

ROAD ACCIDENT PREVENTION RESEARCH UNIT

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**The Relationship Between Alcohol-Related
Medical Conditions and Road Crashes**

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Abstract

The problem of drink driving is well documented. Many interventions have been implemented around the world in an attempt to deter drink drivers and prevent road crashes. However, these programs may not always target high risk offenders. If high risk drivers could be identified prior to receiving convictions for drink driving, or prior to being involved in a crash, they could then be targeted for a brief road safety intervention. For example, such an opportunity would occur when a road user was in hospital receiving treatment for an alcohol-related problem. The aim of this study was to measure the association between alcohol-related medical conditions and road crashes. This was achieved through a longitudinal analysis of the hospital records of people first admitted to hospital for an alcohol-related condition over the period 1980 to 1997 in Western Australia. During this period there were 41,537 people admitted to hospital at least once for an alcohol-related medical condition. About 11.7% of these people were also involved in a road crash requiring hospitalisation. However, only 23.6% were admitted to hospital for a road crash after being admitted for an alcohol-related medical condition. The remainder were either involved in a crash prior to being admitted to hospital for an alcohol condition, or were treated for an alcohol condition at the same time as being involved in a road crash. The implications of these findings for early drink driving intervention are discussed.

Keywords

Drink Driving, Alcohol Usage, Addiction, Hospital, Prevention

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EXECUTIVE SUMMARY

There have been many interventions implemented around the world in an attempt to deter drink drivers. However, high risk offenders who repeatedly drink and drive are difficult to target. If high risk drivers could be identified prior to receiving convictions for drink driving, or prior to being involved in a crash, they could then be targeted for a brief road safety intervention. For example, such an opportunity would occur when a road user was in hospital receiving treatment for an alcohol-related problem.

The aim of this study was to measure the association between alcohol-related medical conditions and road crashes. This was achieved through a longitudinal analysis of the hospital records of people first admitted to hospital for an alcohol-related condition over the period 1980 to 1997 in Western Australia.

During this 18 year period there were 41,537 people admitted to hospital at least once for an alcohol-related medical condition. No details prior to 1980 were available somewhat limiting the ability to define the start of an alcohol career. About 11.7% of these people were also involved in a road crash requiring hospitalisation.

Those who were admitted only once for an alcohol-related condition were generally younger than those admitted more than once. Three quarters of those admitted to hospital were male, and while the majority of people resided in the Perth metropolitan area, a larger than expected proportion lived in the remote areas of Western Australia. Aboriginal people also appeared over represented.

The majority of people involved in a road crash resided in the metropolitan area, however, those living in the remote areas of Western Australia were over represented, as were Aboriginal people. While the majority of those who were admitted were motor vehicle drivers (23.7%), a large group were pedestrians (18.3%), and 9.1% were motorcyclists.

Only 23.6% of those admitted to hospital for road injuries had been admitted earlier for an alcohol-related medical condition. The remainder were either involved in a crash prior to being admitted to hospital for an alcohol condition, or were treated for an alcohol condition at the same time as being involved in a road crash.

It appears from these findings that since only about one quarter of crash admissions were preceded by an alcohol-related admission, an intervention aimed at reducing crashes which was applied in all alcohol-related admissions not associated with a crash would not be practical, as only about 2.5% of such admissions would potentially precede a crash. Such an intervention, however, might be made more specific by concentrating on males, those under 30 years of age, and Aboriginal people. An alternative approach would be to apply an alcohol-related intervention to all young males admitted for a crash. For almost half the crash cases, there was an alcohol-related admission at a later date. A cost effective intervention may be appropriate in these cases. Further research is required to explore the potential of these interventions.

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1. INTRODUCTION

The size of the problem of drink driving is well documented. Programs such as random breath testing and community-based education campaigns have been used in Australia as a means of deterring drink drivers and preventing alcohol-related road crashes. However, these programs may not always target high risk offenders. Many states of Australia have designed rehabilitation courses for drivers who have repeat drink driving convictions. These courses are often based on the assumption that a high proportion of drink drivers have alcohol-related problems (Sanson-Fisher, Redman, Homel & Key, 1990). However, this intervention targets drivers after they have been apprehended for drink driving offences, or after they have been involved in a road crash. If drivers could be identified prior to receiving convictions for drink driving, or prior to being involved in a crash, they could then be targeted for a road safety intervention. Such an opportunity would occur when a road user was in hospital receiving treatment for an alcohol-related problem.

The aim of this study was to measure the association between alcohol-related medical conditions and road crashes through a longitudinal analysis of the hospital records of people first admitted to hospital for an alcohol-related condition over the period 1980 to 1997 in Western Australia.

2. BACKGROUND

Alcohol use precedes many fatal road crashes. In 1997, around 25% of fatal crashes in Western Australia involved at least one driver with a blood alcohol concentration (BAC) exceeding the legal limit of 0.05gm%. In addition, 36% of all pedestrian fatalities had a BAC of at least 0.05gm% (Cercarelli, Kirov, Legge & Rosman, 1998).

