinguished from urban 80 km/h roads. For this reason all 80 km/h roads from Tasmania and Western Australia have been excluded from this analysis.

Figure 2.9: Average annual casualty crashes by speed zone (1999 to 2003) - Australia and New Zealand

2.8 Rural and remote casualty crashes by type of location

In both Australia and New Zealand, casualty crashes at mid-block locations outnumber those at intersections (Figure 2.10). Also common to both countries is the higher number of crashes at T-intersections than at cross intersections. At mid-block locations, the proportion of crashes on straights and curves is higher in New Zealand. This may reflect the different topography in the two countries, with roads more likely to be winding and mountainous in New Zealand than in Australia.

Figure 2.10: Average annual casualty crashes by location type (1999 to 2003) - Australia and New Zealand



2.9 Casualties on rural and remote roads

Similarly to the assessment of casualty crashes, this tabulation of casualties compares fatal and non-fatal injuries across Australia and New Zealand where severity information was provided. (See Table 2.2) Values represent average annual casualty numbers by severity for each country, averaged over the five years (1999-2003).

There was an average of 1,025 fatalities per year (20 fatalities per week) in Australia and 336 per year (6 fatalities per week) in New Zealand over the study period. During this period there were, on average, 22,443 non-fatal injuries per year (432 per week) in Australia and 5,277 per year (101 per week) in New Zealand.

Four per cent of the injuries in Australia were fatal, while 6% of New Zealand injuries were fatal. These proportions were based on the sums of the fatal and non-fatal averages for each country. The equivalent proportions in the serious injury and other injury columns for Australia were based on the sums of the fatal, serious and other injury averages and therefore do not include New South Wales.

Table 2.2: Average annual casualty severity in rural and remote areas (1999 to 2003) - Australia and New Zealand

	Fatalities		Non-fatal injuries		Serious injuries [^]		Other injury [^]		Average total fatalities and non-fatal injuries
	crashes	%	crashes	%	crashes	%	crashes	%	
Australia [#]	1,025	4	22,443	96	5,078	31	10,408	64	23,468
New Zealand	336	6	5,277	94	1,311	23	3,966	71	5,613

[#] South Australia's casualty figures are only complete to the end of 2002.

[^] Serious injury and other injury data not available for all NSW; figures do not include this state. Percentages in those columns are therefore based on totals of average annual fatal, serious and other injuries for all states other than NSW and will not add to 100 with the Australian fatal percentage, which includes NSW.

2.10 Rural and remote casualties by age and sex

Figures 2.11 and 2.12 show that casualties were most common among those in the 17-25, 26-39 and 40-59 age groups. For males in both countries, more injuries were sustained by those in the 26-39 age group than in the 17-25 group, but the opposite was true for females. However, total casualty numbers were lower for females than for males. Note that the available data for South Australia only covers the period of 1999 to 2002.

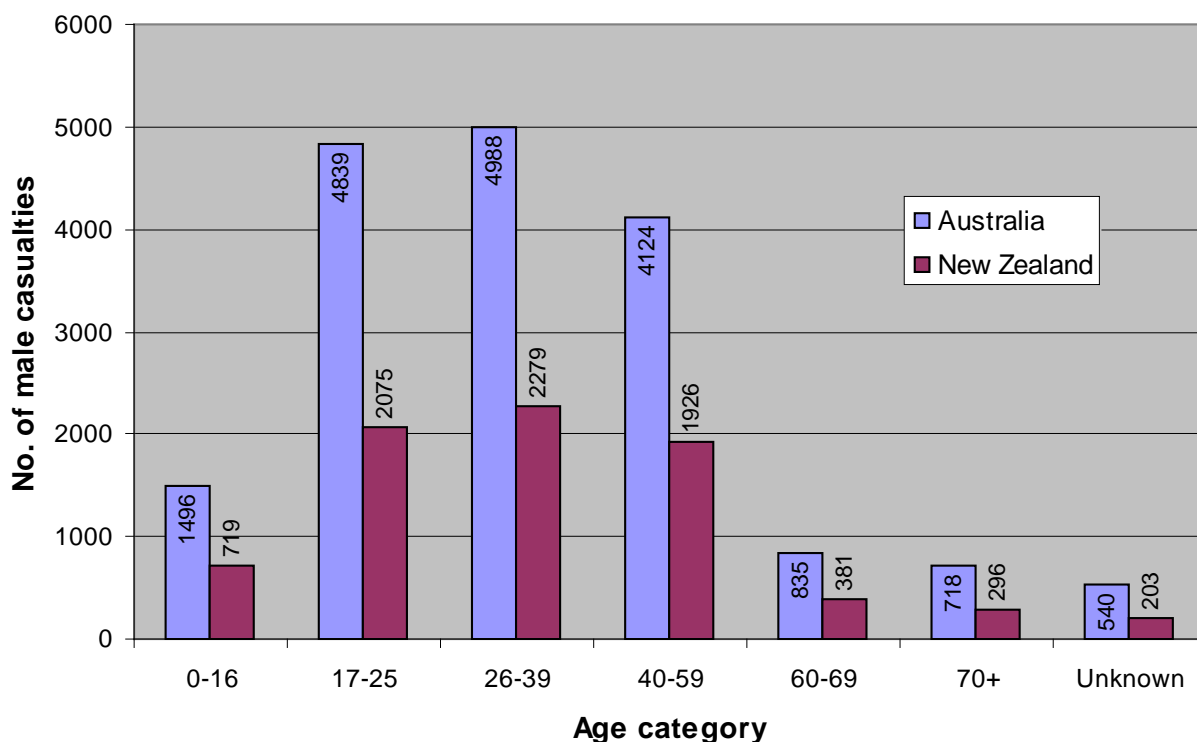
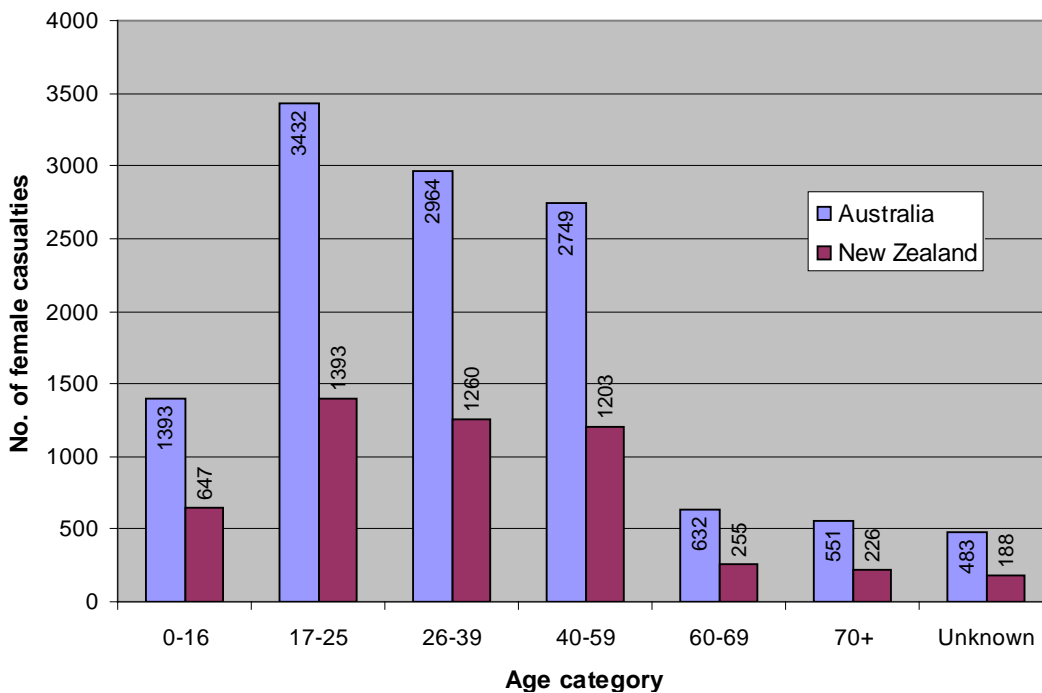
Figure 2.11: Average annual male casualties by age group (1999 to 2003) - Australia and New Zealand

Figure 2.12: Average annual female casualties by age group, 1999 to 2003, Australia and New Zealand

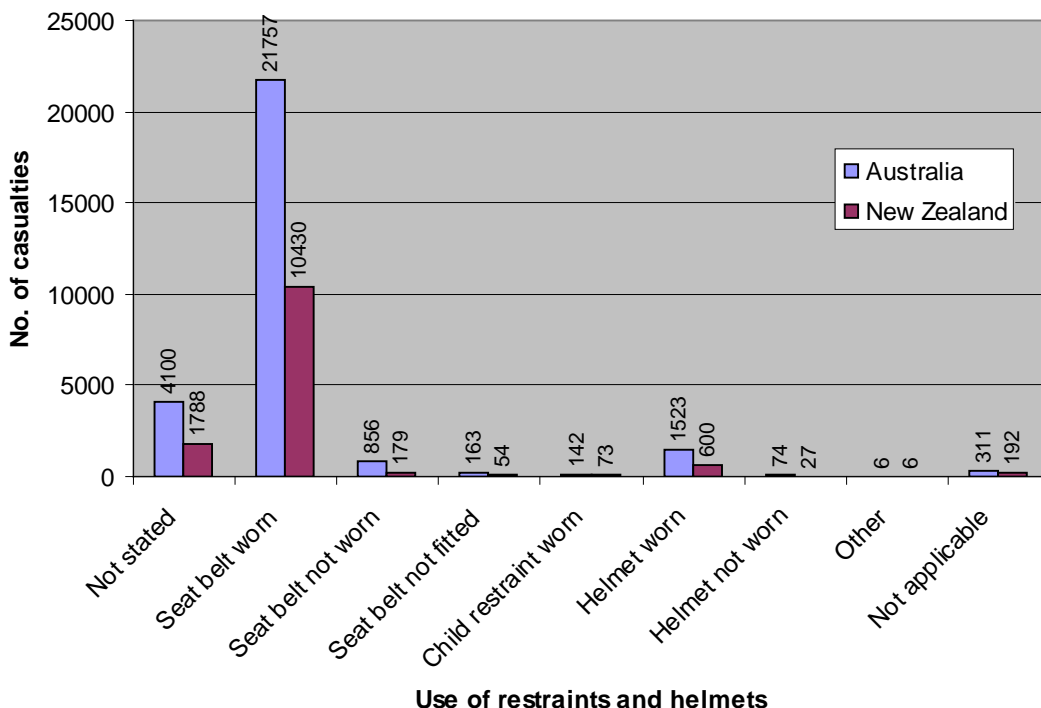


2.11 Rural and remote casualties by restraint and helmet use

Crash numbers according to the use of restraints (seat belts, helmets or child restraints) are presented in Figure 2.13. Due to the large number of cases where the usage was 'not stated', caution must be exercised when working with these data.

Note that the chart does not incorporate South Australian figures at this stage, but they will be added when the data from that state are confirmed.

Figure 2.13: Average annual casualties by restraint use, 1999 to 2003, Australia and New Zealand



3. Risk Factors

Ryan et al. (1988) reported that the rural road crash injury rate is almost double that of urban road injury crashes, with 38.6% of a sample of rural crashes resulting in injuries and only 20.9% of urban crashes resulting in injuries. When the more severe death rates were compared in an earlier study (McLean & Robinson 1979) greater differences were found, with only 0.9% of urban crashes, but 10.8% of rural crashes, resulting in a death within thirty days.

These data show that a person involved in a rural crash is over ten times more likely to die than if they had been involved in a crash in an urban area.

The Queensland Parliamentary Travelsafe Committee (1999a) also reported that:

Drivers in rural areas are more than twice as likely as urban drivers to be involved in a serious road incident. Despite population and traffic volume being far greater in urban areas, as many people die in rural road crashes as in urban crashes. [...] Although there have been drops in the road toll generally, the decreases in rural areas have been significantly less than falls in urban areas.

The higher road crash rates in rural and remote areas are in part a product of the role transport plays in these areas and its unique characteristics. In contrast to city environments, rural and remote residents cannot manage life tasks without their vehicles, nor can they use alternative transportation (National Road Safety Strategy Implementation Task Force, 1996). According to Strong et al. (1998) and Haworth et al. (1997b), the higher mortality and hospitalisation rates from road crashes in rural and remote areas are directly related to higher levels of alcohol consumption. Other causal factors include increased exposure through greater distances travelled, higher speeds and poorer road quality, increased diversity in types of vehicles, lower seatbelt wearing rates, and delays in retrieval and accessing medical treatment and rehabilitation (Armour & Cinquegrana 1990, Hasson 1999, Honor 1995, Moller 1995, Pettitt et al. 1994, Ryan et al. 1988 and Ryan et al. 1992, Strong et al. 1998).

3.1 Behavioural crash factors

3.1.1 Overview of risk characteristics

Observational and correlation research (Armour & Cinquegrana 1990, Haworth et al. 1997b, Honor 1995 and Shinar 1978) has identified a range of factors that contribute to the occurrence and severity of crashes in rural and remote areas. These factors include:

- driver error in judgement
- fatigue
- alcohol and cannabis use
- young drivers (under 25 years of age) and older drivers (over 60 years of age)
- excessive speed
- failure to wear a seatbelt
- driving on unfamiliar roads.

3.1.2 Crash risk as a function of lifestyle, personality and attitudes

Human risk factors can be divided into behaviours that increase the likelihood of a crash occurring (such as speeding or driving a mechanically unsafe vehicle) and those which increase severity if a crash occurs (such as speeding or failing to wear a seatbelt). An understanding of why drivers do or do not perform such behaviours has the potential to improve interventions to modify unsafe behaviours and reduce road trauma.

Although the above risk factors are generally recognised, very little research has been done on the impact of lifestyle, personality, road safety attitudes, and the psychological reactions of drivers on crash risk. This is especially true of rural and remote populations, and of people of lower socioeconomic standing (Moller & Cantwell, 1999). Irrespective of background, motorists' personalities and propensity to aggressive and competitive behaviour, are reflected in their driving behaviour (Watson, 1997).

3.1.3 Crash severity as a function of seatbelt compliance

Rural and remote road crashes are typically characterised by lower seatbelt wearing rates than urban crashes, particularly among male drivers (King 1986; Sahai et al. 1998). It was found that 48% of males involved in rural casualty crashes in South Australia were not wearing a seatbelt (Ryan et al. 1988), while 21% of people killed in rural crashes in New South Wales between 1998 and 2002 were not wearing an available seatbelt (Roads and Traffic Authority 2004).

Wearing seatbelts reduces rural road crash injuries (McCarthy 1989, Pettitt et al. 1994, Sahai et al. 1998, Ryan et al. 1998), in particular, reported that 96% of people wearing seatbelts in Western Australian rural crashes, compared with 30% of non-seatbelt wearers, remained in their seats during the crash. In rural casualty crashes in South Australia, 53% of occupants not wearing a seatbelt were thrown to the vehicle floor and 10% were either partially or completely ejected from the vehicle (Ryan et al. 1988).

3.1.4 Crash risk as a function of driver fatigue

Driver fatigue is considered to be a major crash contributory factor in rural and remote areas (Honor 1995, Haworth 1998, Sagberg, 1999). In Australia, Henderson (1995) noted that if *unexplained* or *unidentifiable* factors caused a road crash in a rural and remote area, then fatigue is often the real causal factor. New South Wales research reported that fatigue was involved in at least 20% of crashes (Roads and Traffic Authority of New South Wales n.d.) and Ryan et al. (1998) reported that 19% of country drivers in the north of Western Australia said that they had fallen asleep at the wheel at least once.

It is estimated that in NSW in 1995 there were 3,600 crashes which were fatigue related. In these crashes, 100 people were killed and 867 seriously injured. Fatigue is estimated to be involved in 16% of fatal crashes, and 13% of serious injury crashes. Driver fatigue is implicated in around 30% of fatal rural crashes. The evidence of it being a significant contributing factor in road crashes on the Newell Highway is clear (Houghton, 1998, p.29).

In a pro-active move, the *National route 39 interstate driver fatigue strategy* was developed in 1998 to address the driver fatigue problem in Queensland, New South Wales and Victoria. The multi-focussed nature of the tri-state strategy is reflected in its actions. Strategy Action 28 of the NR39 action plan is to 'conduct surveys every two years of drivers using NR39, researching their characteristics, knowledge of driver fatigue, attitude and behaviours, and satisfaction with rest area facilities'.

Similarly, NR39 Strategy Action 12 – 'Inform drivers of the risk of driver fatigue whilst travelling National Route 39' - and Action 24 – 'Promote the co-ordination of interstate enforcement activity' – support conducting regular and coordinated surveys.

As a result, numerous surveys of drivers travelling the Newell Highway (NR39) have been conducted over the past three years (Houghton 1998) and Queensland Transport has been delegated the responsibility for conducting the next *Tri-State Fatigue Survey* later this year. In conjunction with Queensland Transport, CARRS-Q has developed an improved survey instrument to enhance the 2001 wave of data. The new questionnaire is: (1) more reflective of risk factors shown (in the literature) to cause driver fatigue (e.g. circadian rhythms, inter- and intra-driver variability) (Corfittsen, 1999); and (2) should better identify defining characteristics of *at-risk* populations – ‘young’ adults aged 16 – 29, especially males; shift workers; and people with untreated sleep apnoea syndrome and narcolepsy’ (NHTSA 2000).

In recent years, another series of Australian studies linking sleep patterns to road trauma have been conducted (Arnedt et al. 2001, Haworth 1998, Williamson et al. 2001). Human sleep requirements follow predictable patterns (i.e. circadian rhythms). So, not surprisingly, lack of sleep leads to impaired performance, attention and reaction time, leading to errors with the potential for road crashes, especially for shift workers and teenagers (National Highway Traffic Safety Administration & National Centre on Sleep Disorders Research 1999). Arnedt et al. (2001), in particular, compared the effects of alcohol ingestion with those of prolonged wakefulness on a simulated driving task among 19 to 35-year-old healthy males.

For mean tracking, tracking variability, and speed variability, 18.5 and 21h of wakefulness produced changes of the same magnitude as 0.05 and 0.08% blood alcohol concentration, respectively (p.337).

Specific countermeasures currently available are telling drivers to plan to get enough sleep, to avoid drinking alcohol when sleepy prior to driving, and to avoid driving between midnight and 6 am to reduce fatigue-related crashes (National Centre on Sleep Disorders Research and National Highway Traffic Safety Administration Expert Panel on Driver Fatigue and Sleepiness, 1998). If a driver is tired, stopping or napping for 15-20 minutes, or drinking two cups of coffee will improve short-term wakefulness. All other interventions have undemonstrated effects (National Centre on Sleep Disorders Research and National Highway Traffic Safety Administration Expert Panel on Driver Fatigue and Sleepiness, 1998). Some of the policy measures that have been implemented to counter the problem of driver fatigue among heavy vehicle drivers (i.e. fatigue management programs) are discussed in a later section.

3.1.5 Crash risk and severity as a function of travelling speed

Henderson (1995) noted that excessive speed ‘not only makes crashes more likely, it makes the crashes that do occur more destructive’. Kloeden et al. (1999) demonstrated that excessive speed leads to more driver errors and gives drivers less reaction time. A case control study of fatal single-vehicle crashes in Victoria in 1995 quantified the assertion that driving above the speed limit significantly increases the chances of involvement in a road crash (Haworth et al. 1997c).

Australian studies indicate that excessive speed is a probable or possible cause in 25% of the rural crashes around Adelaide (Kloeden et al. 1997), a factor in more than 37% of fatalities on ‘country’ roads in New South Wales (Roads and Traffic Authority of NSW n.d.) and a factor in 22% of fatal crashes in Queensland (Honor 1995). In New Zealand, driving too fast for the conditions was highlighted as a contributory factor in 23% of all rural fatal and injury crashes, and in 32% of rural fatal crashes (based on the New Zealand Crash Analysis System, 2000 to 2005). Rural crashes are generally more severe than comparable urban crashes because higher impact speeds reveal weaknesses in vehicle systems such as tyres and crumple zones (Hasson 1999).

Kloeden et al. (2001) in an in-depth study quantified the relationship between free travelling speed and the relative risk of involvement in a casualty crash for sober drivers of passenger vehicles in rural areas. The study found that ‘...the risk of involvement in a casualty crash is more than twice as great when travelling 10 km/h above the average speed of non-crash involved vehicles and nearly six times as great when travelling 20 km/h above that average speed’.

3.1.6 Crash risk as a function of alcohol consumption

In a case-control study of rural crashes outside Adelaide, Ryan et al. (1988) found that blood alcohol concentrations over 0.08% are associated with up to 30-times increased likelihood of involvement in a crash. Henderson (1985) reported that alcohol is a factor in 25% to 28% of rural fatal crashes in Australia, where 'rural' and 'urban' had been based on population distribution and density. In Queensland, Police data shows that alcohol and/or drug use was a causal factor in 28% of fatal crashes in rural Queensland during 1993 (Honor, 1995).

Although it is widely accepted as an unsafe practice, drinking and driving still occurs and considerable police and court resources are devoted to its detection and prosecution (Queensland Police Service 2000). In a survey conducted in Queensland in April 1999, 9% of respondents reported drinking and driving (Queensland Police Service 2000). The general community does, however, appear to be aware of the danger associated with drink driving, as evidenced by the fact that a substantial proportion of road users regularly engage in conscious behaviours to reduce the chance that they will be affected by a drunk driver unknown to them (Applegate et al. 1999).

The decision to drink and drive is affected by the individual's direct and indirect experience with enforcement (i.e. specific and general deterrence). Vulcan et al. (1995), for example, reported that an increase in the number of random breath tests performed by police in the early 1990s reduced the number of serious casualty crashes in Victoria during high alcohol hours (Table 3.1).

Table 3.1: Times of day and week (shaded) when casualty crashes are at least 10 times more likely to involve alcohol

	12am - 6am	6am - 8am		8am – 10am	10am – 2pm	2pm – 4pm	4pm – 6pm	6pm – 12pm
Monday								
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday								
Sunday								

Source: Transport Accident Commission Road Safety Monthly Reports (2006)

Ryan et al. (1988), reported that alcohol use in rural traffic incidents was highly correlated with the use of dangerous drugs, and Haworth et al. (1997b) found that 52% of drivers involved in fatal single-vehicle crashes with a BAC >0.15% were also cannabis users. Drink driving in rural areas has also been associated with driving while fatigued (Ryan et al. 1988), and speeding and not wearing seatbelts (Pettitt et al. 1994). Henderson (1995) found that in remote area crashes where the driver's BAC was above 0.05% and where seatbelt use was known, only 13% of fatalities were wearing seatbelts. Pettitt et al. (1994) also found that in fatal rural single-vehicle crashes, drivers with a BAC \geq 0.05% were less likely to wear seatbelts than drivers with a BAC < 0.05%.

These studies are consistent with earlier Australian work which concluded that speeding and drink driving combined lead to more than half of the total number of fatal single-vehicle rural road crashes (Pettitt et al. 1994). The National Road Safety Strategy Implementation Task Force (1996) stressed that driving while fatigued, without wearing a seatbelt, after consuming alcohol occurs in combination and more often in rural and remote areas.

3.1.7 Consistency of risk factors in rural regions: the Queensland experience

The disproportionately high risk of fatality and injury from motor vehicle crashes due to behavioural risk factors of people living in rural and remote areas is illustrated by the data provided in Table 3.2 and Table 3.3, extracted from the Travelsafe Committee (2002) report on Rural Road Safety in Queensland.

Table 3.2: Urban fatalities by nature of crash, 1994-2000 per 100,000 population

Fatalities per 100,000 population for key causal factors					
Year	Speed	Alcohol	Single-vehicle	Fatigue	Seatbelt not used
1994	1.12	1.51	3.06	0.39	0.30
1995	1.11	1.76	2.46	0.49	0.37
1996	1.00	1.76	2.92	0.76	0.68
1997	1.36	1.64	2.22	0.31	0.51
1998	0.54	1.13	2.13	0.54	0.43
1999	0.95	0.91	2.05	0.19	0.76
2000	0.79	1.43	1.81	0.29	0.79

Source: Queensland Transport (2002).

Table 3.3: Rural fatalities by nature of crash, 1994-2000 per 100,000 population

Fatalities per 100,000 population for key causal factors					
Year	Speed	Alcohol	Single-vehicle	Fatigue	Seatbelt not used
1994	3.91	6.68	12.60	4.16	4.16
1995	3.35	9.95	15.34	5.03	4.43
1996	3.63	6.56	10.65	4.33	3.28
1997	2.63	5.02	10.04	4.57	3.65
1998	2.27	3.64	8.52	2.50	2.61
1999	2.12	4.46	6.91	3.12	2.90
2000	3.74	6.17	11.56	3.52	4.07

Note: Population data were calculated using reliable 1996 LGA figures as the base proportion. Queensland population data were then allocated for each year using the 1996 proportion.

Source: Queensland Transport (2001).

Calculations indicated that in 2000, the ratio of fatal crashes per 100,000 people in rural areas compared to urban areas in Queensland was:

- 12.1 times higher for fatigue-related crashes
- 6.4 times higher for single-vehicle crashes
- 5.2 times higher for crashes where the victim was not wearing a seatbelt
- 4.7 times higher for speed-related crashes
- 4.3 times higher for alcohol-related crashes.

3.2 At-risk populations

3.2.1 Local residents

Contrary to the belief amongst some residents of rural and remote areas that locals are not involved in serious road traffic incidents in rural and remote areas, crash evidence reveals that most of those involved were rural residents. The Australian Federal Government in 1996 recognised that rural crash victims were more likely to be rural residents, and recommended that this information should be publicised as part of *Australia's Rural Road Safety Action Plan* (National Road Safety Strategy Implementation Task Force 1996).

3.2.2 International visitors

Although local residents comprise the bulk of casualties involved in crashes that occur in rural and remote areas, international visitors may be at higher risk because of unfamiliarity with the road environment and rules. During a project designed to inform the development of the Australian Transport Council's National Road Safety Action Plan for International Visitors 2004-2005, CARRS-Q and Queensland Transport jointly examined the involvement of international visitors in road crashes in Australia (Watson et al. 2004). It was revealed that, between 1999 and 2002, the proportion of international visitor fatalities that occurred on rural roads ranged from 54% in New South Wales to 100% in Tasmania. The report also indicates that international visitor road crash casualties were more likely than those in other crashes to involve fatigue, non-use of restraints and disorientation (especially visitors from countries where they drive on the right-hand side of the road).

3.2.3 Young male drivers

It is widely accepted that young persons, especially males, both as drivers/riders and passengers, are at greater risk of being injured in rural and remote road crashes than all other persons (Moller, 1994). This conclusion has been consistently replicated:

- 80% of drivers involved in a fatal-single-vehicle crash were male (Haworth et al. 1997a)
- 38% of Australian road crash fatalities in 1995 were under 25 years of age (Kloeden et al. 1997)
- 40% of drivers involved in a fatal single-vehicle crash were less than 25 years of age (Haworth et al. 1997a)
- male country drivers from 17 to 25 years of age are more likely to be involved in a fatal crash than comparable city drivers (Australian Transport Safety Bureau 1999).

In contrast, crash risk is much lower for female drivers (Beenstock & Gafni 2000). Moller (1995) found that in *remote other* areas, females under 24 are rarely killed as drivers and in fact have similar rates of death as passengers to their *capital city* counterparts. The increased risk for young males is generally ascribed to reckless driving as an important means of attaining and maintaining attention and personal power (Butchart et al. 2000).

3.2.4 Indigenous communities

The indigenous Australian population across all rural and remote areas has higher mortality and hospitalisation rates compared with the non-Indigenous population (Strong et al. 1998). Cercarelli (1997), examined Western Australian road crashes which occurred from 1988 to 1996 and found that Indigenous people are highly over-represented in hospitalisation rates in rural and remote areas, especially following single-vehicle and pedestrian crashes. During the study period, approximately one in every 3,000 non-indigenous people road users was hospitalised, compared with about one in every 1,000 Indigenous road users.

Rae (1995) noted that alcohol is 'a major factor in many Indigenous fatalities' and that they are over-represented in fatal vehicle roll-over incidents and pedestrian fatalities in the Northern Territory. Not unexpectedly, high levels of blood alcohol concentration are usually involved in these crashes and 13 of the 38 pedestrian fatalities in the five-year period from 1987 to 1991 involved persons who were run over while asleep upon a roadway (Rae, 1995).

More recently, Brice (2000) conducted a major review of Indigenous road trauma in Australia and '...estimated that in 1997 there were 31 indigenous deaths per 100,000 population, compared with 10 deaths per 100,000 for the non-Indigenous population'. Furthermore, an analysis of ABS data based on the causes of death in the Indigenous populations of Western Australia, South Australia and the Northern Territory for the period 1994-1997, revealed that road crashes represented 5.6% of all deaths. This figure was comparable to other major causes, such as diabetes (6.7%) and stroke (6.3%), but in stark contrast to non-Indigenous populations in the same jurisdictions, where road crashes accounted for 1.7% of all deaths (Brice, 2000). Road crash-related hospitalisation rates have also been shown to be about 1.5 times higher for the Indigenous population in South Australia than for the non-Indigenous population (Brice, 2000).

In an attempt to identify causal factors underpinning the over-involvement of Indigenous populations in road trauma, Brice (2000) examined Coronial records in South Australia in the 1990s and:

discovered that alcohol intoxication together with night-time occurrence (in the case of pedestrian deaths), and alcohol intoxication of drivers together with the lack of use of seatbelt restraints (in the case of other crash fatalities), accounted for the majority of deaths. Indeed, the results of this investigation were startling as over 60% of non-pedestrian fatalities resulted from 'no restraint – deceased ejected' type crashes – some at low speed.

More recently, during the 2004 Indigenous Road Safety Forum, the issues identified by Brice (2000), and a few additional issues, emerged as still needing attention. The fourth recommendation to result from the forum was:

Implement changes and monitor progress in the following key areas: improved data collection; increased licensing; increased seatbelt wearing, including child restraints; reduction in road trauma involving alcohol; improved infrastructure at high risk locations; and decrease in pedestrian risk (Australian Transport Safety Bureau 2005).

In New Zealand the indigenous Maori population is more rurally based than the general population and also younger and less affluent than the general population. This tends to make Maori more at risk from the greater hazards in rural areas than the general population.

3.2.5 Truck drivers

Another subgroup in the context of rural and remote road safety is heavy vehicle drivers. Generally car drivers were found to be at fault in crashes involving a collision between a car and a truck. The Federal Office of Road Safety (1997a) found that car drivers were primarily responsible for 5 out of every 6 crashes involving an articulated truck. It should be noted, however, that these figures include urban crashes.

The Federal Office of Road Safety (1997a) also determined that when the driver was at fault and at least one fatality resulted, the truck driver was not wearing a seatbelt in 94% of cases. It was also found that if a truck crash was the truck driver's fault, it was usually caused by loss of control, inappropriate speed, or fatigued driving, and occurred in a non-capital city area.

3.3 Vehicle and environmental crash factors

After examining serious crash data for Queensland 1989-1990, Pettitt et al. (1994), noted that vehicle defects are a major causal factor in rural and remote road crashes, whereas other factors such as vehicle occupancy rates, seating positions and seatbelt use contributed to the nature of injuries received by crash victims, and to the type of medical attention which they received.

3.3.1 Crash risk and severity as a function of vehicle type

Residents of rural and remote areas are highly dependent on their vehicles. Their dependency is exacerbated by the general lack of alternative transportation (National Road Safety Strategy Implementation Task Force (1996). Within these types of environment there is also a diverse mixture of vehicles including cars, buses, heavy trucks, agricultural vehicles, mopeds and bicycles sharing rural roads (Hasson, 1999). In addition, rural and remote roadways are used by motorcycles, light trucks and four wheel drive vehicles. All of these vehicle types have different road handling characteristics. This diverse vehicle mix increases the risk to all users of rural and remote area roads (Hasson, 1999).

Australian data from 1995 show that the risk of road crash death (calculated as the number of deaths for every 100 million kilometres travelled by each vehicle type) is greatest for motorcycles (at 14.0), articulated and rigid trucks (at 3.9 and 3.2 respectively), buses (1.4) and passenger vehicles (1.1) (Federal Office of Road Safety 1997b). The same data indicate that the corresponding relative risk of involvement in a serious road crash is 176.1 for motorcycles, 13.6 and 20.1 for articulated and rigid trucks respectively, 13.1 for passenger vehicles and 21.0 for buses (Federal Office of Road Safety 1997b). It has also been observed that utilities are seven times as likely to be involved in a crash outside metropolitan Perth as within that city (Ryan et al. 1998).

Different vehicle types are also associated with various social and cultural groups. In rural and remote area crashes, Indigenous people are usually injured as passengers, often in inappropriate situations, such as in the backs of trucks and utes (Ryan et al. 1998). Indigenous people comprise 22.4% of the Northern Territory population, but were involved in 53% of the 108 fatal vehicular rollovers in the Northern Territory in the five year period from 1987 to 1991 (Rae 1995). Indigenous people were over-represented in road crashes in Western Australia from 1988 to 1994, especially single-vehicle and pedestrian crashes (Cercarelli 1997). Indigenous people are over-represented in passenger deaths, and are under-represented as drivers of crashed cars and motorcycles (Cercarelli 1997).

Impacts occur equally on left and right sides of vehicles, but a much higher proportion of potentially fatal impacts (i.e. impacts which apply force which would result in the death of a person in the seat adjacent to the impact point) occur on the left side of vehicles. It might be expected that once drivers recognise imminent collision danger, they instinctively turn the vehicle so that they are away from the impact point. Passenger seats on the left side of vehicles, however, are often unoccupied, and so these left-side crashes generally do not result in deaths (Ginpil et al. 1995).

3.3.2 Crash risk and severity as a function of vehicle safety features and design

The equipment and design of vehicles substantially affect the outcomes of rural road crashes. For example, child safety seats reduce fatal injury by 69% for infants less than one-year-old, and reduce fatal injury by 47% for children from one to four years old (National Safety Council, 1999).

Moller (1994) notes that the age of vehicles contributes to higher death rates in rural and remote areas. Specifically, pre-1978 cars were observed in 9% of control data, but were involved in 21% of fatal single-vehicle crashes, in a 200 kilometre zone around Melbourne during 1996 (Haworth et al. 1997c). The solution to this apparently socio-economic status related factor is unclear. It has been stated that even if older cars are driven more slowly this cannot compensate for their low safety standards relative to new model cars (Beenstock & Gafni 2000). Increased injury severity is also likely to result when a crash involves an older vehicle that does not comply with current safety standards (Haworth et al. 1997a).

It must also be noted that lower SES (socio-economic status) rural and remote areas have worse roads and that local residents usually have older cars, possibly leading to poorer road crash outcomes (Elkington 1999a, 1999b). In contrast, wealthier persons drive newer and safer cars, often upon better roads (Beenstock & Gafni 2000), leading to socio-economic differences that should not be directly ascribed to differences in education or psychological make-up.