Recent community surveys show that drink driving is also common behaviour. Around 40% of drivers surveyed in May 1997 in Western Australia indicated that they had consumed alcohol and then drove a vehicle (Cercarelli, Hendrie, Ryan, Legge & Kirov, 1998).

2.1 Identifying High Risk Drink Drivers

Identifying high risk individuals is important for targeting road safety interventions effectively. Three recent studies in Western Australia have shown that drivers arrested for drink driving (and repeat drink driving) and drivers involved in alcohol-related crashes were more often young and male.

In a longitudinal study of drink driving offenders, Ryan, Ferrante, Loh and Cercarelli (1996) found that repeat drink drivers tended to be younger than single offenders, with 65% aged less than 25 years, compared with 45% of single offenders. Secondly, Ryan, Kirov and Cercarelli (1999) showed that drivers who were involved in alcohol-related crashes were more likely to be young, male and aged under 29 years. Finally, Rosman, Ferrante and Marom (1998) found that male drivers who were arrested for drink driving were nearly twice as likely to be subsequently involved in an alcohol-related crash as female drink drivers. Among male drink drivers, those aged between 18 and 35 years when first arrested were nearly twice as likely to be involved in an alcohol-related crash as those aged over 35 years.

Dunbar, Ogston, Ritchie, Devgun, Hagart and Martin (1985), in a study of motorists arrested for drink driving, found the traditional strong association between younger drivers and high BAC levels and crash involvement. However, these authors found among older drivers (those aged over 30 years) a strong association between raised

gamma glutamyltranspeptidase (γ GT) activity in the blood, indicating alcoholism, and being involved in a crash.

In France, Herve, Gaillard, Roujas and Huguenard (1986) examined injured drivers who were hospitalised and found a relationship between raised γ GT levels and driver BAC. Around 80% of those who had elevated γ GT levels in their blood had a BAC over 0.05gm% when admitted to an emergency room, while in a non-alcoholic group, 20% had a BAC over 0.05gm%. In another French study of around 4,800 injured patients, around 30% of all injured males had high γ GT levels, while in the French population, the levels were estimated to be around 17% for males. Around 17% of injured females had elevated γ GT compared with 6% in the female population (Papoz, Weill, L'Hoste, Chich, Got & Goehrs, 1986).

Recently in the United States, Soderstrom, Dischinger, Smith, Hebel, McDuff, Gorelick, Kerns, Ho and Read (1997) used an interview method to determine alcoholism among hospitalised road users. The authors found that around 18% of drivers in road crashes (25% males and 10% females), and around 48% of pedestrians injured in road crashes (52% males and 32% females) were current alcoholics (i.e. diagnosed as having alcohol dependence and were not in full or partial remission for at least 6 months). Maio, Waller, Blow, Hill and Singer (1997) also used a diagnostic interview method to determine the prevalence of current alcoholism. They found that almost 23% of motor vehicle crash patients were alcohol dependent and that BAC did not identify these patients, as around 45% of those identified as current alcoholics were found to have zero BAC.

2.2 Early Intervention for Drink Drivers

It has been hypothesised that prior crash history and alcohol abuse are predisposing factors for being involved in an alcohol-related crash. In a study of motor vehicle crash patients admitted to hospital, 51% of those with a prior crash history, and 65% of those with a BAC of at least 0.10gm% were diagnosed (via questionnaires) as being alcohol abusers (Mancino, Cunningham, Davidson and Fulton, 1995). Mancino et al (1995) concluded that motor vehicle crash patients with either a prior

crash history or a BAC of at least 0.10gm% were highly likely to be alcohol abusers and suggested that their admission for trauma was an opportunity to intervene and treat alcohol-related problems.

Identifying alcoholic patients, so that some brief intervention in the form of counselling for alcohol use could be provided while the patient was admitted, has been suggested by Soderstrom et al (1997). Other research has suggested that "patients injured in motor vehicle crashes should be screened for alcohol abuse in the emergency department and referred for treatment if it appears warranted" (Madden & Cole, 1995, p.177). Another suggestion made by Dunbar et al (1985) was to inform the patient's general practitioner when the patient has been convicted for drink driving.

Drivers who have been drinking are known to have an increased risk of casualty crash involvement (McLean, Holubowycz & Sandow, 1980). In a 10 year longitudinal study in California, Piette, Barnett and Moos (1996) also found that patients with alcohol-related medical conditions were significantly at risk of being involved in a casualty crash compared with a random sample of non-alcoholic patients.

2.3 Conclusion

Offering intervention before a crash has occurred is beneficial. Pre-crash community-wide interventions used in Western Australia, such as random breath testing, have been implemented with the aim of deterring drink driving and thus preventing alcohol-related crashes. However, the proportion of drivers with a high BAC involved in fatal crashes has not decreased, although fewer drivers with a high BAC are thought to be on the road (about 1% of the driving population in Australia) (Ross, 1993). Ryan et al (1996) also found that about 25% of drivers arrested for drink driving subsequently re-offended. It seems possible, therefore, that population-based countermeasures such as random breath testing may not be effective against long term alcohol abusers.