Vehicle defects are not common contributors to road crashes, unless vehicles are improperly maintained (Chew et al. 1998), and this is closely related to the personality and socioeconomic circumstances of the vehicle owner or operator. Whether the vehicle is maintained, and the manner in which it is driven if not maintained, are decisions usually made by the driver. For example, poor tyre condition contributes to many single-vehicle rural traffic crashes (Armour & Cinquegrana 1990). However, it is inevitably the decision of the driver not to replace worn tyres, either through lack of knowledge about the safety implications, not caring, psychologically minimising concern about such implications, or even not being able to afford new tyres. No matter what the motive, the driver is at the centre of this decision, and effective interventions should be targeted in that direction.

Other vehicle systems that must be maintained by the driver, such as brakes and suspension are also critical to post-crash safety as well as pre-crash dynamics and handling. In addition, vehicle tyre and suspension characteristics can interact with shoulder width and other road characteristics to contribute to, or reduce the likelihood of, a crash occurring (Ryan et al. 1988).

3.3.3 High-risk modes of transport

Rigid trucks and articulated vehicles

Rigid trucks and articulated vehicles driven in rural and remote areas are over-represented in crash statistics. One in five fatal crashes on Australian roads involves a truck, but the truck driver is not usually at fault (Federal Office of Road Safety, 1997a). Moreover, nearly 60% of the persons killed in those crashes were car occupants (Federal Office of Road Safety, 1997a).

During 1988-1989, Sweatman et al. (1990) studied fatal heavy vehicle crashes on the Pacific and Hume Highways in New South Wales, and available countermeasures. At the time, these highways combined carried nearly 70% of the nation's total interstate freight. Sweatman et al. (1990) deemed the major factors contributing to severe truck crashes in New South Wales to be:

- undivided roads
- poor road alignment and poor shoulders
- light conditions (night driving)
- roadside hazards
- excessive car and truck speed
- speed variation (slow car speed)
- truck instability
- car and/or truck driver alcohol use
- drivers falling asleep.

Many of these issues are discussed in the Australian Transport Council's National Heavy Vehicle Safety Strategy 2003-2010 (2003) while a potential countermeasure for the latter issue, fatigued driving, is highlighted below.

Motorcycles

Motorcyclists, as road users, are inherently vulnerable. Motorcycle riders are far more likely to be killed or seriously injured in road crashes than all other vehicle types (Federal Office of Road Safety 1997b). Rural areas appear to be less safe than cities for motorcyclists and younger males (i.e. 15 to 35 years) are at greatest risk (Moller, 1994). Table 3.4 shows the high incidence of motorcycle crashes in the predominantly rural and remote statistical divisions of Northern, North Western and Far Northern Queensland. The information is extracted from Health data and once again highlights the need to look at multiple data sources to get a holistic picture of the rural and remote road safety problem.

Table 3.4: Hospital admissions for Northern Queensland 1995/6-1998/9

Hospital	Drivers	Motorcyclist ³	Passengers	Bicyclists	Pedestrians	Total
Cairns	287	291	285	284	118	1,265
Townsville	244	248	173	148	75	888
Mount Isa	100	63	89	70	23	345
Atherton	105	59	73	61	15	313
Mareeba	45	46	49	38	11	189
Total	781	707	669	601	242	3,000
Indigenous persons	40	20	79	53	65	257

Note: An additional 124 persons of unclassified type were admitted to these hospitals.

Source: Queensland Health (2000)

According to Legge et al. (2001), the increased crash risk associated with motorcyclists in rural areas could be contributed to by helmet wearing rates. In Western Australia in 2000, '...ten percent of motorcyclists seriously injured (i.e. killed or hospitalised) in police attended crashes were not wearing a helmet at the time of the crash (8% in the metropolitan area and 16% in rural areas)'.

3.3.4 Environmental risk factors

The rural road network is perhaps the only aspect of rural road safety that is genuinely outside the influence of the individual road user. This road network features long distances, isolated travel, gravel surfaces, dust, and the presence of wildlife and livestock (Honor 1995). Across Australia, roads in rural areas are of lower quality, which contributes to the increased trauma resulting from crashes upon those roads (Ryan et al. 1992).

Crash risk as a function of road condition and design

This lower road quality is often reflected in poorer road shoulder condition and design, non-optimal road alignment, and the presence of roadside objects. All of these factors are important contributors in fatal or serious injury crashes, and similarly affect the nature of injuries received and the type of medical attention given to victims (Pettitt et al. 1994).

McLean & Armour (1983) reported that sealed shoulders provide safety and operational benefits over gravel shoulders, however, the effects of varying shoulder widths were unclear. It was also reported that the safety benefits of shoulders were mainly as a result of their function in providing a recovery area, and that this was best achieved by paved shoulders, particularly as gravel shoulders could increase the incidence of loss of control crashes.

McLean (1985) developed empirical crash-width relationships using base crash rates from early studies conducted for 7.2 m travelled-way and/or 3.0 m shoulders (may be in part sealed) and/or 13.2 m roadways. The relationship provided revealed that as the travel section of the road way decreases crash rates increase. Similarly, as shoulder widths decrease, crash rates also increase. Armour & Cinquegrana (1990) also found in a study in rural Victoria that unsealed road shoulders and narrow lanes were associated with increased crash occurrence.

³ Includes off-road crashes.

The condition and design of a rural roadway and its surrounding environment can significantly impact on crash severity (Hasson 1999). For example, about half of the variation in traffic incident rates upon German autobahns has been found to be due to characteristics of the roadway such as lower width and poor alignment (Kloeden et al. 1997), while a study of rural crashes on two lane roads in the United States found that line of sight distances over 1500 feet were associated with fewer single-vehicle crashes (Ivan et al. 1999).

Rural road systems are often characterised by inconsistent speed design along their length. This means that as drivers move along a roadway, variations occur in the maximum speed at which safe travel is possible. Such variations in rural roadways significantly contribute to higher crash numbers and risk (Hasson 1999).

When more than one vehicle is involved in a collision, road design effects also interact with other variables. For example, collisions between oncoming vehicles are as likely to occur on a curve as on a straight road (King 1986). The rarest crash types on high speed Queensland roads are sideswipes with vehicles travelling in the same direction, collisions with unattended cars or stationary objects on the road, and collisions involving vehicles entering the road (King 1986). The probability of a collision is higher when a driver is leaving the carriageway than when a driver is entering the carriageway (King 1986). United States research has produced similar results. Examination of traffic incident data from 1985 through to 1990 upon rural, multilane, non-freeway roads in Minnesota linked intersections and driveways with road traffic incident occurrence (Wang et al. 1997).

Another aspect of road design is the speed environment in which the driver operates. Although speed is a key factor in crashes, public support for raising speed limits in some instances in rural or remote areas remains high. Following such public pressure, United States federal control of speed limits was discontinued in 1995 with the repeal of the National Maximum Speed Limit, and accounting for exposure, fatalities on interstate highways increased 17% in the 24 states that raised speed limits (Farmer et al. 1999). Raising speed limits does not just legalise existing widespread behaviour, it encourages drivers to go faster, and results in more crashes (Kedjidjian 1998). This is related to the risk perception effects noted earlier.

The manner in which roads are constructed is also related to occurrence of road trauma. Ryan et al. (1998), for example, reported that single-vehicle crashes usually occurred at high speed and were more prevalent on curved and unsealed roads. This situation was reflected in a recent review of reported rural and urban road crashes in Western Australia for the year 2000. Legge et al. (2001) reported that in rural areas crashes were more likely to occur on curved sections of the roadway (25.5%) than in metropolitan areas (15.7%). Also, crashes in rural areas were much more likely to occur on unsealed surfaces (13.8%) than in metropolitan areas (0.9%) (Legge et al. 2001).

In Victoria, Haworth et al. (1997a) examined all types of roads and found that single-vehicle fatal crashes were more than twice as likely to occur on curved sections. Acknowledging that there are other characteristics differentiating between rural and urban roads, road use and road users, it is highly plausible that such characteristics interact with road design to determine crash likelihood and severity. In an earlier Victorian study, Armour and Cinquegrana (1990) found that crash sites were associated with low skid resistance and degraded road surfaces.

Tziotis (1992) found that on the outskirts of provincial cities, crash risk increased when traffic, which slowed to enter or leave the major road, interacted with faster moving through traffic. Speed zones along the major roads in these areas were typically 70 or 80 km/h, reflecting partial roadside development.

Other factors identified by Tziotis as factors contributing to crash occurrence or crash severity in partially developed areas included:

- inadequate curve delineation
- absence of deceleration, acceleration lanes and turning lanes
- shoulders that were unsealed or absent
- hazardous poles and trees.

The study also found that there were relative increases in head-on, out-of-control and rear-end casualty crashes along roads within this environment. The study also found that as the density of roadside development increased, the proportion of cross-traffic, right-turn-against and pedestrian crashes also increased.

Lower socio-economic status areas may have poorer roads (Elkington 1999a, 1999b), which may be a factor in the greater involvement of low socio-economic status individuals in road crashes. However, this effect may be mediated by other factors in a rural environment. It has been noted that a single low-quality section on an otherwise high-quality road can be more dangerous than if it were in a lower standard road (VicRoads 1998). Honor (1995) noted that rural roads in Queensland often consist of extremely long sections of highway, and it may be expected that rural drivers will come upon a greater variation in road quality.

Rural and remote areas typically include loss of control crashes, and the shoulders, or edges, of the formed roadway have been found to be implicated in such high speed crashes either during or prior to loss of vehicle control (King 1986). It is widely accepted that typical and common rural crash involves unsealed road shoulders (National Road Safety Strategy Implementation Task Force 1996). In this type of crash, the two left wheels of a car (or car derivative) leave the left side of the road for some reason. At high speed, and possibly due to the sudden increase in wheel suspension vibration and noise, the driver may overcorrect the required steering input to place the car back on the road, and such overcorrection may lead to a loss of vehicle control (Ryan et al. 1988). Sixty-two per cent of single-vehicle crashes occur on sealed roads with unsealed shoulders (Henderson 1995), and in rural areas, problems arising from the condition or construction of the left-hand road shoulder were directly causally implicated in 23% of fatal single-vehicle rural crashes, and 13% of serious injury single-vehicle crashes (Pettitt et al. 1994).

In 1992, 48% of fatal crashes (and 66% of fatal single-vehicle crashes) occurred on rural roads. In the case of vehicles travelling in opposite directions, two-thirds of these occurred on sealed roads with unsealed shoulders (Henderson 1995).

Crash risk and severity as a function of roadside environment (hazards)

The roadside environment has been identified as the second most important factor associated with rural highway crashes (Chew et al. 1998). Kloeden et al. (1999) reported a series of studies examining causal contributors to rural road trauma in Victoria and noted that 22% of casualty crashes from 1978 to 1982 directly involved roadside hazards. More recently, South Australian data for the three years from 1994 to 1996 for cars and light commercial vehicles show that once a crash has occurred, then the presence of roadside hazards significantly increases the outcome severity of the crash (Kloeden et al. 1999), because more severe injuries are associated with a crashed vehicle striking an immovable roadside object such as a tree (Haworth et al. 1997c).

Ryan et al. (1988) examined rural South Australian crashes within 100 kilometres of Adelaide in 1986/87, and found that there was a higher proportion of crashes with high-impact speeds into immovable objects or trucks. The most dangerous roadside hazards were trees and poles (Kloeden et al. 1999) and, in a case-control study of single-vehicle crashes within a 200 km radius of Melbourne in 1995-1996, Haworth et al. (1997c) found that 78% of these rural crashes involved running off the road and hitting a pole or tree. Similarly, Armour & Cinquegrana (1990) identified unsealed road shoulders, narrow lanes, trees or steep slopes and objects close to the road, as being associated with sites of increased crash occurrence in rural Victoria. In extremely remote areas, Pettitt et al. (1994) suggest that crashes are more likely to involve an animal.

In a review of reported road crashes in Western Australia for the year 2000, Legge et al. (2001) provided strong evidence to suggest that roadside hazards play a major role in rural road trauma.

In the metropolitan area, the most common crash types which resulted in fatality were 'hit pedestrian' crashes (24% of all fatal metropolitan crashes), followed by 'hit object' crashes (22%), and 'head on' crashes (19%). In rural areas, the most common fatal crashes were 'hit object' crashes (45%), 'non-collision' crashes (17%) and 'hit pedestrian' crashes (14%).

3.4 Post-crash factors

3.4.1 Crash outcome as a function of emergency response and retrieval time

The vastness of rural road networks poses obvious trauma management and retrieval problems when a crash occurs. Emergency response is noticeably slower following rural crashes and subsequently impacts on crash outcomes (Brodsky 1990, Brodsky & Hakkert 1983, National Road Trauma Advisory Council 1993). Based on archival data in America, Evanco (1999) pointed out that rural areas have lower traffic density, and crash notification times are longer (average 9.6 minutes) than for urban crashes (average 5.2 minutes). Moreover, it is now widely accepted that a short time window exists during which the application of pre-hospital support care can enhance patient survival, because trauma victims can go into irremediable shock within 10-20 minutes of a traffic incident (Stewart 1990). In an American study, it was found that when the time interval from the crash until arrival of Emergency Medical Services (EMS) personnel increased, the multi-fatality rate rose from 3.9% for a five-minute response time to 8.3% for a response time of more than thirty minutes (Brodsky 1990). Multi-fatality crashes were studied because of their increased importance for remote area trauma. If a crash has occurred, involving forces severe enough to kill at least one occupant of one vehicle, then the timely arrival of EMS becomes even more critical for the survival of the remaining victims.

The delayed crash notification period is further exacerbated by slower emergency response times in rural areas due to the wider area emergency medical personnel have to service (Evanco 1999).

In America, personal income per capita has been shown to be good predictor of response time, with more affluent communities investing in helicopters, highly trained EMS staff, and high-quality private hospitals and medical facilities (Evanco 1999). In remote areas of Australia, of those deaths that did not occur instantaneously, 45% occurred before the road crash victim received medical attention, compared to 37% in rural areas, and only 21% when the crash occurred on an urban road. These statistics were calculated on the basis of the figures provided by Henderson (1995) presented in Table 3.5. Henderson (1995) contends that the establishment of regional trauma teams headed by a doctor operating 24 hours a day and the provision of more prompt medical attention has the potential to save 16% of Australian rural road crash fatalities.

Table 3.5: Percentage dying before medical attention in urban and rural regions (not including pedestrian or two-wheeled)

	Death instantaneous	Other death before medical attention	All deaths in area	% dying instantaneously	% others dying before medical attention ⁴
Urban					
>50,000	139	44	330	42	23
<50,000	75	13	154	49	16
Urban total	214	57	484	44	21
Rural					
Boundary	36	9	62	58	35
Non-remote	146	44	270	54	36
Semi-remote	230	65	403	57	38
Remote	25	5	36	69	45
Rural total	437	123	771	57	37
Total	651	180	1255	52	30

Source: Adapted from Henderson, 1995 (based on figures from the Federal Office of Road Safety Fatality File - 1992)

The Royal Australasian College of Surgeons (1992) advocates a similar view. Deaths from road trauma typically occur in one of three distinguishable time periods: (1) immediately (within seconds/minutes of the injury), where only prevention of the crash could have saved lives; (2) during the *golden hour* (two to four hours post-injury), resulting in 35% of trauma-related deaths in motorised countries; or, to a lesser degree, (3) several days or weeks after the initial injury due to sepsis or multiple organ failure (Evans & Evans 1992). Hence, the medical priority in the event of road crash should be to make a fast and accurate clinical assessment and rapidly institute the appropriate resuscitative and medical measures (Royal Australasian College of Surgeons 1992; Somers et al. 1997). Several promising early notification systems (Evanco, 1999) are discussed in a later section of this report.

3.4.2 Crash outcome as a function of rehabilitation services in rural areas

The treatment of persons involved in a road crash involves many levels of care ranging from appropriate first-aid and emergency response and mobilisation, through to definitive care and rehabilitation. Unlike the relationship between mortality and emergency response, the effect of definitive care and rehabilitation on the subsequent recovery of rural versus urban persons involved in trauma remains relatively unexplored (Heinemann et al. 1995, Whyte, 2001).

⁴ Calculation of percentage values excludes the number of instantaneous deaths from all deaths in the area.

In Australia, data availability, consistency and linkage difficulties have typically been major barriers to rigorous rehabilitation outcomes research in the domain of road safety (Cameron & Oxley 1995). So, not surprisingly, there have been strong pleas from the public health research community for the linking and cross-referencing of existing police, transport, ambulance, health and Medicare databases to increase accuracy (Cameron & Oxley 1995; Chan et al. 2001). Hartley et al. (1996), in particular, suggest that the establishment of a consortium of key stakeholders could better facilitate the administration, coordination and delivery of rural rehabilitation resources and research findings. 'Adequate linkage of ... rehabilitation service delivery and coordination of administrative efforts is necessary to maximize reduced funding and to counteract a reduction in the number of staff' (p.1). This consortium would also be able to identify certain critical variables (e.g. nature of the injuries sustained and emergency treatment received) that are not routinely recorded in all relevant reporting systems.

Grimmer and May (2001), examined the relationship between several patient-related and service-based factors and the length of time required to complete an episode of outpatient occupational therapy. Three country hospitals and five metropolitan hospitals collected data for three to 10 months. Six of the hospitals were in South Australia (two rural and four metropolitan). The two comparison sites were in Queensland (rural hospital) and Tasmania (metropolitan hospital). In total, the study collected information on 360 completed episodes of occupational therapy. Factors that were strongly associated with longer occupational therapy episodes were age (i.e. under five and over 75 years), communication difficulties and hospital location (Grimmer & May 2001).

Interestingly, patients treated in a metropolitan hospital had longer episodes of care than patients treated in rural settings. Grimmer and May (2001) hypothesise that the effect of hospital location may well reflect therapist availability and skill, as well as patient access to services. This explanation is consistent with survey and focus group research identifying the following barriers to utilising health care services in rural areas: cost; lack of insurance coverage; travel distance to services; transportation problems; difficulty in taking time off work; traditional rural values, such as self-reliance; reduced referrals; and a lack of knowledge about the potential benefits of specialised medical care (Casey et al. 2001; Schur & Franco 1999; Strickland & Strickland 1996, Veitch et al. 1996).

4. Road Safety Countermeasures

The following section presents a suite of road safety interventions and strategies suitable for implementation in rural and remote areas of Australia. In addition to traditional behavioural interventions, the potential of programs utilising improved vehicle safety standards, infrastructure management and emergency services are discussed. Throughout the section, there is an underlying theme that '... rural and remote road safety is completely different from freeway or urban road safety and thus requires a separate management approach' (Hasson 1999). Following each section, several core elements of effective interventions are highlighted.

4.1.1 Behavioural interventions

Education and community change strategies

One of the goals of the *Australia's Rural Road Safety Action Plan* was to improve driver behaviour and attitude in relation to alcohol, excessive speed, seatbelt compliance and driving while fatigued, through increased enforcement, education and promotion (National Road Safety Strategy Implementation Task Force 1996). The Victorian Road Safety Committee (2002) has recommended that positions be created within rural local governments specifically to promote road safety within the community. Ryan et al. (1992) noted that road safety interventions that have been successful in urban areas have not achieved the same success in rural areas, so there is a pressing need to ensure that the overall package of interventions complement each other and above all '...pay special attention to raising awareness of rural road safety both within the general public and within the organisations of all key actors – government, peer groups and others' (OECD, 1999). In order to do this, a 'regular program of intensive crash research into rural crashes should be instituted, to monitor the effects of countermeasures, and to detect trends in crash and injury causation' (Ryan et al. 1988). Once common crash causation factors are identified, tailored countermeasures for rural and remote drivers can be developed.

Attempting to convince high-risk individuals to alter their behaviour or adopt safety precautions only works with drivers who believe they need to change their behaviour to become safer on the road (Todd, 1999). Road safety interventions must also be 'designed and targeted using local knowledge and framed in the local culture and understanding of the problem ... (to avoid) ... the tendency for generic information to repeat what people already know' (Butchart et al. 2000) or prove to be ineffective. Ryan et al. (1988) stated that 'preventive campaigns can be appropriately directed primarily at the residents of rural areas' because most rural crash victims were local residents driving on familiar roads. Moller and Cantwell (1999) also recommended that tailored interventions be targeted towards at-risk populations.

In Australia, there has been a rapid expansion of community participation in road safety initiatives and preliminary evaluations suggest they are highly effective (Howat et al. 2001). Arguably, the most successful example of a community change initiative in Australia is the Northern Territory's *Living with alcohol* program (Stockwell et al. 2001). In April 1992, a comprehensive population-based alcohol harm reduction program (funded by 5 cents per standard drink levy) was introduced by the Northern Territory Government and key stakeholders. The program included a range of initiatives such as: increased alcohol and drug-related services in hospitals; high-profile mass media education programs about drink driving and responsible service of alcohol; the introduction of a 0.05% BAC for drivers in 1994; and restrictions on hours of trading for licensed premises. During the first four years of the *Living with alcohol* program, the Northern Territory experienced significant health and safety benefits.

After its inception,

there were reductions in estimated alcohol-caused deaths from acute conditions (road deaths 34.5%, other 23.4%) and in road crash injuries requiring hospital treatment (28.3%). In addition there were substantial reductions in per capita alcohol consumption and self-reported hazardous and harmful consumption via surveys. These reductions were evident immediately...and were largely sustained throughout the four years studied (Stockwell et al. 2001).

The Department of Social and Preventive Medicine (University of Queensland) developed, in conjunction with Magistrates, Community Corrections, Queensland Transport, TAFE, Queensland Police and Queensland Health, an 11-week drink driving prevention and rehabilitation program – *Under the limit*. The program commenced in January 1993 and is offered through Magistrates' Courts as a probationary requirement. The intersectional nature of the development team ensured that the program was tailored to the target group and was based on current best practice models in the areas of problem drinking and drink driving. Since its inception in 1993, nearly 4,000 people convicted of a drink driving offence have participated in the program which is delivered through TAFE colleges throughout Queensland or via distance education. The delivery flexibility of the program has ensured its accessibility to rural and remote areas. A follow-up evaluation of offenders participating in the program in Central Queensland between January 1993 and December 1995 revealed that 85.2% ($n = 757$) successfully completed the program. Furthermore, successful completers had an overall reduction in re-offence rates of approximately 15% compared with controls. For the most serious offenders (those with both prior drink driving offences and high BAC at the index offence), completion of the *Under the limit* program reduced recidivism by 55% (Ferguson et al. 2000).

Brownlow (1998) cited the Queensland *Driver reviver* program as an example of effective community involvement in the development and delivery of a road safety initiative. Established in 1990 and coordinated by Queensland Transport and Queensland Police Service, *Driver reviver* boasts 30 sites throughout Queensland staffed by almost 3,000 volunteers. Each year the program has increased in patronage and '...in 1996, some 283,000 travellers dropped in for a drink, a 17% increase on the previous year' (Brownlow 1998). Queensland's experience of the program has been that communities display high levels of energy, ownership, involvement and autonomy. 'These, matched with effective state-wide coordination and governmental support, account for the program's success in terms of both patronage and impact on road trauma' (Brownlow 1998). As there are virtually no enforcement provisions for driver fatigue, public education and community-based strategies predominate in this area. For example, the Victorian Road Safety Committee (2002) recommends that a program to guide the improvement of resting places to combat driver fatigue throughout the rural road network be developed. A description and overview of both local and interstate light-vehicle fatigue countermeasures can be seen in Table 4.1.

Table 4.1: An overview of fatigue countermeasures

Driver reviver programs - all Australian states and the Northern Territory participate in the national driver reviver program.

Driver fatigue linked to occupational health and safety (OH&S) legislation - Western Australia and the Northern Territory have developed a code of practice for both heavy and light vehicle drivers. The code is designed to assist employers in meeting their OH&S obligations.

Public education strategy – all Australian states and the Northern Territory have integrated driver fatigue activities into a public education strategy.

Driver fatigue linked to workplace fleet safety program – Western Australian fleet safety information is included in their *Code of practice: fatigue management for commercial drivers*. Other publications also inform employers about how to develop a road safety policy and plan for their business. Victoria is developing a Corporate Safety Package that aims to provide information to employers about building driver fatigue programs into their workplace fleet safety system.

Driver fatigue information included in the school curriculum - New South Wales, Victoria and Western Australia have developed road safety resources containing information about driver fatigue to be included in the school curriculum.

Driver fatigue linked to licensing legislation – New South Wales has introduced legislation to suspend a licence if a driver loses control of a vehicle because of the unexpected onset of sleep or blackout and an accident occurs whereby someone is killed or seriously injured.

Power nap program – is being developed in Victoria and advises tired motorists to stop at a safe place and take a power nap for at least 15 minutes.

Driver fatigue awareness training for employees/shift workers – The National Transport Commission (NTC) in association with VicRoads developed an educational training package for shift workers.

Source: Queensland Transport, 2002

Queensland police have also developed a program to increase teenagers' awareness of trauma arising from irresponsible driving (Queensland Police Service 2000). Even so, the situation remains whereby young persons (especially males) respond less well to interventions than older persons (Moller & Cantwell, 1999). However, education campaigns may not be as useful as planned strategies to directly modify behaviour. One option in this regard, the graduated licensing system, allows novice drivers to gain critical experience in lower risk settings, such as having no passengers, controlling cars with smaller engines, and driving with non-zero levels of blood alcohol concentration, before graduating to higher-risk environments (United States National Safety Council 1999).

It is important to recognise when planning interventions, that many youths may be more open to safety messages if they are given by female passengers of the same age group as the driver (National Highway Traffic Safety Administration 1999, Todd 1999). In Australia, the *rural anti-speed campaign* targets young males in rural and regional areas, and encourages them to reduce speeding by using humour and the prospect of social embarrassment (Australian Transport Safety Bureau, 1999). It might be that these people are a suitable target group for educative, anxiety-provoking measures.

Indigenous road safety countermeasures: The importance of cultural context

According to Moller and Cantwell (1999), there needs to be increased resources channelled into identifying unique road safety problems in indigenous communities and harnessing the local knowledge to develop culturally-appropriate interventions. These sentiments were recently advocated by leading researchers in the area of Indigenous road safety in both South Australia (Brice 2000) and Western Australia (Cercarelli et al. 2000). Brice (2000), in particular, reviewed both national and international literature on Indigenous road safety and countermeasures and proposed 18 recommendations to improve information availability and quality, potential collaboration between government and Indigenous community sectors, community-based initiatives and research strategies. While the recommendations listed specifically refer to South Australian directions, their nature ensures that they have national applicability.

A comprehensive compendium of recommendations is provided by Brice (2000) and supported by a number of successful case examples of indigenous interventions highlighting the importance of social context and values. For example, in Navajo Nation (USA), Sexton (1996, cited in Brice 2000) reported that in the early 1980s less than 5% of drivers and passengers wore seatbelts. However, in 1988, the Navajo Nation Tribal Council modified its motor vehicle safety code to require all motor vehicle occupants to use seatbelts and infant car seats. An extensive public health information and advertising campaign was sponsored by Government to strictly enforce the new tribal law. The results were unquestionable. 'By 1992, seatbelt use had increased dramatically to almost 70% and motor vehicle collisions requiring hospitalisation fell by greater than 25% since 1988' (Sexton 1996, cited in Brice). Similar success was achieved by the Whariki Maori research team's Uru Atu: *Community Action to Reduce Alcohol Related Traffic Injury Among Maori* [www.aphru.ac.nz/whariki/default.htm]. The intersectional three-year collaborative project targeted Maori males 20-30 years and raised awareness of, and support for, culturally viable strategies to reduce drunkenness in public and strategies complementing compulsory breath testing (Brice 2000). 'The importance of Maori as providers of the program, both as deliverers and as the umbrella organisation, heightened the acceptability and effectiveness of the message. It was perceived to reflect the community. 'Street credibility' was vital to this acceptance'.

Macaulay et al. (2003) conducted a comprehensive review of indigenous road safety in Australia and summarised many of the countermeasures which have been undertaken to address relevant problems, including vehicle overloading and unlicensed driving. This report, which is currently being updated, is available at the ATSB website www.atsb.gov.au/publications/2003/indig_3.aspx.

Road safety advertising as an adjunct to enforcement

The effectiveness of road safety advertising as an adjunct to enforcement in Australia is well documented (Cameron et al. 1992, Cameron et al. 1993, Cameron et al. 1997, Cavallo & Cameron 1992, Elliott & Shanahan Research 1992, Wundersitz et al. 2000). Wundersitz et al. (2000), for example, evaluated the effectiveness of a police and mass media intervention aimed at increasing restraint use in Whyalla and rural South Australia. The trial was evaluated by observing restraint use: (a) before the campaign (February 1998); (b) directly after the campaign (December 1998); and (c) and then three months following a second campaign (March 1999). Telephone surveys examining self-reported restraint use were also conducted before (May 1998) and after the intervention (December 1998). Following the intervention, Wundersitz et al. (2000) reported that large increases in the level of restraint use in Whyalla and rural South Australia were matched by a substantial increase in the knowledge of penalties incurred for seatbelt non-compliance as shown in self-reported surveys. 'Observed restraint use levels for all vehicle occupants increased in Whyalla from 84 percent in February 1998, to 93 percent in December 1998. This increase was maintained four months later after supplementary education and enforcement'.

The Transport Accident Commission (TAC) in Victoria has made a major investment in high-profile and intense television advertising which, coupled with increased enforcement efforts by the Victoria Police, has reaped obvious road safety benefits. For example, Cameron et al. (1992) conducted an economic analysis of the effect on crashes of several major TAC advertising campaigns with increased enforcement efforts by the Victoria Police. They report that the multifaceted evaluation study revealed clear links between levels of TAC publicity supporting speed and alcohol enforcement programs and reductions in casualty crashes when other factors were held constant. The estimated benefits in terms of reduced TAC payments (at the point of diminishing returns) were 3.9 and 7.9 times the costs of advertising supporting the speed and alcohol enforcement programs respectively (Cameron et al. 1992). In the investigation, Cameron et al. (1992) also looked at the effect of road safety advertising that is not related to enforcement (e.g. driver concentration). While the 'Concentrate or Kill' advertisements, that targeted young drivers on rural roads aimed to raise awareness of the safety issues, the evaluation examining its effectiveness provided no conclusive evidence to suggest they reduced crash involvement of the target group (i.e. young drivers on country roads) (Cameron et al. 1992).

Public education campaigns addressing the key road safety areas – drink driving, speeding, seatbelt compliance, driver fatigue - also need to be widespread (Sahai et al. 1998). Newstead et al. (1998) report that from 1990 to 1996, television publicity encouraging drivers to avoid speeding and to concentrate while driving in Victoria led to an eight to ten per cent reduction in serious casualty crashes.

The analysis carried out by Cameron applied complex mathematical modelling techniques. These techniques were required to separate out concurrent initiatives and other changes that may have also affected casualty crashes. The resultant complexity, however, means that the analysis is not straight forward, and some other researchers have queried the appropriateness of the models applied and conclusions reached (White et al. 2000 and 2002).

According to the Protection Motivation Model, the effectiveness of fear or deterrence-based advertising is dependent upon three cognitive processes: (a) appraisal of the severity of the threat (e.g. dying in a fatigue-related crash); (b) the probability of occurrence; and (c) self-efficacy and belief in the efficacy of the coping response or message (Maddux & Rogers 1983, Tanner et al. 1989). With the permission of TAC and Western Australia's Office of Road Safety, CARRS-Q examined the effectiveness of television advertisements delivering fear-evoking messages about driver fatigue and advertisements presenting strategies to avoid the potentially negative consequences of driver fatigue. The advertisements selected were developed and aired in Australian states other than Queensland, thus minimising any previous exposure to messages (Tay & Watson 2002). The participants in the study (n = 134) consisted primarily of university students who were administered two questionnaires. In the first questionnaire, participants were asked to provide some demographic information and answers regarding their attitudes toward road safety and driver fatigue. Then, participants were presented with some road safety advertisements. Half of the sample were only shown a highly-threatening message regarding the consequences of driver fatigue, while others were shown the same message as well as advertisements showing some suggested coping strategies (i.e. regular breaks, napping, etc.).

After viewing the advertisements, participants were required to complete the remaining questionnaire items which assessed reactions to the message(s) and attitudes and intentions towards driving while tired. A follow-up questionnaire was administered two weeks later to measure the same intentions and subsequent self-reported driving behaviour. Message acceptance and message rejection were measured by items that assessed participants' intentions to use strategies to avoid driving when fatigued, and self-reported driving-when-fatigued behaviours. The results showed perceived efficacy to have a significant positive influence on behavioural intentions and self-reported behaviours. In particular, response efficacy appeared to be sustainable over time. As a result, the authors concluded that the inclusion of explicit coping strategies in road safety messages has a significant positive effect on message acceptance (Tay & Watson 2002). Hence from a policy perspective, road safety advertisements should strive to increase perceived response efficacy by increasing the variety and applicability of coping strategies presented. The need to highlight options and/or coping strategies is of equal, if not greater, importance in rural areas (Tay & Watson 2002).

Enforcement and deployment styles

While education, advertising and community change strategies are integral road safety interventions, traffic legislation and ongoing police enforcement need to be core components of all rural and remote road safety campaigns (Harrison 2000, Honor 1995, OECD 1999, Parliamentary Travelsafe Committee 1996). When coupled with appropriate penalty regimes and publicity, deterrence-based enforcement has been shown to consistently achieve positive long-term behavioural change in drivers and the general population (Cameron et al. 1992, Cameron et al. 1993, Cameron et al. 1997, Cavallo & Cameron 1992, Vulcan et al. 1995). However, due to the length of the rural road network, enforcement by conventional means is not always ideal or practical (Brown 1995). As a result, rural police services often have to better deploy or manage resources as opposed to simply operating via a concentrated police enforcement approach. The OECD (1999) report suggests that '...repeated enforcement creates longer halo effects compared to blitz campaigns'. The effectiveness of these programs can be further increased by introducing a random enforcement element. Early evaluations of Queensland's *Random road watch* approach to speed management show the program to be effective overall, resulting in an estimated 31% reduction in fatal crashes and significant cost savings at the state level (Leggett 1999). Innovative enforcement and deployment styles of this nature appear to be particularly suited to rural and remote areas characterised by less resources.

Police enforcement strategies are especially important given the contribution of inappropriate and excessive speed to road crashes in rural and remote areas. So, as the rural road network is so vast, automated enforcement technologies (i.e. speed cameras) that require minimal staff to operate should be considered. Furthermore, the OECD (1999) '...recommends that a portion of the funds generated from traffic enforcement activities be earmarked for rural road safety' and research. With specific regard to drink driving enforcement in rural areas, Harrison (2000) highlighted the need for police to be actively seen in the community. Based on interviews with hotel patrons in rural Victoria and South Australia, Harrison (2000) concluded that the most effective enforcement programs '...favoured an increase in the level of overt (or detection-oriented) enforcement activity in rural areas'.

Enforcement must also be flexible in the face of changing social expectations and beliefs. Pro-active initiatives in New South Wales such as driver behaviour modification through the introduction of road-rage legislation, and double demerit points on long-weekends, appear to be effective (New South Wales Department of Transport, 1998). Additionally, Kines (1997) acknowledged the potential of exposure-control enforcement measures (i.e. licence revocation, vehicle impoundment, etc.) to manage high-risk drivers who appear resistant to education.