If a high proportion of road users considered at high risk are found to have an alcohol-related medical condition (indicating alcohol dependence) an opportunity may exist, while these patients are admitted to hospital for their condition, to offer early intervention. These individual-based interventions may prevent these patients from later becoming involved in alcohol-related road crashes. The purpose of this report was to measure the association between alcohol-related medical conditions and road crashes, and to investigate the possibility of early intervention before a crash has occurred.

3. METHOD

The Health Services Research Linked Database is maintained by the Health Department of Western Australia and the Department of Public Health at The University of Western Australia (Holman, Bass, Rouse & Hobbs, in press). This database consists of individually linked hospital admission records, mental health records, cancer registrations and other health records for the whole of Western Australia since 1970.

All the hospital admission and death records for each patient admitted to hospital for an alcohol-related medical condition between 1980 and 1997 were extracted from this database. That is, if an individual was admitted at least once during this period for an alcohol-related condition, all other admissions (both alcohol-related and other) for that person were also extracted.

For this study, an "alcohol-related medical condition" was defined as a medical diagnosis that could only have resulted from excessive alcohol consumption. These diagnoses were defined as having an aetiological fraction of 1.0 (100% attribution) by English, Holman, Milne et al (1995) and were identified by the following ICD9 CM codes (ICD9 CM, 1986):

- 291 (alcohol psychosis)
- 303 (alcohol dependence)
- 305.0 (alcohol abuse)
- 357.5 (alcohol polyneuropathy)
- 425.5 (alcohol cardiomyopathy)
- 535.3 (alcoholic gastritis)
- 571.0 to 571.3 (alcoholic liver cirrhosis)
- 980.0 (ethanol toxicity)
- 980.1 (methanol toxicity)
- E860.0 to E860.2 (external cause of injury ethanol or methanol poisoning)
- E911 (external cause of injury alcohol aspiration)

Age, gender, area of residence and Aboriginality were available for each hospital admission record for each person in the study. In addition, up to 18 diagnosis codes (ICD9 CM) and the external cause of admission codes were available for analysis.

Inpatient Episodes

Any extra hospital admissions records generated by transfers of a patient between hospitals were combined with the original admission into one inpatient episode. That is, an inpatient episode was defined to be the collection of all the hospital admissions for a single event. These included the original admission and all transfers that occurred between hospitals, until the patient was either discharged or died. Hospital admissions that occurred on the same day or the next day after a separation date were deemed to be transfers and became part of an inpatient episode. Hospital admissions that did not involve an overnight stay were not included.

Causes of Hospital Admissions

The first and last admission to hospital were classified into one of the following four groups of admission causes:

- An alcohol-related admission;
- A crash-related admission;
- An alcohol and crash-related admission; or
- A non-alcohol related admission.

Crash-Related Admissions

Individuals were assumed to have been involved in a road crash in the period 1980 to 1997 if the following ICD9 CM external cause of injury codes were contained in any of their hospital admission records:

- E810.0 to E816.9
- E819.0 to E819.9
- E929.0

Areas of Residence

The following five regions defined by the Department of Human Services and Health (1994) (Figure 3.1) were used in this analysis:

- Metropolitan Area (Perth and the metropolitan area);
- Rural Major (Albany, Bunbury, Busselton, Geraldton, Mandurah and Northam);
- Rural (most of the South West and agricultural regions of the state);
- Remote Major (Carnarvon, Esperance, Kalgoorlie/Boulder, Port Hedland and Roebourne); and
- Remote (pastoral and mining areas in the north and east of the state).

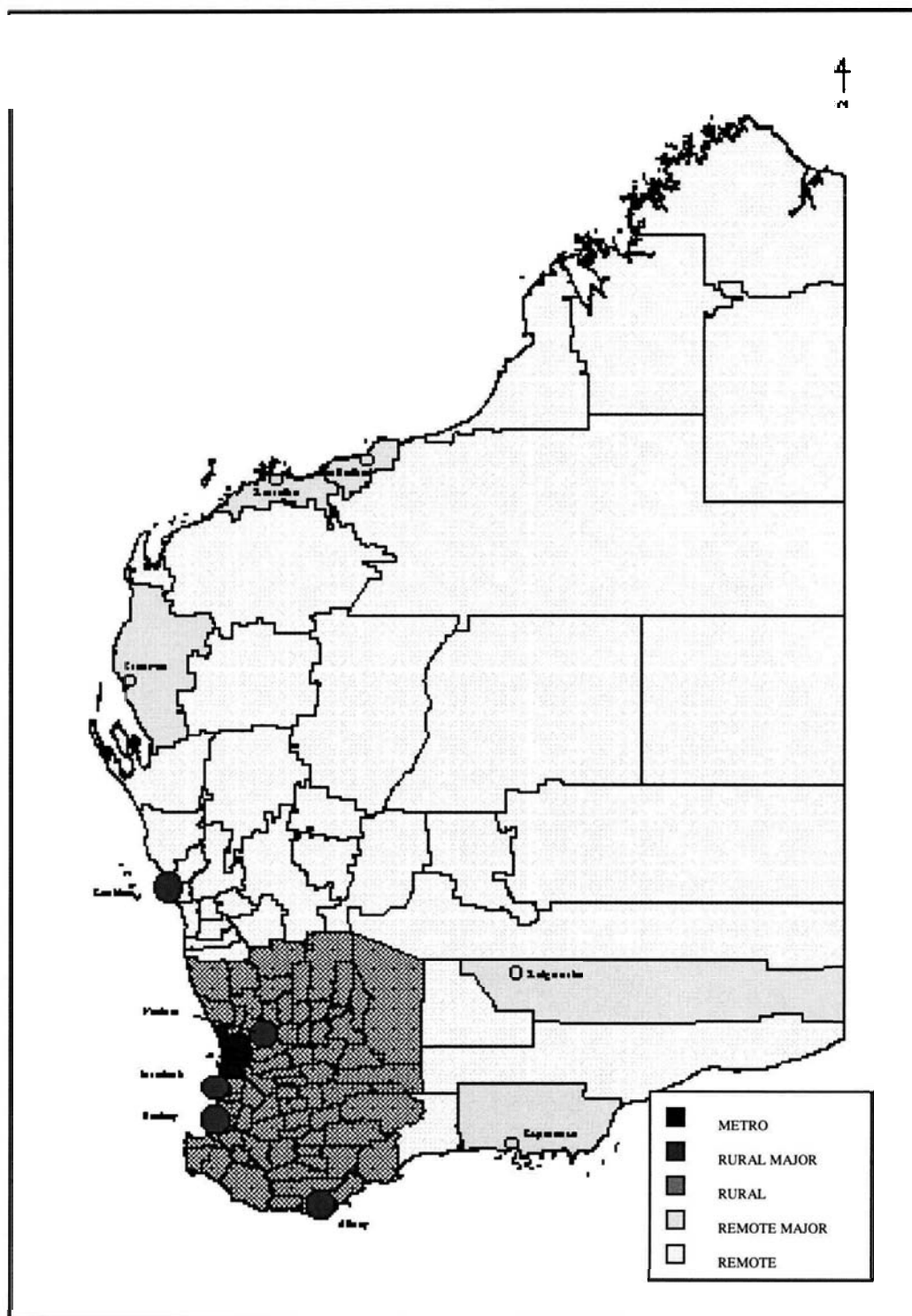


Figure 3.1 Regional Classification for Western Australia

4. RESULTS

There were 41,537 individuals admitted to hospital at least once for an alcohol-related medical condition between 1980 and 1997, involving a total of 330,585 admissions (307,476 distinct inpatient episodes). Among these admissions, 100,631 contained at least one diagnosis of an alcohol-related medical condition.

Of these 41,537 individuals admitted for at least one alcohol condition, 4,875 (11.7%) were involved in a road crash. Furthermore, of those who were involved in at least one road crash, 1,151 (23.6%) were admitted to hospital for an alcohol-related condition prior to being admitted as a result of a road crash. Of the remainder, 1,557 (31.9%) were diagnosed with an alcohol-related condition at the time of their road crash, and 2,167 (44.5%) were admitted for a crash before an alcohol condition was recognised.

Of those admitted to hospital for an alcohol-related medical condition, 9,281 died, and of these, 4,279 (46.1%) were admitted only once for an alcohol-related condition. There were 128 (1.4%) people who died as a result of a road crash; 103 of these were male, 42 were under the age of 25 years, and 39 were Aboriginal. In the following sections, these cases will be included with all admissions to hospital.

The data are presented in five sections. The first is an overview of people admitted to hospital for an alcohol-related condition (along with all of their other admissions). It describes the causes of hospital admission experienced by these people the first time they were admitted. A description is also provided of the last admission to hospital for those who were admitted on more than one occasion during the 18 year period.

The second section examines the first alcohol-related inpatient episode in more detail.

The third section examines the last alcohol-related inpatient episode (for those who were admitted more than once) in more detail. The demographic characteristics of individuals with persisting alcohol problems are described and some comparisons are made between the first and last alcohol-related admission for these individuals.

The fourth section focuses on the subset of cases who were also admitted to hospital as the result of a road crash at some time during the 18 year period of 1980 to 1997.

The fifth section examines predictors of being involved in a road crash, if admitted to hospital for an alcohol-related medical condition.

4.1 Overview of Admissions to Hospital for an Alcohol-Related Medical Condition

Table 4.1 shows that from 1980 to 1992, the number of admissions per year fluctuated between about 4,500 and 5,500, whereas there were 6,185 in 1993; 7,284 in 1994; 8,230 in 1995 and 8,047 in 1996. For 1997 the number fell to 5,348. The reason for this rise is unclear, but could be due to changes in hospital admission policies.