The most comprehensive summary of the educational and enforcement needs for rural and remote Australia remains *Australia's Rural Road Safety Action Plan* (National Road Safety Strategy Implementation Task Force 1996). See Table 4.2.

Table 4.2: Effective behavioural interventions in rural and remote communities

- The fact 'that rural people die in rural crashes' should be highly publicised.
- Localised education campaigns should target local road safety problems and 'at-risk' populations.
- Local communities should be actively engaged in public health decision-making and the subsequent development and distribution of resources/interventions.
- Increased resources need to be channelled into identifying unique road safety problems in Indigenous communities and harness their local knowledge to develop culturally appropriate interventions.
- Ongoing 'Fatal Four' (i.e. speeding, drink driving, fatigue and non-seatbelt wearing), education should complement rural enforcement campaigns.
- Road safety advertising should include explicit coping strategies (decision alternatives) to increase message acceptance and effectiveness.
- Rural enforcement programs need to utilise randomised scheduling or deployment methods to enable low levels of police presence to achieve more widespread coverage of vast road networks.
- A portion of the funds generated from traffic enforcement activities should be earmarked for rural road safety and associated research.
- Road safety training programs for practitioners should be developed and encouraged by Government to ensure the professionalism of the industry.

Source: Based on issues raised by the National Road Safety Strategy Implementation Task Force (1996) and the Parliamentary Travelsafe Committee (2002).

4.1.2 Vehicular interventions

Vehicle safety standards and design

Newstead et al. (1999) examined data relating to crashes in New South Wales, Victoria and Queensland, controlling for driver sex, driver age, speed limits, the number of vehicles in the crash, the state of occurrence, and the year of the crash, and found that the greatest improvements in vehicle crashworthiness occurred during the 1970s. Thousands of lives have been saved since then through the introduction of vehicle safety features such as seatbelts, laminated windscreens and non-flammable interior materials (National Highway Traffic Safety Administration 1999, Todd 1999). Li and Routley (1998), in particular, demonstrated that improvements in vehicle crashworthiness greatly contributed to observed reductions in traffic fatality and injury rates in Victoria between 1984 and 1996.

Priority areas identified by the Federal Office of Road Safety for 1992-2000 included crash protection of vehicle occupants and reducing the crash involvement of heavy vehicles (Travelsafe Committee 1999a). Improvements to vehicles which are expected to further reduce trauma resulting from road crashes include: removing the centre front seating position from cars and car derivatives because of the lack of effective restraint; installing roll cages in the back of trucks and utility vehicles used by Indigenous persons in remote and rural areas (if the use of such vehicles cannot be avoided) (Ryan et al. 1998); and the fitting of 'Tattletale' airbags which record impact forces during crashes (Mateja 1995).

Enforcement of minimum safety standards can also serve to bolster public education campaigns. An example of this is the ongoing vehicle inspection program known as '*Wobbly Wheels*'. This program is carried out by Queensland Police officers and Queensland Transport inspectors, who cooperate in the detection and prosecution of the drivers of unroadworthy vehicles, at randomly placed roadside inspection locations (Queensland Police Service 2000).

Intelligent transport systems (ITS)

Improved technology and intelligent transport systems (ITS) are emerging as effective tools to enhance vehicle safety and reduce the prevalence and cost of rural road trauma both overseas (Apogee/Hagler Bailly 1998, Bland et al. 1997, McCormack & Legg 1999, OECD 1999, U.S. Department of Transportation 2001) and in Australia (Lewis 1999). Booz-Allen Hamilton (1998), in particular, conservatively estimated a potential \$3.8 billion in safety benefits from the widespread introduction of ITS in Australia by 2012. Lewis (1999) reported that ITS is already contributing to road safety in Australia through speed and red light cameras, Safe-T-Cam, weigh-in-motion devices to combat overloading, and traffic management systems such as SCATS (Sydney Coordinated Adaptive Traffic System). However, many other ITS applications designed to address priority road safety areas have not been trialled locally. Austroads (1999) cited intelligent seatbelt interlocks, electronic drivers' licences, smart daytime running lights and emergency response systems as examples of immediately available, effective and inexpensive ITS solutions.

In America, the development of ITS applications for rural areas is a growth industry. So much so, that the U.S. Department of Transportation (2001) compiled a registry of emerging ITS technologies. The *Rural ITS Toolbox* is a best practice document and identifies successful rural ITS projects and applications throughout America. The resource is broken up into seven sections each corresponding with a specific rural ITS user need: (1) emergency services; (2) tourism and travel information; (3) traffic management; (4) rural transit and mobility; (5) crash prevention and security; (6) operations and maintenance; and (7) surface transportation and weather (U.S. Department of Transport 2001). Sections one and five are of particular relevance to this report and associated key findings are synthesised under appropriate headings in Table 4.3.

In an earlier document, McCormack and Legg (1999) studied applications of ITS to safety issues on rural roadways in Washington. In doing so, they developed a framework for examining rural ITS initiatives based on contributing crash factors being addressed (McCormack & Legg 1999).

Table 4.3: ITS applications to rural road safety

Contributing crash factors	Rural safety issue	% of vehicles in rural crashes in Washington	Possible ITS solutions
Human	Unsafe speed or exceeding speed limit	22%	<ul style="list-style-type: none"> ● Speed radar linked to warning sign ● Variable speed limits ● Photo enforcement system
	Inattention or sleeping	9%	<ul style="list-style-type: none"> ○◆ Driver monitoring system ○◆ Roadway departure systems
	Judgement errors	16%	<ul style="list-style-type: none"> ● Computer designed roadway signs ○◆ Crash avoidance countermeasures system for older drivers
	Drug or alcohol	5%	<ul style="list-style-type: none"> ●◆ Ignition interlock with breath analyser
Road	Weather	23%	<ul style="list-style-type: none"> ● Area-wide weather warning systems ● Fog, dust or smoke warning systems ● Wind gust warning systems ● Intelligent road markers with weather sensors
	Wildlife collisions	5%	<ul style="list-style-type: none"> ●◆ Night vision systems ○◆ Roadway obstruction detection
	Work zone	3%	<ul style="list-style-type: none"> ● Adaptable variable message signs ● Portable work zone safety systems ● Work zone intrusion warnings
	Pedestrian or bicycle involvement	0.7%	<ul style="list-style-type: none"> ● Self-activated warning signs for roads and tunnels
	Railroad crossings	>1%	<ul style="list-style-type: none"> ● Train conflict sensors and warning signs ○ In-locomotive vehicle in crossing warning systems
	Rural intersections	28%	<ul style="list-style-type: none"> ● Approaching vehicle warning sensors and signs
Vehicle	Truck (over 10,000 lb) involvement	7%	<ul style="list-style-type: none"> ● Truck classification detectors and warning signs at hazardous locations ● Automated commercial vehicle inspection and enforcement programs
Post-crash	Emergency notification		<ul style="list-style-type: none"> ● New technology call boxes ○◆ In-vehicle mayday systems
	Incomplete or inaccurate crash reports		<ul style="list-style-type: none"> ● Total stationing for crash reporting ● Portable computers in police vehicles ● Crash reporting systems utilizing GPS and GIS at software

● = Application feasible currently or in the near future

○ = Potential future application

◆ = Application from vehicle manufacturers

Adapted from McCormack and Legg (1999)

ITS and human factors

Given the major role speed plays in rural road crashes, speed control technologies such as speed advisory/warning systems, roadside controlled speed systems (allowing remote traffic flow coordination) and adaptive cruise control (where vehicle speed is computer controlled to respond to changing traffic conditions) should be explored and evaluated extensively (Chew et al. 1998, Lewis 1999). Other in-vehicle ITS initiatives such as smart seatbelts, airbags and vehicle data recorders (to provide black box post-crash data) also appear to be effective (OECD 1999).

However, the barriers of high cost and rural poverty create difficulties in the implementation of such initiatives. Lewis (1999) warns that in-car safety technology is likely to be expensive initially, like ABS was, and will take time to filter through the vehicle fleet.

Similarly, Chew et al. (1998) reported on the importance of alerting drivers to the conditions ahead and driver monitoring systems. In the United States, trials have shown that the introduction of radar-linked speed signs, variable speed limit systems, and fatigue detectors (such as in-car driver position sensors) have reduced crashes caused by driver error on rural highways (Chew et al., 1998). In lieu of no on-site test for driver fatigue, Hasson (1999) cites the potential of driver monitoring devices, coupled with rumble strips on high-speed limited access rural roads in fatigue management (The National Centre on Sleep Disorders Research and National Highway Traffic Safety Administration Expert Panel on Driver Fatigue and Sleepiness 1998). In Western Australia, ARRB has developed a fatigue monitor for heavy vehicles and mining equipment. The device requires drivers to respond to random warning rings to indicate alertness, with all results being centrally monitored. While devices monitoring driver alertness are becoming prevalent, Hartley et al. (2000) warn that the exact predictive relationship of monitored variables (such as attention, vigilance, hyper-vigilance, alertness, micro-sleeps or vulnerability to error) to crashes is usually unknown; hence emerging technologies remain largely unproven. McCormack and Legg (1999) go even further to suggest that most human behavioural issues, such as inattention or poor driver judgement, cannot be directly addressed by the suite of ITS applications currently available.

Finally, with regard to drink driving, there is strong evidence to suggest that alcohol ignition interlocks are a useful addition to punitive and rehabilitative sanctions, and effectively reduce recidivism over and above conventional drink driving sanctions such as fines and licence disqualification (Coben et al. 1999, Marques et al. 1999, Weinrath 1997). Encouraging results from the United States and Canada have since prompted other countries, like Sweden and Australia, to introduce ignition interlock devices as a drink driving countermeasure.

ITS applications have been proven in their ability to avert crashes and save lives through collision avoidance and warning. For example, a working group, convened by the NHTSA, examined the number of crashes that could be avoided using in-vehicle devices to reduce lane change/merge, rear-end, and single vehicle run-off-the-road crashes. Based on experimental data, Apogee/Hagler Bailly (1998) demonstrated that the use of such devices could reduce crashes by up to 17% annually or 1.1 million crashes per year. Greyhound Coaches and Transport Besner Trucking Company in America also reported 20-30% percent reductions in crash frequency following the installation of collision-warning devices (Apogee/Hagler Bailly 1998).

ITS and road factors

Research indicates that drivers require advance warning of rural intersections and need to be clearly shown who has right of way, as well as being given the opportunity to judge the speed of converging vehicles (VicRoads 1998). According to McCormack and Legg (1999), ITS offers a viable alternative to traditional engineering solutions for crashes resulting from road factors by informing drivers about roadside hazards. Some of the more promising initiatives for rural Australia include: ITS weather systems and traveller information systems; work zone safety systems; automated (night) visibility warning systems; animal warning systems; and highway-railway crossing alert and safety systems (McCormack & Legg 1999 U.S. Department of Transportation 2001). Noy (1997) points out that many of these applications are still in the planning or experimental stage and greater care needs to be taken with improving the device-human interface before mass introduction.

ITS and vehicle factors

Electronic stability control (ESC) is currently gaining acceptance and application as a key vehicle safety. Dang (2004) found in a study into the effectiveness of ESC that single vehicle crashes reduced by 67% for vehicles fitted with ESC. Their study also found that fatal crashes for passenger cars fell by 30% while the reduction for sport utility vehicles (SUV) was 67%.

ITS also has the potential to make trucks and the heavy vehicle industry more compliant with safety legislation and improve the efficiency of safety checks through automated commercial vehicle inspection and enforcement programs (McCormack & Legg 1999).

ITS and post-crash factors

According to the U.S. Department of Transportation (2001), ITS should essentially guide emergency response procedures and trauma management through the consistent adoption of: emergency vehicle traffic signal pre-emption; mayday systems; accident investigation systems; and dispatching systems. Notification of emergency services following a rural crash is an avenue in which emerging technologies could be successfully applied. Rural public telephones with satellite coverage are proven in reducing crash notification time (Chew et al. 1998, McCormack & Legg 1999 U.S. Department of Transportation 2001). State-of-the-art global positioning systems (GPS) can also aid in the development of notification systems to improve trauma response (Henderson 1995).

The United States National ITS Program Plan includes the provision of rural mayday systems to reduce crash notification to about a minute (Evanco 1999). If this proves feasible it would greatly increase survival rates in remote areas. Chew et al. (1998) report that in-vehicle mayday systems (consisting of a satellite location device, in-vehicle collision sensors, and a communication system to notify rescue authorities of a crash) have immense potential to reduce response time. These systems are already available in high-end production model cars. The location device is usually a satellite-based system such as the Global Positioning System (GPS), which may be supplemented by Low Earth Orbit (LEO) satellites to avoid problems raised by terrain blockages, and also by dead reckoning backup systems. Widespread introduction of in-vehicle mayday systems has been modelled in the United States, and predictions suggest that it will drastically reduce fatality rates in rural areas. Evanco (1999) estimates that, if every car in the United States was fitted with an in-vehicle mayday system, annual savings of over US\$6b in current road trauma expenditure would result.

During January 2004 researchers funded by the European Union (EU) commenced testing the ECall system which automatically detects a crash, sending a text message advising emergency services that a crash has occurred. Vehicles are fitted with cell-sized devices fitted to the underside of the dash and are activated by the same sensors that trigger an airbag in a collision. The device, developed by ERTICO, includes a cell-phone circuit, a GPS positioning unit, and a microphone and loudspeaker. The severity of the crash is determined by reading the deceleration data from the airbag's sensor. The device is able to automatically determine the precise crash location and alert the emergency services. The vehicle occupants, if conscious, may communicate with the operator via the speaker and microphone.

Renault concluded that the system could save up to 6,000 of the 40,000 lives lost each year on Europe's roads. Renault also estimated that fitting every car in Europe with E-merge would eventually save about 150 billion Euros, about AUD\$260 billion per year in terms of reduced costs to health services, insurance costs and lost days of work (Randerson 2004).

General Motors in the US has commenced offering the Advanced Automatic Crash Notification (AANC) system in a range of their vehicles. Together with their wholly owned subsidiary company OnStar their AANC system was designed to automatically notify specially trained emergency call centre advisors of moderate to severe frontal, rear or side-impact crashes. Sensors strategically placed within the vehicle provide crash severity information and metrics that are relayed to emergency dispatchers to assist them in determining suitable emergency personnel, equipment and medical requirements. AANC combines in-vehicle telemetric, electronics, crash sensing and human safety engineering (PRNewswire n.d.). Since its introduction in 2003, about 2.7 million motorists have subscribed to its use. Other crash notification systems include Lexus's Lexus Link, BMW's BMW Assist and Mercedes-Benz's TeleAid (Edmunds.com Editors 2004).

4.1.3 Environmental safety measures

Changes to the road environment

The road environment is one of the few direct intervention opportunities available to reduce road trauma. Vehicle systems may be designed and implemented, but drivers may still fail to use them. Drivers may be educated via media campaigns, or punished for disobeying traffic laws, but ultimately they still decide the manner in which they act on the road. In contrast, recognition and improvement of risky road environments before they actually become blackspots is one of the few direct intervention opportunities available to government. For example, it has been found that cross-intersections are less safe than other intersection types and that converting cross-intersections to right-left staggered-tee configurations can reduce local crashes by 40-80% (Safe Roads 1998). As previously stated, research indicates that drivers require advance warning of rural intersections and need to be clearly shown who has right of way, as well as being given the opportunity to judge the speed of converging vehicles (VicRoads 1998). Therefore, clearing trees near curves can improve sight distances, thus reducing crashes (VicRoads 1998). Removing hazardous roadside objects, such as trees and poles has been shown to reduce the severity of run-off-road crashes (Ryan et al. 1998), and planting frangible trees near roadways may achieve a similar outcome (Armour & Cinquegrana 1990). In remote areas, where animals are more often involved in road crashes, the installation of Wildlife Warning Reflectors, which reflect car lights into bushland when headlights illuminate them, and discourage wildlife from crossing the road, would also reduce road trauma (Armour & Cinquegrana 1990).

The primary means to identify roadside hazards is the road safety audit process, and processes which uses key crash risk factors to identify the hazards. The continued expansion and improvement of road safety audit systems, the setting of minimum safety features for rural roads, and the development of tailored implementation programs, should form a major component of the national approach to reducing rural and remote road trauma (Austroads 1997, Vulcan et al. 1995). There are various ways of determining how improvements to roadways should be prioritised. Barker et al. (1999) in a European context, state that improvements in rural roadways should be prioritised to reduce either crashes per kilometre, crashes per vehicle kilometre, crashes per intersection, crashes per curve, or proportions of crash types occurring disproportionately at specific sites. In Australia, there has been a strong push for the better use of crash data and increased road safety auditing to identify hazardous locations (i.e. blackspots) for the effective allocation of limited road safety funds (Grigg 2000, Lydon 1997).

Road safety auditing

From an engineering perspective, there is a strong evidence to show that road safety auditing is a vital process in maximising the safety of the road network and minimising road trauma (Jordan & Barton 1992, Austroads 2002). Regardless of the project cost, the audit process has potential to identify deficiencies and associated treatments with a significantly high return on investment (Austroads 2002). The evaluation conducted by Austroads (2002) found that: Of the group of design stage audits assessed, the benefit cost ratio of implementing the recommendations from individual audits ranged from 3:1 to 242:1.

- The BCRs of individual recommendations within the design audits ranged between 0.06:1 and 2,600:1.
- Over 90% of all implemented recommendations had BCRs > 1.0.
- Approximately 75% of all implemented recommendations had BCRs > 10.

- The majority of design audit findings required only very low-cost responses (65% of recommendations had a cost < \$1,000). Of these low-cost responses 85% had BCRs > 10.