Table 4.1 **Number of Alcohol-Related Inpatient Episodes for People Admitted to Hospital Each Year in Western Australia, 1980 to 1997**

Year	n	%
1980	4,422	4.4
1981	4,550	4.5
1982	4,764	4.7
1983	5,578	5.5
1984	5,491	5.5
1985	5,416	5.4
1986	5,149	5.1
1987	4,732	4.7
1988	4,604	4.6
1989	5,266	5.2
1990	4,951	4.9
1991	5,187	5.2
1992	5,427	5.4
1993	6,185	6.1
1994	7,284	7.2
1995	8,230	8.2
1996	8,047	8.0
1997	5,348	5.3
Total	100,631	100.0

On average, each person had 7.4 inpatient episodes involving both alcohol-related and non-alcohol related hospitalisations between 1980 and 1997, and an average of 2.4 inpatient episodes involving an alcohol-related condition.

Table 4.2 shows the distribution of the number of alcohol-related inpatient episodes among the 41,537 people in the study. The majority of people had only one alcohol-related admission (62.8%). Around 26.1% of people experienced 2 to 4 inpatient

episodes, and 7.4% experienced 5 to 9 episodes in hospital for an alcohol-related condition.

The median time between admissions for alcohol-related conditions is also shown in Table 4.2. For those with between 2 to 4 episodes, the median time between admissions for an alcohol-related condition was 362 days (or about 12 months). For those with 5 to 9 admissions, the median time was 176 days (or about 6 months); 10 to 19 admissions, the median time was 106 days (or about 3 months); and for those with more than 20 alcohol-related admissions, the median time between admissions was 54 days (or about 2 months).

Table 4.2 Number of Alcohol-Related Inpatient Episodes, Median and Range of Time Between Episodes for People Admitted to Hospital in Western Australia, 1980 to 1997

Number of Inpatient Episodes	n	%	Median (days)	Range (days)
1	26,099	62.8	-	-
2 to 4	10,841	26.1	362	6,380
5 to 9	3,088	7.4	176	6,069
10 to 19	1,109	2.7	106	5,082
20 +	400	1.0	54	4,034
Total	41,537	100.0		

The hospital admission records were classified as being either: an alcohol-related admission; a crash-related admission; an alcohol and crash-related admission; or, a non-alcohol related admission. For the majority of people (55.5%), their first admission to hospital for the period 1980 to 1997 was for a non-alcohol related condition, while for 40.7% of people, their first admission was for an alcohol-related condition. Around 3.8% were first admitted to hospital for being involved in a crash and about half of these (2.0% of the total) also required treatment for an alcohol-related condition (Table 4.3).

Table 4.3 Cause of First Admission to Hospital as a Result of an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Cause of First Admission	n	%
Alcohol-related admission	16,885	40.7
Crash-related admission	753	1.8
Alcohol and crash-related admission	828	2.0
non-Alcohol related admission	23,071	55.5
Total	41,537	100.0

Table 4.4 shows that for people admitted to hospital more than once for any condition, 55.7% were last admitted to hospital for a non-alcohol related condition. While 42.0% of those with repeated alcohol admissions had an alcohol-related condition at the time of their last hospital episode, another 1.3% were diagnosed with an alcohol-related condition at the same time that they were admitted for injuries in a road crash. For a further 1.0% of people with repeat alcohol admissions, a road crash without any diagnosis of an alcohol condition was the last event requiring admission to hospital.

Table 4.4 Cause of Last Admission to Hospital as a Result of an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Cause of Last Admission	n	%
Alcohol-related admission	14,476	42.0
Crash-related admission	355	1.0
Alcohol and crash-related admission	443	1.3
non-Alcohol related admission	19,226	55.7
Total	34,500	100.0

Table 4.5 shows the specific alcohol-related diagnosis involved in the first alcohol admission. The most common type of diagnosis was alcohol abuse (48.1%), followed by alcohol dependence (29.9%), alcoholic liver cirrhosis (7.7%), and alcohol psychosis (6.4%).

While 48.1% of all people in the study were diagnosed as suffering from alcohol abuse at their first presentation, this accounted for 74.4% of first alcohol admissions for those aged 17 to 24 years and 60.1% for those aged 25 to 29 years. Alcohol dependence, on the other hand, was recorded as the first diagnosis for 29.9% of all people in the study compared with 61.8% of those aged 30 to 59 years. As expected, medical conditions caused by pathological change from high alcohol intake over an extended period (eg. liver cirrhosis) were more frequent at older ages.

Table 4.5 Diagnosis for First Alcohol-Related Medical Condition Admission to Hospital in Western Australia, 1980 to 1997

Diagnosis of First Admission	n	%
Alcohol psychosis	2,656	6.4
Alcohol dependence	12,418	29.9
Alcohol abuse	19,991	48.1
Alcohol polyneuropathy	236	0.6
Alcohol cardiomyopathy	422	1.0
Alcoholic gastritis	903	2.2
Alcoholic liver cirrhosis	3,209	7.7
Ethanol toxicity	1,262	3.0
Methanol toxicity	12	0.0
External cause of injury ethanol or methanol poisoning	196	0.5
External cause of injury alcohol aspiration	232	0.6
Total	41,537	100.0

Table 4.6 shows the specific diagnosis recorded on the last alcohol-related hospital admission for those people admitted to hospital more than once for an alcohol-related condition. The most common diagnosis was alcohol abuse (36.3%), followed by alcohol dependence (32.9%), alcoholic liver cirrhosis (14.7%), and alcohol psychosis (9.3%). This shows a decrease in alcohol abuse (48.1% to 36.3%) and an increase in alcohol dependence (29.9% to 32.9%) among the group with repeated alcohol admissions (see Table 4.5).

Table 4.6 Diagnosis for Last Alcohol-Related Medical Condition Admission to Hospital in Western Australia, 1980 to 1997

Diagnosis of Last Admission	n	%
Alcohol psychosis	1,443	9.3
Alcohol dependence	5,072	32.9
Alcohol abuse	5,602	36.3
Alcohol polyneuropathy	98	0.6
Alcohol cardiomyopathy	306	2.0
Alcoholic gastritis	300	1.9
Alcoholic liver cirrhosis	2,274	14.7
Ethanol toxicity	311	2.0
Methanol toxicity	3	0.0
External cause of injury ethanol or methanol poisoning	11	0.1
External cause of injury alcohol aspiration	18	0.1
Total	15,438	100.0

4.2

First Inpatient Episode for an Alcohol-Related Medical Condition

This section examines the first alcohol-related inpatient episode for people who had been admitted to hospital for an alcohol-related medical condition. Variables examined were age, gender, area of residence, and Aboriginality.

At their first admission, about half (49.0%) were aged 30 to 59 years, 22.2% were aged 60 years and older, 15.4% were aged 17 to 24 years and 10.0% were aged 25 to 29 years (Table 4.7).

In addition, three quarters of these 'alcohol' patients (75.1%, n=31,187) were male, but females were on average younger than males when first admitted. That is, a larger proportion of the females were in the 17 to 24 and 25 to 29 age groups than males (Table 4.7).

Table 4.7 Age Group and Gender at First Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Age Group	Gender					
	Male		Female		Total	
	n	%	n	%	n	%
0 to 16 years	741	2.4	621	6.0	1,362	3.3
17 to 24 years	4,718	15.1	1,671	16.1	6,389	15.4
25 to 29 years	3,040	9.7	1,119	10.9	4,159	10.0
30 to 59 years	15,457	49.6	4,577	47.1	20,334	49.0
60 + years	7,193	23.1	2,030	19.6	9,223	22.2
Unknown/missing	38	0.1	32	0.3	70	0.2
Total	31,187	100.0	10,350	100.0	41,537	100.0

People who resided in remote major and remote regions appeared to be over represented (Table 4.8). Around 72% of the Western Australian population live in the metropolitan area, 19% live in rural major and rural areas and around 9% live in remote major and remote areas (Ryan, Cercarelli & Mullan, 1998). Yet, at the time of their first episode in hospital for an alcohol-related condition, 65.8% were residing in the Perth metropolitan area, 12.6% were living in rural major and rural areas and 18.4% were residing in remote major and remote areas.

Table 4.8 Area of Residence at First Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Area of Residence	n	%
Metropolitan area	27,335	65.8
Rural major area	2,390	5.8
Rural area	2,810	6.8
Remote major area	4,109	9.9
Remote area	3,533	8.5
Unknown/missing	1,360	3.3
Total	41,537	100.0

Aboriginal people also appeared to be over represented. Table 4.9 shows that 16.0% of people admitted to hospital for an alcohol-related condition were Aboriginal, while the Aboriginal population of Western Australia is around 3% of the total (Ryan et al, 1998).

Table 4.9 Aboriginality at First Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Aboriginality	n	%
non-Aboriginal	34,839	83.9
Aboriginal	6,647	16.0
Unknown/missing	51	0.1
Total	41,537	100.0

4.3 Last Inpatient Episode for an Alcohol-Related Medical Condition

This section examines the last inpatient episode for the 15,438 (37.2%) people who had been admitted to hospital for an alcohol-related medical condition on more than one occasion. The episode examined is for the last alcohol-related episode. Variables examined were age, gender, area of residence, and Aboriginality.

More than half of the 15,438 people (56.7%) were aged 30 to 59 years at last their alcohol-related admission, while 31.5% were aged 60 years and older, 5.0% were aged 17 to 24 years and 6.5% were aged 25 to 29 years (Table 4.10). As for the first admission, three quarters (75.4%, n=11,647) were male, and as expected there were more individuals in the older age groups than for the first admission (see Table 4.7).