Evaluation of the proposed actions emanating from audits of existing roads resulted in the following findings:

- The analysis of a range of existing road safety audits indicated BCRs of implementing the proposed actions between 2.4:1 and 84:1.
- The BCRs of individual proposed actions within the existing road audits ranged between 0.003:1 and 460:1.
- Over 78% of all proposed actions had BCRs > 1.0.
- Approximately 47% of all proposed actions had BCRs > 5.0.
- Approximately 95% of proposed actions with a cost less than \$1,000 had BCRs > 1.0.

The Victorian Road Safety Committee (2002) has also recognised the importance of road safety audits in identifying road hazards and has recommended that they be mandatory for road projects funded by state government and that safety reviews of existing roads be undertaken regularly. In addition to pro-actively identifying and treating road hazards, the audit process has the potential to guide safety improvements to engineering standards and procedures (Jordan & Barton 1992). A recent example in Queensland, was the development of a 'guide for the road safety management of rural school bus routes and stops' (Queensland Department of Main Roads & Queensland Transport 2001). The guide is based on risk-management principles and '...is designed to provide engineering practitioners with a better understanding of rural school bus safety needs in Queensland ... (and) ... should be read in conjunction with other traffic engineering and road design guidelines' (Queensland Department of Main Roads & Queensland Transport 2001).

To assist road authorities prioritise the treatment of road network deficiencies based on the crash risk they pose to road users, ARRB, in association with Austroads, developed the computer based 'expert' system: the Road Safety Risk Manager (RSRM). The RSRM is designed to be used as a tool for the programming of road safety improvements and is based on relationships between road elements and crash risk that have been identified.

Treatment of blackspots

The treatment of crash blackspots has been a highly successful engineering countermeasure in recent years. In 1996, a federally-funded blackspots program to improve over 400 high crash sites throughout Australia was implemented. 'Half (\$18 million per year) of the total blackspot funding (approximately \$149 million in total to the year 2000) was made available for projects in rural areas' (Grigg 2000).

The Federal Government, in conjunction with the Queensland and New South Wales governments, has also earmarked \$150 million to upgrade the entire Pacific Highway over 10 years. This highway has the worst crash record in Australia (Grigg 2000).

Following the successful completion of the five year \$240 million Statewide Blackspot Program during 2004 in Victoria, another \$240 million was allocated in 2005 in the state's Safe Road Infrastructure Program to treat 'high' crash locations. An evaluation of the Statewide Blackspot Program found that crashes at sites treated fell by a statistically significant 31%, which returned an estimated present value saving of \$494 million to the Victorian community. The net present value achieved represented a benefit-cost ratio (BCR) of 2.4 (Scully et al. 2006).

Further Australian research has also shown that blackspot programs are able to deliver high returns for monies spent. An evaluation by the Bureau of Transport Economics (2001) found that during the first three years of the Federal Blackspot Program 1996-2002, a BCR of 14:1 was able to be achieved. A similar study in New Zealand (Land Transport Safety Authority, 2004) identified a BCR of 28:1 from the New Zealand Crash Reduction Program⁵.

Changes to road design and infrastructure improvements

The importance of providing roads with consistent design standards was highlighted in a Victorian Road Safety Committee (2005) inquiry into the state's country road toll. The inquiry reported that homogenous roads provide drivers with a more predictable road environment which encourages safer driving behaviour. The inquiry also highlighted the need to provide a safe infrastructure, one which does not penalise a driver who makes a driving error with death or serious injury, a key feature in creating a 'safe road system'.

Amongst its findings the inquiry also indicated the need to increase the minimum 'clear zone' distance for high speed high-volume roads, which is currently nine metres, the clear zone being defined as the distance out from the traffic lane available for safe use by errant vehicles. Studies have shown that on high speed highways about 80% of out-of-control vehicles are able to safely recover within 9 metres of the traffic lanes (AASHTO 2002). In recognition that it would be very costly to provide a clear zone that would safely cater for 100% of errant vehicles, road design standards across Australia have adopted 9 metres as the clear zone value to be achieved. The Committee conducting the inquiry noted overseas practice in first world European countries using clear zone values of 10 metres or more.

The Royal Automobile Club of Victoria (RACV 1990) also contended that the greatest road safety benefits in rural areas would be achieved by improved road design, blackspot countermeasures and improved vehicle occupant protection, as opposed to enforcement. Subsequently policy-makers have sought to improve:

- road design and rural intersection design
- signing and delineation
- roadside hazard management (Safe Roads 1998).

Armour and Cinquegrana (1990) found that the key to reducing rural road trauma involves sealing road shoulders, removing roadside hazards, placing protection around bridges and drains, and installing tactile edge lining. The Road Safety Committee, Inquiry into Rural Road Safety and Infrastructure (2002) offered some concordant recommendations, advocating a pro-active approach to shoulder sealing, greater attention to roadside hazards, the upgrading of bridges with increased attention to bridge visibility, signing, guard-rails and end posts, and a review of edgelineing and other delineation practices. Other recommended improvements have included providing more overtaking lanes (VicRoads 1998), better safety treatments at curves (Ryan et al. 1998, Road Safety Committee 2002), increased use of guard-rails, and improved road maintenance, especially measures that improve surface grip in wet weather (Road Safety Committee 2002). Hasson (1999) categorised road improvements by cost, thus providing policy-makers with an array of design options. Low cost road improvements include upgrading edge and centre lines, providing improved sight lines at intersections and providing advance warnings of changes in road characteristics. Medium cost road improvements include removal or protection of hazards, flattening side slopes, and increasing lane and shoulder widths. High cost improvements to the road environment include flattening horizontal curves and traffic separation.

⁵ It should be noted that there are differences in the way that BCR is calculated in Australia and New Zealand. The willingness to pay approach is used in New Zealand, resulting in higher crash costs and therefore higher benefits.

Tziotis (1992) identified a range of road and roadside improvements that may be implemented on the outskirts of provincial cities to reduce the risk of crash occurrence and crash severity. The measures included:

- provision of acceleration, deceleration and turning lanes
- provision of shoulders and the sealing of shoulders
- improved delineation, particularly for curves (e.g. edgelineing, chevron hazard markers, etc.)
- roadside hazard management measures (e.g. install safety barriers, flatten batters and hazard removal)
- improvement in sight distance at intersections.

Improvement of road shoulders in rural areas has become a national priority (National Road Safety Strategy Implementation Task Force 1996). Ryan et al. (1998) reported that the sealing of road shoulders is a long-lasting, and very effective trauma reduction intervention. Similarly, Armour and Cinquegrana (1990) found that sealed road shoulders were associated with lower crash rates in Victoria, while Kloeden et al. (1999) suggested that sealing shoulders on curves is particularly useful in reducing the risk of a driver running off the road. In an Australian study, Ogden (1997) sought to determine the safety and economic consequences of paving shoulders on rural roads in Victoria. Using a before-and-after case control comparison, Ogden (1997) found that '...shoulder paving was associated with a statistically-significant reduction ... (41 percent on a per vehicle kilometre basis) ... in casualty accident frequencies at sites where it was installed on two-lane two-way rural highways'. Ogden (1997) also estimated the benefit-cost ratio of shoulder paving to be 2.9 times the Annual Average Daily Traffic (AADT) in thousands. So, if the AADT was 4,000 vehicles per day, a benefit-cost ratio of about 11.6:1 could be expected. These findings were confirmed by Wang et al. (1997), who developed a statistical model of crash occurrence which predicts that increased outside shoulder and median widths reduced crash frequency on non-freeway rural roads.

Driving simulator studies have demonstrated that when roadway delineation is improved, motorists drive faster, especially on curves (Ranney & Gawron 1986). However, in reality, Henderson (1995) suggests that crashes in *boundary zones* (outside population centres) can be reduced by the provision of acceleration and turning lanes, better delineation of curves, shoulder sealing, and better placement or protection of utility poles. Installing audible side- and centre- lines on roads has also been shown to directly reduce trauma resulting from driver fatigue (Henderson 1995).

Finally, slip-base poles, which detach when struck by a vehicle, and fall to the ground behind the vehicle as it passes by, can improve safety on high-speed roads (VicRoads 1998). These poles reduce the roadside hazard where such amenities as intersection lighting are required but are not suitable for slower speed urban environments as they cannot carry live electricity connections and may fall on slow-moving vehicles (VicRoads 1998).

Queensland Department of Main Roads is seeking to bolster rural road safety by improving road shoulder sealing and construction, painting edge lines, providing overtaking lanes, widening and delineating existing lanes, and targeting blackspots (Parliamentary Travelsafe Committee, 1999a,b). On a larger scale, New South Wales has been spending very large sums of money on state roads, including replacing timber bridges, and strengthening, widening and sealing country roads, rebuilding rural roads, and improving arterial roads leading to major tourist attractions (New South Wales Department of Transport 1998).

In addition to improving existing roads, there is a growing body of evidence to suggest that engineering countermeasures (e.g. different road textures) and manufactured perceptual treatments (e.g. painted transverse lines with gradually reduced spacing) should be used in conjunction with appropriate speed limits and enforcement to reduce speed and crash rates in rural areas (Barker 1997, Kines 1997, Parsonson et al. 1996). Chevrons (i.e. inverted 'V'-shaped markings in lanes at 40 m intervals), for example, have been found to reduce close-following behaviour and improve safety in rural areas when coupled with appropriate driver education (Barker 1997).

ARRB (Macaulay et al. 2004) in association with MUARC has trialled two perceptual engineering treatments to reduce speed on rural roads in Victoria and New South Wales (Figures 4.1 and 4.2).

Figure 4.1: Typical intersection treatment



Figure 4.1 shows a typical rural intersection treatment that creates the perception that the road is narrowing, thus alerting drivers to slow down as a cross-intersection is ahead.

Figure 4.2: Typical curve treatment



Figure 4.2 shows a typical rural curve treatment. By varying the height and distance of guideposts from the edge of the roadway, the illusion is created that the curve is sharper than it actually is, and this may lead motorists to reduce speed and be more cautious. The study revealed while average speeds did not appear to change in the short term, reductions could be achieved in the longer term.

Although their impact on crash risk reduction is yet to be fully assessed there are a number of traffic engineering measures that may potentially reduce road trauma. For example, in New South Wales centre of the road wire rope barriers on undivided roads are being installed to reduce the incidence of head-on crashes.

Speed limits on rural and remote roads

Based on assessments of possible higher open road speed limits (Donald & Cairney 1997, Henderson 1995, Kloeden et al. 2001) and the American experience (Kedjidjian 1998), there is strong evidence to suggest that increases in rural and remote speed limits would result in a consequent increase in crash numbers and severity. For example, speed limit increases on rural interstates in Missouri from 60 mph to 70 mph were followed by a 43% increase in fatal crashes (Kedjidjian 1998). Similarly, Kloeden et al. (1997) reported that speed limit increases in 1991 to 65 mph on some rural interstate highways in the USA coincided with a net increase of 26% in fatalities on those roads as compared to roads where the limit remained at 55 mph. Furthermore, USA insurance claims data showed that traffic fatalities increased 12% on interstates and 6% on all roads in states which legislated increased speed limits (Kedjidjian 1998). A National Highway Traffic Safety Administration study (using a different methodology) found a 9% increase in fatalities in those states, which translated into 350 extra deaths that cost \$820 million (Kedjidjian 1998).

Patterson et al. (2002) also found that raising the maximum speed limit on rural interstates in the USA resulted in an increase in road fatalities. Within a year of the repealing of the National Maximum Speed Limit in November 2005, 23 states increased their rural interstate speed limits to 70 or 75 mph. Analysis of before and after crash data revealed that the number of fatalities increased by 35% and 38% on rural interstates in those states that increased the maximum limits to 70 and 75 mph, respectively, when compared with the states which did not raise their speed limits.

The Australian situation is similar (Kloeden et al. 1997). Observational data revealed that lowering speed limits from 110 km/h to 100 km/h on Victorian roads caused a net reduction of 19.3% in the casualty rate from 1990 to 1992 (Vulcan et al. 1995). A Western Australian study concluded that a reduction in their 'rural speed limit from 110 km/h to 100 km/h would potentially result in a saving of about 40 lives and about \$40 million each year' (Ryan et al. 1998). More recently, Kloeden et al. (2001) examined the effect of various hypothetical speed reductions on rural casualty crash frequency and found that even small reductions in travelling speed in rural areas have the potential to greatly reduce serious crashes in those areas.

Core elements of effective environment safety measures Table 4.4 provides a summary of core elements of effective environment safety measures.

Table 4.4: Core elements of effective environmental safety measures

- Treatment of crash blackspots.
- Road engineering improvements that include:
 - widening and sealing of road shoulders
 - proving protection around bridges and drains
 - improved delineation (i.e. guide posts, line markings and chevron alignment markers)
 - increased usage of tactile edge lining
- treatment of roadside hazards (e.g. trees, drains, culverts, steep embankments, etc.). Refer to *Part 9: Roadside Hazard Management* of the Austroads Guide to Road Safety for more information.
- provision of more overtaking lanes
- improved road maintenance practices
- improved road surfacing
- improving signage (i.e. advisory and hazard warning signs)
- improving sight distance at intersections.
- Expansion and improvement of road safety audit systems and the setting of minimum safety standards for rural roads.

- Improved risk assessment and risk management of hazards identified through the road safety audit process using the Road Safety Risk Manager⁶ will allow for the treatment of deficiencies that pose the greatest risk to road users to be given priority. Taking this approach ensures that the highest crash risk reduction may be achieved for a given budget.
- Based on experience, there is strong evidence to suggest that rural speed limits on open roads should not be raised.
- Authorities when investigating the safety performance of their road networks should consider reducing speed limit as a safety option. Refer to *Part 3: Speed Limits* of the Austroads Guide to Road Safety for more information.

4.1.4 Medical interventions and trauma management

While immediate medical attention has the potential to significantly increase survival rates (Brodsky 1990, Evanco 1999, Henderson 1995) and reduce the use of costly intensive care units, it can only be successfully delivered through a co-ordinated trauma management system. Unfortunately, a large-scale national trauma plan is not possible due to distance, communication, resource and staffing constraints. Centralised health care has meant that small rural towns without hospitals are becoming increasingly prevalent and general practitioners and nurses, in many cases, are the first to attend a crash scene (Somers et al. 1997, Tolhurst et al. 1995). This situation is not confined to Australia with an influx of general practitioners migrating into the emergency medicine field of road trauma in the United Kingdom (Silverston 1985), Canada (Cohen 1991) and America (Roth 1991). America, for example, has built its local emergency medicine services around paramedics, and has regional centres to supplement and support the local response to disasters (Pretto & Safar 1991).

Australian GPs have called for emergency medicine to be developed into an organised response for 30 years (Pacy 1972). However, with the exception of a few proactive initiatives like *Medical Displan* Victoria (1997), the *Major Trauma Project* in South Australia (Martin et al. 1999), and the Canberra Hospital's *Disaster Medicine* plan (Richardson 2001, personal communication), little progress has been made. *Medical Displan* Victoria (1997) requires local rural GPs to attend a crash site upon notification by their local networks (i.e. ambulance, police or patients) and provide medical attention while in contact (via telephone or other ITS communication means) with the Divisional GP key contact person located at the nearest regional hospital. The Divisional GP key contact person, who has a close working relationship with the Area Medical Coordinator (AMC), then notifies the AMC of developments (Somers et al. 1997). The AMC subsequently organises for more volunteer GPs, nurses and/or a GP Field Medical Team (FMT) to be deployed as required. Prior to deployment, the FMT is briefed regarding the incident and condition of injured persons. Trauma management systems like Department of Human Services (1997) have been associated with promising road safety outcomes (Hasson 1999, Huntington 1996). Nathens et al. (2000), in particular, examined USA motor vehicle mortality crash data from 1979 to 1995, held in the Fatality Analysis Reporting System (FARS), for the 22 states wherein an organised trauma care system had been established by law.

They concluded that about 10 years after system implementation, it appears that mortality due to traffic crashes begins to decline; about 15 years following trauma system implementation, mortality was ... (significantly) ... reduced by 8%. ... The starting date for each system may have little immediate impact on what actually happens to trauma patients ... (however) ... over time, trauma centre protocols mature, triage policies change, and ultimately patient outcomes improve.

⁶ Road Safety Risk Manager is a relative risk prioritisation tool developed by ARRB for Austroads.

These research findings, coupled with strong, persistent lobbying from health professionals (Campbell et al. 1996, Royal Australasian College of Surgeons 1992, Somers et al. 1997), has forced the government to commit to:

- increasing emergency medicine (paramedical) training for rural nurses and GPs
- improving communication links and liaison between rural and regional staff; and, above all else
- supporting localised efforts to develop a comprehensive trauma management plan, complete with regular trauma audits (National Road Safety Strategy Implementation Task Force 1996, National Road Trauma Advisory Council 1993).

In response, Queensland health professionals and the Royal Australasian College of Surgeons are working closely with Government to develop state-wide trauma pathways in the Queensland Emergency Medical System (QEMS). These pathways will be capable of harnessing the resources of local emergency services throughout the state and will house a Critical Incident Management Plan for the entire bus and coach industry (School Transport Safety Task Force 2001).

The development and coordination of national trauma management procedures for rural road crashes will not be a quick process. In the interim, therefore, it was recommended that rural and remote residents receive basic first-aid and resuscitation training, possibly as an adjunct to the issuance of drivers' licences (Henderson 1995, United States National Safety Council 1999). It is considered that training would dramatically increase the pool of available helpers in the event of a crash and counter some of the resource limitations synonymous with rural and remote areas.