Table 4.10 Age Group and Gender at Last Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Age Group	Gender					
	Male		Female		Total	
	n	%	n	%	n	%
0 to 16 years	27	0.2	20	0.5	47	0.3
17 to 24 years	512	4.4	254	6.7	766	5.0
25 to 29 years	704	6.0	304	8.0	1,008	6.5
30 to 59 years	6,575	56.4	2,179	57.5	8,754	56.7
60 + years	3,829	32.9	1,033	27.2	4,862	31.5
Unknown/missing	0	0.0	1	0.0	1	0.0
Total	11,647	100.0	3,791	100.0	15,438	100.0

When examining area of residence at last admission, once again people who resided in remote major and remote areas appeared to be over represented (Table 4.11). Around 64.9% were residing in the Perth metropolitan area, 13.0% were living in rural major and rural areas, and 19.4% were residing in remote major and remote areas. This was a similar pattern to first admissions (see Table 4.8).

Table 4.11 Area of Residence at Last Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Area of Residence	n	%
Metropolitan area	10,022	64.9
Rural major area	984	6.4
Rural area	1,021	6.6
Remote major area	1,668	10.8
Remote area	1,329	8.6
Unknown/missing	414	2.7
Total	15,438	100.0

Again, Aboriginal people were over represented and to a greater extent than for the first admission. Table 4.12 shows that 21.7% of people admitted to hospital were Aboriginal, while 78.2% were non-Aboriginal (see Table 4.9).

Table 4.12 Aboriginality at Last Admission to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Aboriginality	n	%
non-Aboriginal	12,078	78.2
Aboriginal	3,356	21.7
Unknown/missing	4	0.0
Total	15,438	100.0

4.4 Road Crashes and Alcohol-Related Medical Conditions

This section describes the 4,875 (11.7%) people in this study who were also admitted to hospital, at least once, as the result of a road crash. Of these, 1,151 (23.6%) had at least one alcohol-related admission prior to their first crash admission, 2,167 (44.5%) had a crash admission before their first alcohol admission, and 1,557 (31.9%) were diagnosed as having an alcohol-related condition while in hospital for injuries resulting from a crash. For those who had at least one road crash admission, the average number of crash admissions was 1.2.

Table 4.13 shows the number of crash-related admissions per person. The majority of people were involved in only one crash (83.3%), however 15.7% were involved in between 2 and 4 crashes.

Table 4.13 Number of Crash-Related Inpatient Episodes for People Admitted to Hospital for an Alcohol-Related Medical Condition in Western Australia, 1980 to 1997

Number of Inpatient Episodes	n	%
1	4,063	83.3
2 to 4	765	15.7
5 to 9	42	0.9
10 to 19	5	0.1
Total	4,875	100.0

Information in the following tables refers to the last inpatient episode as a result of a road crash (if a person was involved in more than one crash in the time period examined). Details for the final crash admission were used as the most recent information was considered more accurate.

Table 4.14 shows the age and gender distribution of the road crash casualties. In comparison with first and last inpatient episodes for an alcohol-related condition, crash admission was at an earlier age (see Table 4.7 and Table 4.10). Whereas about 32.7% of these crash admissions occurred at age 17 to 24 years, only 5.0% of other

admissions occurred during these years (see Table 4.10). Similarly for the oldest age group, only 6.9% of crash casualties were aged 60 years and older when admitted, compared with one third (31.5%) of people in this age group at their last admission for an alcohol-related condition (see Table 4.10). When comparing both groups (i.e. road crash casualties, and all people at their last alcohol-related admission), fewer people in crashes were aged 30 to 59 years (38.3% of crash casualties and 56.7% of all hospitalisations (see Table 4.10)). Around 80.7% of crash casualties were male (compared with 75.4% of all last admissions for an alcohol-related condition (see Table 4.10)).

Table 4.14 Age Group and Gender of People Admitted to Hospital for an Alcohol-Related Medical Condition and a Road Crash in Western Australia, 1980 to 1997

Age Group	Gender					
	Male		Female		Total	
	n	%	n	%	n	%
0 to 16 years	290	7.4	86	9.1	376	7.7
17 to 24 years	1,316	33.5	277	29.4	1,593	32.7
25 to 29 years	566	14.4	138	14.6	704	14.4
30 to 59 years	1,475	37.5	390	41.4	1,865	38.3
60 + years	286	7.3	51	5.4	337	6.9
Unknown/missing	0	0.0	0	0.0	0	0.0
Total	3,933	100.0	942	100.0	4,875	100.0

Most of the crash casualties resided in the Perth metropolitan area (61.6%) (Table 4.15). The next largest group consisted of those who lived in remote areas (21.6%), followed by those from the rural areas (14.7%). A similar proportion of crash casualties (21.6%) were from remote areas, when compared with those admitted more than once for an alcohol-related condition (19.4%) (see Table 4.11).