The rehabilitation focus of most rural allied health services requires lengths of time for improvement to be achieved (Grimmer et al. 2000). Therefore, a treatment regime for persons involved in rural road crashes can extend over many months. Consequently, there is a need to move beyond short-term randomised clinical trials and to longitudinally examine the complex relationships that exist between treatments (i.e. trauma management and rehabilitation) and subsequent health outcomes (Grimmer & May, 2001). Similarly, there is an urgent need to more closely examine potential barriers to utilising health care services in rural areas including: cost; lack of insurance coverage; travel distance to services; transportation problems; difficulty in taking time off work; traditional rural values, such as self-reliance; reduced referrals; and a lack of knowledge about the benefits of specialised medical care (Casey et al. 2001, Schur & Franco 1999; Strickland & Strickland, 1996).

Table 4.5 provides the core elements of effective medical interventions and trauma management.

Table 4.5: Core elements of effective medical interventions and trauma management

- Increasing emergency medicine (paramedical) training should be given to rural nurses and GPs who are often the 'first to respond' at rural crash scenes.
- Improving medical and emergency services response times.
- Improving communication links and liaison between rural and regional medical staff and the Government should increase support for localised efforts to develop comprehensive trauma management systems (that include regular audits).
- Research into the effectiveness of rural and remote residents training in first-aid and resuscitation (as part of the driver licensing system) to increase the pool of helpers at rural crash scenes and counter slower response times and resource limitations should be undertaken.
- Future research directions include: an investigation of potential barriers to utilising health care services and rehabilitation in rural areas; and the feasibility of collecting standard data from emergency medical services professionals, to be forwarded to, and managed by, a central agency.

References

- American Association of State Highway and Transportation (AASHTO), 2002. *Roadside Design Guide*. Washington, USA.
- Anderson, J 1998 *Transport ministers attack driver fatigue.*, media release A12/98, accessed 31 May 2006, <http://www.ministers.dotars.gov.au/ja/releases/1998/december/a12_98.htm>.
- Apogee/Hagler Bailly 1998, *Intelligent transport systems: real world benefits*, FHWA-JPO-98-018, Federal Highway Administration (FHWA), Intelligent Transportation Systems Joint Program Office, Washington, DC.
- Applegate, BK, Cullen, FT, Richards, PJ, Lanza-Kaduce, L & Link, BG 1999, 'Avoiding drunk drivers: the level and sources of protective behaviour', *Violence and Victims*, vol.14, no.3, pp.323-36.
- Armour, M & Cinquegrana, C 1990, 'Victorian study of single-vehicle rural accidents', *Australian Road Research Board Conference, 15th, 1990, Darwin, Northern Territory, Australia*, Australian Road Research Board (ARRB), Vermont South, Vic., part 7, pp.79-91.
- Armstrong, JL & Jamieson, KG 1973, *Sociology of drivers: a longitudinal sociological study of drivers involved in serious road accidents*, Department of Transport, Canberra, ACT.
- Arndt, JT, Wilde, GJ, Munt, PW & MacLean, AW 2001, 'How do prolonged wakefulness and alcohol compare in the decrements they produce on a simulated driving task?', *Accident Analysis and Prevention*, vol.33, no.3, pp.337-44.
- Australian Transport Council 2003, *National heavy vehicle safety strategy, 2003-2010*, Australian Transport Council, Canberra, ACT.
- Australian Transport Council 2004, *National road safety action plan for international visitors, 2004-2005*, Australian Transport Council, Canberra, ACT.
- Australian Transport Safety Bureau 1999, *Rural anti-speed campaign: media kit*, Australian Transport Safety Bureau, Canberra, ACT.
- Australian Transport Safety Bureau 2005, *Indigenous Road Safety Forum and Working Group, Alice Springs, Northern Territory 27-28 September 2004*, Australian Transport Safety Bureau, Canberra, ACT.
- Austroroads 1997, *Australia at the crossroads: roads in the community: a summary*, AP-48/97, Austroroads, Haymarket, NSW.
- Austroroads 1999, *The implications of intelligent transport systems for road safety*, AP-134/99, Austroroads, Sydney, NSW.
- Austroroads 2002, *Evaluation of the proposed actions emanating from road safety audits*, AP-R209/02, Austroroads, Sydney, NSW.
- Austroroads 2005, *Road Safety in Rural and Remote Areas of Australia*, AP-R273/05, Austroroads, Sydney, NSW.
- Barker, J 1997, *Trials of rural road safety engineering measures*, report 202, Transport Research Laboratory, Berkshire, Crowthorne.
- Barker, J, Farmer, S & Taylor, M 1999, *The development of accident-remedial intervention levels for rural roads*, report 425, Transport Research Laboratory, Berkshire, Crowthorne.
- Beenstock, M & Gafni, D 2000, 'Globalization in road safety: explaining the downward trend in road accident rates in a single country (Israel)', *Accident Analysis and Prevention*, vol.32, no.1, pp. 71-84.
- Bland, CE, Deeter, D & Pisano, P 1997, 'Simple solutions to rural transportation needs', *Traffic Technology International*, Oct/Nov, pp.100-5.
- Booz-Allen and Hamilton Limited 1998, *Intelligent transport solutions for Australia*, Booz-Allen and Hamilton Limited, Sydney, NSW.

- Brice, GA 2000, *Australian Indigenous road safety: a critical review and research report, with special reference to South Australia, other Indigenous populations, and countermeasures to reduce road trauma*, report 7/2000, Transport SA, Walkerville, SA.
- Brodsky, H 1990, 'Emergency medical service rescue time in fatal road accidents', *Transportation Research Record*, no.1270, pp.89-96.
- Brodsky, H & Hakkert, AS 1983, 'Highway fatal accidents and accessibility of emergency medical services', *Social Science and Medicine*, vol.17, no.11, pp.731-40.
- Brown, SL 1995, 'The effect on vehicle speeds of signs warning of police enforcement in rural areas of South Australia', *Road and Transport Research*, vol.4, no.1, pp.86-90.
- Brownlow, D 1998, 'Utilising volunteers to reduce fatigue related crashes in Queensland', *Australasian Traffic Education Conference, 7th, 1998, Brisbane, Queensland, Australia*, EMU Press, Armidale, NSW, pp.81-90.
- Butchart, A, Kruger, J & Lekoba, R 2000, 'Perceptions of injury causes and solutions in a Johannesburg township: implications for prevention', *Social Science and Medicine*, vol.50, no.3, pp.331-44.
- Cameron, M & Oxley, J 1995, *Investigation of improved exposure data for the assessment of road safety*, report RIIP-6, National Injury Surveillance Unit, Road Injury Information Program, Bedford Park, SA.
- Cameron, M, Diamantopoulou, K, Mullan, N, Dyte, D & Gantzer, S 1997, *Evaluation of the country random breath testing and publicity program in Victoria, 1993-1994*, report 126, Monash University, Accident Research Centre, Clayton, Vic.
- Cameron, MH, Cavallo, A & Gilbert, A 1992, *Crash-based evaluation of the speed camera program in Victoria 1990-1991; phase 1: general effects; Phase 2: effects of program mechanisms*, report 42, Monash University, Accident Research Centre, Clayton, Vic.
- Cameron, MH, Haworth, N, Oxley, J, Newstead, S & Le, T 1993, *Evaluation of Transport Accident Commission road safety television advertising*, report 52, Monash University, Accident Research Centre, Clayton, Vic.
- Campbell, D, Strasser, R & Kirkbright, S 1996, *Survey of Victorian rural general practitioners in towns without a hospital*, Monash University Centre for Rural Health, Traralgon, Vic.
- Casey, MM, Thiede Call, K & Klingner, JM 2001, 'Are rural residents less likely to obtain recommended preventive healthcare services?', *American Journal of Preventive Medicine*, vol.21, no.3, pp.182-8.
- Cavallo, A & Cameron, MH 1992, *Evaluation of a random breath testing initiative in Victoria 1990 & 1991: summary report*, report 39, Monash University, Accident Research Centre, Clayton, Vic.
- Cercarelli, LR 1997, 'Road crash involvement of Aboriginal people in Western Australia from 1988 to 1994', *Road Safety Research and Enforcement Conference, 1997, Hobart, Tasmania, Australia*, Department of Transport, Hobart, Tas., 5p.
- Cercarelli, LR, Ryan, GA, Knuiman, MW & Donovan, RJ 2000, 'Road safety issues in remote Aboriginal communities in Western Australia', *Accident Analysis and Prevention*, vol.32, no.6, pp.845-8.
- Chan, L, Houck, P, Prael, CM & MacLehose, RF 2001, 'Using Medicare databases for outcomes research in rehabilitation medicine', *American Journal of Physical Medicine and Rehabilitation*, vol.80, no.6, pp.474-80.
- Chew, J, Rogers, F & Frobig, C 1998, 'Enhancing safety and mobility in rural America', *Technology Development Newsletter*, Federal Highway Administration, Washington, DC.
- Coben, JH & Larkin, GL 1999, 'Effectiveness of ignition interlock devices in reducing drunk driving recidivism', *American Journal of Preventive Medicine*, vol.16, no.1, supplement, pp.81-7.
- Cohen, L 1991, 'Federal disaster-planning exercise brings 30 emergency MDs together for week-long course', *Canadian Medical Association Journal*, vol.145, no.7, pp.871-2.
- Corfittsen, MT 1999, 'Fatigue among young male night-time car drivers: is there a risk-taking group?', *Safety Science*, vol.33, no.1, 47-57.

- Cowan, J 1997, *The Queensland classification of rural, remote and metropolitan towns and postcodes*, University of Queensland Graduate School of Medicine, Brisbane, Qld.
- Dang, JN 2004, *Preliminary results analysing the effectiveness of electronic stability control*. DOT HS 809 790, National Highway Traffic Safety Administration, Washington, DC.
- Department of Health and Ageing 2005, *Review of the rural, remote and metropolitan areas (RRMA) classification*, discussion paper, Department of Health and Ageing, Canberra, ACT.
- Department of Human Services 1997, *Victoria state medical emergency response plan: medical displan* Victoria, Department of Human Services, Melbourne, Vic.
- Department of Main Roads & Department of Transport 2001, *Guide for the road safety management of rural school bus routes and bus stops*, Department of Transport, Brisbane, Qld.
- Department of Transport 1998, *Action for transport 2010: an integrated transport plan for Sydney*, Department of Transport, Sydney, NSW.
- Department of Transportation 2001, *Rural ITS toolbox*, Federal Highway Administration, Washington DC.
- Donald, D & Cairney, P 1997, *Higher open road speed limit: an objective assessment*, research report ARR 298, ARRB Transport Research, Vermont South, Vic.
- Edmunds.com Editors 2004. *Most Important Safety Features for a Family Vehicle*. <http://www.edmunds.com>
- Elkington, J 1999a, *Directions in injury prevention: report 1: research needs*, National Injury Prevention Advisory Council, Canberra, ACT.
- Elkington, J 1999b, *Directions in injury prevention: report 2: injury prevention interventions - good buys for the next decade*, National Injury Prevention Advisory Council, Canberra, ACT.
- Elliott and Shanahan Research, 1992, *Monitoring the impact of the rural fatigue campaign*, Federal Office of Road Safety, Sydney, NSW.
- Ellis, B, 1999, 'A national road safety overview', in J Wilks, B Watson & R Hansen, (eds), *International visitors and road safety in Australia: a status report*, Australian Transport Safety Bureau, Canberra, ACT, pp.19-26.
- Evanco, WM 1999, 'The potential impact of rural mayday systems on vehicular crash fatalities' *Accident Analysis and Prevention*, vol.31, no.5, pp.455-62.
- Evans, RC & Evans, RJ 1992, 'Accident and emergency medicine', *Postgraduate Medicine Journal*, vol.68, pp. 714-34.
- Farmer, CM, Retting, RA & Lund, RC 1999, 'Changes in motor vehicle occupant fatalities after repeal of the national maximum speed limit', *Accident Analysis and Prevention*, vol.31, no.5, pp.537-43.
- Federal Office of Road Safety 1997a, *Trucks and road trauma*, monograph 18, Federal Office of Road Safety, Canberra, ACT.
- Federal Office of Road Safety 1997b, *Vehicle type and the risk of travelling on the road*, monograph 17, Federal Office of Road Safety, Canberra, ACT.
- Ferguson, M, Schonfeld, C, Sheehan, M & Siskind, V 2001, *The impact of the "Under the Limit" drink driving rehabilitation program on the lifestyle and behaviour of offenders*, report CR 187, Australian Transport Safety Bureau, Canberra, ACT.
- Ginpil, S, Attewell, RG & Jonas, A 1995, *Crashes resulting in car occupant fatalities: side impacts*, report OR15, Federal Office of Road Safety, Canberra, ACT.
- Grigg, C 2000, Rural road safety in context: some historical findings and recommendations', *Roadwise*, vol. 12, no.3, pp.17-20.
- Grimmer, K, Bowman, P & Roper, J 2000, 'Episodes of allied health outpatient care: an investigation of service delivery in acute public hospital settings', *Disability and Rehabilitation* vol.22, no.1-2, pp. 80-7.
- Grimmer, K & May, E 2001, 'Cost drivers of public hospital occupational therapy outpatient care', *Australian Occupational Therapy Journal*, vol.48, no.4, pp.150-6.

- Grossman, DC, Kim, A, Macdonald, SC, Klein, P, Copass, MK & Maier, RV 1997, 'Urban-rural differences in prehospital care of major trauma', *Journal of Trauma*, vol.42, no.4, pp.723-9.
- Harrison, WA 2000, 'Drink driving in rural areas: recommendations for enforcement and public education based on surveys of hotel patrons', *Road safety research, policing and education conference, 2000, Brisbane, Queensland, Australia*, Queensland University of Technology, Centre for Accident Research and Road Safety, Brisbane, Qld, pp.477-82.
- Hartley, LR, Arnold, PK, Penna, F, Hochstadt, D, Corry, A & Feyer, AM 1996, *Fatigue in the Western Australian transport industry. Part one: the principal and comparative findings*, Murdoch University, Institute for Research in Safety and Transport, Murdoch, WA.
- Hartley, LR, Horberry, T, Mabbott, N, and Krueger, GP 2000, *Review of fatigue detection and prediction technologies*, National Road Transport Commission, Melbourne, Vic.
- Hasson, P 1999, 'Rural road safety: a global challenge', *Public Roads*, vol.63, no.2, pp.16-25.
- Haworth, N, Vulcan, P, Bowland, L & Pronk, N 1997a, *Characteristics of fatal single-vehicle crashes*, report 120, Monash University, Accident Research Centre, Clayton, Vic.
- Haworth, N, Vulcan, P, Bowland, L & Pronk, N 1997b, *Estimation of risk factors for fatal single vehicle crashes*, report 121, Monash University, Accident Research Centre, Clayton, Vic.
- Haworth, N, Vulcan, P, Bowland, L & Pronk, N 1997c, *Fatal single-vehicle crashes study: summary report*, report 122, Monash University, Accident Research Centre, Clayton, Vic.
- Haworth, NL 1998, 'Fatigue and fatigue research: the Australian experience', *Australasian Traffic Education Conference, 7th, 1998, Brisbane, Queensland, Australia*, EMU Press, Armidale, NSW, pp.27-38.
- Heinemann, A, Hamilton, B, Linacre, JM, Wright, BD & Granger, CV 1995, 'Functional status and therapeutic intensity during inpatient rehabilitation', *American Journal of Physical Medicine and Rehabilitation*, vol. 74, no. 4, pp. 315-26.
- Henderson, M 1995, 'An overview of crash data and countermeasure implications', *Rural Road Safety Seminar, 1995, Wodonga, Victoria, Australia*, National Road Trauma Advisory Council, Canberra, ACT, 22p.
- Honor, AB 1995, 'The nature of the enforcement problem in rural and remote Australia', *Rural Road Safety Seminar, 1995, Wodonga, Victoria, Australia*, National Road Trauma Advisory Council, Canberra, ACT.
- Houghton, M 1998, 'The decision to take breaks whilst on extended car vacation trips', Roads and Traffic Authority, Parkes, NSW. Unpublished report.
- Howat, P, Cross, D, Hall, M, Iredell, H, Stevenson, M, Gibbs, S, Officer, J & Dillon, J 2001, 'Community participation in road safety: barriers and enablers', *Journal of Community Health*, vol.26, no.4, pp.257-70.
- Huntington, G 1996, *Local emergency plan: the initial response: relative to the Emerald, Clematis and Menzies Creek areas*, standing plan: revised copy.
- Ivan, JN, Pasupathy, RK & Ossenbruggen, PJ 1999, 'Differences in causality factors for single and multi-vehicle crashes on two-lane roads', *Accident Analysis and Prevention*, vol.31, no.6, pp.695-704.
- Jordan, PW and Barton, EV 1992, 'Road safety audit: what is it and why do we need it?', *Australian Road Research Board Ltd (ARRB) Conference, 16th, 1992, Perth, Western Australia, Australia*, Australian Road Research Board, Vermont South, Vic, vol.16, no.4, pp.67-80.
- Kedjidjian, CB 1998, 'Not so fast', *Traffic Safety*, vol.98, no.4, pp.12-3.
- Kines, P 1997, 'Multidisciplinary in-depth analysis of serious frontal collisions in Denmark', *International Conference on Accident Investigation, Reconstruction, Interpretation and the Law, 2nd, 1997, Brisbane, Queensland, Australia*, Queensland University of Technology, School of Civil Engineering, Brisbane, Qld.
- King, ML 1986, *Rural traffic crashes in Queensland, 1984*, report CR45, Federal Office Of Road Safety, Canberra, ACT.
- Kloeden, CN, McLean, AJ, Baldock, MRJ & Cockington, AJT 1999, *Severe and fatal car crashes due to roadside hazards: a report to the Motor Accident Commission: final report*, Government of South Australia. Adelaide, SA.

- Kloeden, CN, McLean, AJ, Moore, VM & Ponte, G 1997 *Travelling speed and the risk of crash involvement: volume 1 – findings*, report CR172, Federal Office of Road Safety, Canberra, ACT.
- Kloeden, CN, Ponte, G & McLean, AJ 2001, *Travelling speed and the risk of crash involvement on rural roads*, report CR 204, Australian Transport Safety Bureau, Canberra, ACT.
- Land Transport Safety Authority 2004, *Overall results of Crash Reduction Study Safety Improvements*. Land Transport Safety Authority, Wellington, New Zealand.
- Legge, M, Kirov, C, & Cercarelli, LR 2001, *Reported road crashes in Western Australia 2000*, University of Western Australia, Injury Research Centre, Crawley, WA.
- Leggett, LMW 1999, 'Results from the use of a state-wide strategic framework to reduce injuries from road crashes', *National Conference on Injury Prevention and Control, 3rd, 1999, Brisbane, Queensland, Australia*, University of Queensland, Centre of National Research on Disability and Rehabilitation Medicine, Herston, Qld, pp.74-8.
- Lewis, A 1999, 'Road safety: can ITS provide smart solutions?', *Highway Engineering in Australia*, vol.31, no.4, pp.19-24.
- Li, L & Routley, V 1998, 'Trends in road traffic fatality and injury in Victoria', *Hazard*, no.36, pp.1-15.
- Lydon, M 1997, 'Rural crashes and available countermeasures' *State Municipal Engineering Conference, 14th, 1997, Perth, Western Australia, Australia*, Institute of Municipal Engineering Australia, Western Australian Division, Perth, WA, 8p.
- Macaulay, J, Gunatillake, T, Tziotis, M, Fildes, B, Corben, B & Newstead, S 2004, *On-road evaluation of perceptual countermeasures*, report CR219, Australian Transport Safety Bureau, Canberra, ACT.
- Macaulay, J, Thomas, R, Mabbott, N, Edmonston, C, Sheehan, M & Schonfeld, C, 2003, *Australian indigenous road safety*. Australian Transport Safety Bureau, Canberra, ACT.
- Maddux, JE & Rogers, RN 1983, 'Protection motivation and self-efficacy: a revised theory of fear appeals and attitude change', *Journal of Experimental Social Psychology*, vol.19, pp.469-479.
- Marques, PR, Voas, RB, Tippetts, AS & Beirness, DJ 1999, 'Behavioural monitoring of DUI offenders with the alcohol ignition interlock recorder', *Addiction*, vol.94, no.12, pp.1861-1870.
- Martin, S, Elkington, J & Cousins, M 1999, 'The major trauma project: integrating rural GPs with the state trauma system', *National Conference on Injury Prevention and Control, 3rd, 1999, Brisbane, Queensland, Australia*, University of Queensland, Centre of National Research on Disability and Rehabilitation Medicine, Herston, Qld., pp.186-8.
- Mateja, J 1995, 'Are bigger cars safer?', *Traffic Safety*, March/April, pp.4-5.
- McCarthy, M 1989, 'The benefit of seatbelt legislation in the United Kingdom', *Journal of Epidemiological Community Health*, vol.43, no.3, pp.218-22.
- McCormack, ED & Legg, B 1999, *The contribution of ITS to rural safety: a look at crashes in Washington State*, report WA-RD 460.1, Washington State Department of Transportation, Olympia, Washington.
- McLean, AJ & Robinson, GK 1979, *Adelaide in-depth accident study 1975-1979, part 1: overview*, Road Accident Research Unit, University of Adelaide, Adelaide, SA.
- McLean, JR, & Armour, M 1983, 'The effect of shoulder width and type on rural traffic safety and operations', *Australian Road Research*, vol 13, No. 4, 259-270.
- McLean, JR 1985 'Accident width relations for single carriageway rural highways', *Australian Road Research*, vol.15, no.4, pp.271-5.
- Moller, J 1994, 'The spatial distribution of injury deaths in Australia: urban, rural and remote areas', *Australian Injury Prevention Bulletin*, no.8, 8pp.
- Moller, J 1995, 'Contrast in urban, rural and remote vehicle related deaths', *Rural Road Safety Seminar, 1995, Wodonga, Victoria, Australia*, National Road Trauma Advisory Council, Canberra, ACT., 14pp.
- Moller, J & Cantwell, G 1999, *Paradigm shift: injury: from problem to solution: new research directions*, National Health and Medical Research Council, Canberra, ACT.

- Nathens, AB, Jurkovich, GJ, Cummings, P, Rivara, FP & Maier, RV 2000, 'The effect of organised systems of trauma care on motor vehicle crash mortality', *Journal of the American Medical Association*, vol.283, no.15, pp.1990-4.
- National Centre on Sleep Disorders Research and National Highway Traffic Safety Administration Expert Panel on Driver Fatigue and Sleepiness 1998, *Drowsy driving and automobile crashes: report and recommendations*, DOT HS 808 707, National Highway Traffic Safety Administration, Washington, DC.
- National Highway Traffic Safety Administration & National Centre on Sleep Disorders Research 1999, *The NHTSA & NCSDR program to combat drowsy driving: a report to Congress on collaboration between the National Highway Traffic Safety Administration (NHTSA) and the National Centre on Sleep Disorders Research (NCSDR)*, NHTSA, Washington, DC.
- National Highway Traffic Safety Administration (NHTSA) 2000, 'A plan to combat drowsy driving', *Driver/Education*, vol.10, no.2, pp. 8-9.
- National Road Safety Strategy Implementation Task Force 1996, *Australia's rural road safety action plan: focus for the future 1996*, Federal Office of Road Safety, Canberra, ACT.
- National Road Trauma Advisory Council 1993, *Report of the Working Party on Trauma Systems*, Australian Government Publishing Service, Canberra, ACT.
- National Safety Council 1999, *Report on injuries in America*, news release, National Safety Council, Washington DC.
- Newstead, SV, Cameron, MH & Le, CM 1999, *Vehicle crashworthiness ratings and crashworthiness by year of vehicle manufacture: Victorian and NSW crashes during 1987-97; Queensland crashes during 1991-96*, report 150, Monash University, Accident Research Centre, Clayton, Vic.
- Newstead, SV, Cameron, MH & Narayan, S 1998, *Further modelling of some major factors influencing road trauma trends in Victoria: 1990-96*, report 129, Monash University, Accident Research Centre, Clayton, Vic.
- Noy, YI 1997, 'Human factors in modern traffic systems', *Ergonomics*, vol. 40, no.10, pp.1016-24.
- Ogden, KW 1997, 'The effects of paved shoulders on accidents on rural highways', *Accident Analysis and Prevention*, vol.29, no.3, pp.353-62.
- Organisation for Economic Co-operation and Development 1999, *Safety strategies for rural roads*, OECD, Paris.
- Pacy, H 1972, 'Rescue and first aid for our highways', *Medical Journal of Australia*, vol.1, no.14, pp.704-7.
- Parsonson, BS, Isler, RB & Hansson, GJ 1996, *Driver behaviour at rural T-intersections*, research report 56, Transit New Zealand, Wellington.
- Patterson, T, Frith, WJ, Povey, LJ, and Keall, MD, 2002, *The Effects of Increasing Rural Interstate Speed Limits in the United States*, Traffic Injury Prevention, 3:316-320.
- Pettitt, AN, Baade, I, Low Choy, S, Darnell, RE & Haynes, MA 1994, *Analysis of single-vehicle rural crashes*, report CR124, Federal Office of Road Safety, Canberra, ACT.
- Pretto, EA & Safar, P 1991, 'National medical response to mass disasters in the United States: are we prepared?', *Journal of the American Medical Association*, vol.266, no.9, 1259-62.
- PRNewswire n.d. *GM Advanced Automatic Crash Notification Available on a Full Range of 2005 Models*. <http://www.prnewswire.com>
- Queensland Police Service 2000, 'Road safety program' in *Queensland Police Service annual report 1998-1999*, Queensland Police Service, Brisbane, Qld., pp.25-30.
- Queensland Transport (2002). *Queensland Transport Annual Report 2001-2002*.
- Rae, A 1995, 'Aboriginal road safety communications study', *Road and Transport Research*, vol.4, no1, pp.77-80.
- Randerson, J 2004, 'Crashed cars to text message for help', *New Scientist*, 14 January 2004, viewed 15 July 2005, <<http://www.newscientist.com/article.ns?id=dn4565>>.

- Ranney, TA & Gawron, VJ & Calspan Corporation 1986, 'The effects of pavement edgelines on performance
- Road Safety Committee 2002, *Inquiry into rural road safety and infrastructure; Report of the Road Safety Committee on the Inquiry into Rural Road Safety and Infrastructure*, Victorian Government Printer, Melbourne, Vic.
- Road Safety Committee 2005, *Inquiry into the country road toll. Report of the Road Safety Committee into the country road toll*, Victorian Government Printer, Melbourne, Vic.
- Roads and Traffic Authority n.d., *Road safety 2010: a framework for saving 2,000 lives by the year 2010 in New South Wales*, Roads and Traffic Authority (RTA), Sydney, NSW.
- Roads and Traffic Authority 2004, *Traffic accident database 2004*, Roads and Traffic Authority (RTA), Sydney, NSW.
- Roth, PB 1991, 'Status of a national disaster medical response', *Journal of the American Medical Association*, vol.266, no.9, p.1266.
- Royal Australasian College of Surgeons 1992, *Early management of severe trauma*, Capitol Press, Box Hill, Vic.
- Royal Automobile Club of Victoria. 1990, *Speed limits: RACV's perspective: a submission to the Parliamentary Social Development Committee*, RACV, Noble Park, Vic.
- Ryan, GA, Barker, JM, Wright, JN & McLean, AJ 1992, 'Human factors in rural road crashes', *Australian Journal of Public Health*, vol.16, no.3, pp.269-76.
- Ryan, GA, Cercarelli, LR, & Mullan, N 1998, *Road safety in the rural and remote regions of Western Australia*, report RR64, University of Western Australia, Road Accident Prevention Research Unit, Nedlands, WA.
- Ryan, GA, Wright, JN, Hinrichs, RW & McLean, AJ 1988, *An in-depth study of rural road crashes in South Australia*, report series 13/88, South Australian Department of Transport., Adelaide, SA.
- Sagberg, F 1999, 'Road accidents caused by drivers falling asleep', *Accident Analysis and Prevention*, vol.31, no.6, pp.639-49.
- Sahai, VS, Pitblado, JR, Bota, GW & Rowe, BH 1998, 'Factors associated with seatbelt use: an evaluation from the Ontario Health Survey', *Canadian Journal of Public Health*, vol.89, no.5, pp.320-4.
- School Transport Safety Task Force 2001, *Final Report*, School Transport Safety Taskforce, Fortitude Valley, Qld.
- Schur, C & Franco, S 1999, 'Access to health care,' in T Ricketts (ed.), *Rural health in the United States*, Oxford University Press, New York, pp.7-24.
- Scully, J, Newstead, S, Corben, B, and Candappa, N. 2006. *Evaluation of the \$240M Statewide Blackspot Program*. Victoria, Australia.
- Shinar, D 1978, *Psychology on the road: the human factor in traffic safety*, John Wiley, New York.
- Silverston, PP 1985, 'Physicians at the roadside: pre-hospital emergency care in the United Kingdom', *American Journal of Emergency Medicine*, vol.3, no.6, pp.561-4.
- Somers, GT, Drinkwater, EJ & Torcello, N 1997, 'The general practitioner as the first responder in a major medical emergency', *Australian Family Physician*, vol.26, no.12, pp.1406-9.
- Stewart, RD 1990, 'Pre-hospital care of trauma', in RY McMurtry & BA McLellan,(eds.), *Management of blunt trauma*, Williams and Wilkins, Baltimore, pp.23-29.
- Stockwell, T, Chikritzhs, T, Hendrie, D, Fordham, R, Ying, F, Phillips, M, Cronin, J. & O'Reilly, B 2001, 'The public health and safety benefits of the Northern Territory's Living with Alcohol programme', *Drug and Alcohol Review*, vol.20, no.2, pp.167-180.
- Strickland, J & Strickland, DL 1996, 'Barriers to preventive health services for minority households in the rural south', *Journal of Rural Health*, vol.12, no.3, pp.206-17.
- Strong, K, Trickett, P, Titulaer, I & Bhatia, K 1998, *Health in rural and remote Australia*,. Australian Institute of Health and Welfare (AIHW), Canberra, ACT.

- Sweatman, P, Ogden, K, Haworth, N, Pearson, R, & Vulcan, P 1990, *Heavy vehicle safety on major NSW highways: a study of crashes and countermeasures*, report CR5/90, Roads and Traffic Authority (RTA), Sydney, NSW.
- Tanner, J, Day, E & Crask, M 1989, 'Protection motivation theory: an extension of fear appeals theory in communication', *Journal of Business Research*, vol.19, pp.267-276.
- Tay, R & Watson, B 2002, 'Changing drivers' intentions and behaviours using fear-based driver fatigue advertisements', *Health Marketing Quarterly*, vol.19, no.4, pp.55-68.
- Todd, KH 1999, 'NHTSA Notes Commentary: strategies to combat aggressive driving', *Annals of Emergency Medicine*, vol.34, no.6, pp.800-801.
- Tolhurst, H, Dickinson, J, & Ireland, MC 1995, 'Severe emergencies in rural general practice', *Australian Journal of Rural Health*, vol.3, pp.25-33.
- Transport Accident Commission 2006, *Road safety monthly summary: April 2006*, Transport Accident Commission, Melbourne, Vic.
- Transport Accident Commission. Road safety monthly summary: April 2006, Victorian Government.
- Travelsafe Committee 1996, *Queensland's road toll: an overview*, report 18, Queensland Legislative Assembly, Brisbane, Qld.
- Travelsafe Committee 1999a, *Rural road safety in Queensland*, issues paper 4, Queensland Legislative Assembly, Brisbane, Qld.
- Travelsafe Committee 1999b, *Annual Report 1998/1999*, report 28, Queensland Legislative Assembly, Brisbane, Qld.
- Travelsafe Committee 2002, *Rural road safety in Queensland*, report 36, Queensland Legislative Committee, Brisbane, Qld.
- Tziotis, M 1992, *Crashes on the approaches to provincial cities*, report 31, Monash University, Accident Research Centre, Clayton, Vic.
- Veitch, PC, Sheehan, MC, Holmes, JH, Doolan, T, & Wallace, A 1996, 'Barriers to the use of urban medical services by rural and remote area households', *Australian Journal of Rural Health*, vol.4, no.2, pp.104-110.
- VicRoads 1998, *Safety on rural roads, report 108*, VicRoads, Road Safety Department, Kew, Vic.
- Vulcan, P, Cameron, M & Newstead, S 1995, 'Road trauma in perspective', *Vehicle Accidents: Their Cause - Reconstruction - Law Conference, Melbourne, Victoria, Australia*, Monash University, Department of Civil Engineering, Clayton, Vic., pp.25-38.
- Wang, J, Hughes, W & Stewart, R 1997, *Safety effects of cross section design on rural multilane highways: summary report*, Federal Highway Administration, Office of Safety and Traffic Operations, McLean, Virginia.
- Watson, B 1997, 'When common sense just won't do: misconceptions about changing the behaviour of road users', *International Conference on Accident Investigation, Reconstruction, Interpretation and the Law, 2nd, 1997, Brisbane, Queensland, Australia*, Queensland University of Technology, School of Civil Engineering, pp.347-59 .
- Watson, B, Tunnicliff, D, Manderson, J, O'Connor, E, Stefaniw, M, Fraine, G, & Samuels, S 2004, *The safety of international visitors on Australian roads*, monograph 2, Centre for Accident Research and Road Safety, Carseldine, Qld.
- Watson, WL. & Ozanne-Smith, J 1997, *The cost of injury to Victoria*, report 124, Monash University, Accident Research Centre, Melbourne, Vic.
- Weinrath, M 1997, 'The ignition interlock program for drunk drivers: a multivariate test', *Crime and Delinquency*, vol.43, no.1, pp.42-59.
- White, M, & Walker, J 2002, *Update and review of research on the effectiveness of the Victorian Transport Accident Commission's road safety campaigns*, Transport SA, Walkerville, SA.

- White, M, Walker, J, Glonek, G, & Burns, N 2000, *Re-investigation of the effectiveness of the Victorian Transport Accident Commission's road safety campaigns*, report 4/2000, Transport SA, Walkerville, SA.
- Whyte, J 2001, 'Building a program of outcomes research: personal reflections', *American Journal of Physical Medicine and Rehabilitation*, vol.80, no.11, pp.865-74.
- Williamson, AM, Feyer, A.M, Mattick, RP, Friswell, R, Finlay-Brown, S. 2001, 'Developing measures of fatigue using an alcohol comparison to validate the effects of fatigue on performance', *Accident Analysis and Prevention*, vol.33, no.3, pp.313-26.
- Wundersitz, LN, Kloeden, CN & Walker, JR 2000, 'An evaluation of interventions aimed at increasing restraint use in Whyalla, South Australia', *Road Safety Research, Policing and Education Conference, 2000, Brisbane, Queensland, Australia*, Queensland University of Technology, Centre for Accident Research and Road Safety, Brisbane, Qld., pp.583-8.

Austroads' **Guide to Road Safety Part 5: Road Safety for Rural and Remote Areas** examines the nature and causes of crashes in rural and remote areas, and identifies measures that will result in reduced road trauma.

Guide to Road Safety Part 5



Austroads

Austroads is the association of Australasian road and transport agencies.

www.austroads.com.au