Table 4.15 Area of Residence of People Admitted to Hospital for an Alcohol-Related Medical Condition and a Road Crash in Western Australia, 1980 to 1997

Area of Residence	n	%
Metropolitan area	3,001	61.6
Rural major area	297	6.1
Rural area	417	8.6
Remote major area	517	10.6
Remote area	536	11.0
Unknown/missing	107	2.2
Total	4,875	100.0

The distribution of the number of crash casualties by Aboriginality is shown in Table 4.16. Around 19.7% of the crash casualties were Aboriginal, a slightly lower proportion to those admitted to hospital more than once for an alcohol-related medical condition (21.7%) (see Table 4.12).

Table 4.16 Aboriginality of People Admitted to Hospital for an Alcohol-Related Medical Condition and a Road Crash in Western Australia, 1980 to 1997

Aboriginality	n	%
non-Aboriginal	3,912	80.2
Aboriginal	960	19.7
Unknown/missing	3	0.1
Total	4,875	100.0

Around 23.7% of crash casualties were motor vehicle drivers, 18.3% were pedestrians, 13.6% were motor vehicle passengers, and 9.1% were motorcycle riders. Around 26.4% of the crash casualties were unspecified road user type (Table 4.17).

Table 4.17 Road User Type of People Admitted to Hospital for an Alcohol-Related Medical Condition and a Road Crash in Western Australia, 1980 to 1997

Road User Type	n	%
Motor Vehicle Occupant:		
- Driver	1,156	23.7
- Passenger	664	13.6
Motorcyclist:		
- Rider	446	9.1
- Passenger	46	0.9
Pedestrian	892	18.3
Cyclist	373	7.7
Other	11	0.2
Unspecified	1,287	26.4
Total	4,875	100.0

4.5 Predictors of Being Involved in a Road Crash

It is important to note that most people admitted to hospital for an alcohol-related condition were not admitted to hospital for a road crash at any time during the 18 year study period. For 1,151 (23.6%) of the 4,875 people who did have a crash admission, an admission for an alcohol-related medical condition preceded the admission for a crash. Among this group whose first alcohol admission preceded their crash admission, 311 were admitted as pedestrians, 102 as motorcycle riders, and 242 as drivers of motor vehicles. The remainder were admitted as passengers or unknown road user type.

In order to determine the factors associated with subsequent crash involvement, a Cox proportional hazard regression model was constructed using the time between the first alcohol-related admission and the first crash admission. Separate models were constructed for crashes involving drivers, riders and pedestrians. Factors included in the models were gender, age at first alcohol admission, Aboriginality, place of residence, and indicators of alcohol dependence and alcohol pathology. For the purpose of this analysis, alcohol pathology was defined to include alcohol polyneuropathy, alcohol cardiomyopathy, alcoholic gastritis, and alcoholic liver cirrhosis.

The Cox proportional hazard model assumes no particular distribution for the time between the alcohol-related medical condition and the crash. For each factor in the model, the relative risk was calculated by comparison to a baseline group. In this way, male patients were compared to female patients, young patients were compared to old patients, Aboriginal patients were compared to non-Aboriginal patients, and patients residing in rural and remote areas of Western Australia were compared to those from the metropolitan area of Perth. Indicators for a diagnosis of alcohol abuse, alcohol dependence or a condition resulting from altered pathology were included in the models.

Table 4.18 gives the results of the Cox proportional hazard models. The models were constructed using records of 39,580 patients for whom there was a subsequent crash admission or no crash admission among the series of hospital admission records in the study.

Results from these analyses indicate that male alcohol patients were significantly more likely than female patients to be involved in a road crash as a pedestrian or motorcycle rider, but not as a motor vehicle driver. For all road user groups, those admitted to hospital for an alcohol-related medical condition at a younger age were much more likely to later be involved in a road crash. For each additional year of age, the relative risk decreased by 1% (risk ratio=0.988) for pedestrians; 3% for drivers (risk ratio=0.967); to 8% for motorcycle riders (risk ratio=0.924). In addition, Aboriginal people were about five times (risk ratio=4.701) more likely to be involved in a pedestrian crash than non-Aboriginal people of similar age, gender, place of residence and alcohol status. Among the alcohol conditions, alcohol dependence was the best predictor of pedestrian crashes for otherwise similar people. Whereas patients with a diagnosis of alcohol abuse, dependence or pathology had significantly increased risks of involvement in a motorcycle crash, the effect for motor vehicle drivers was not significant for any of these conditions.

Table 4.18 Factors Associated with the Time Between an Admission for an Alcohol-Related Medical Condition and an Admission for a Road Crash in Western Australia, 1980 to 1997

	coefficient	std error	p-value	risk ratio*
Any Crash (n=1,156)				
male	0.2411	0.0703	0.0006	1.273
age	-0.0310	0.0020	0.0001	0.969
Aboriginality	0.6417	0.0749	0.0001	1.900
rural	0.1092	0.0090	0.2298	
remote	0.1840	0.0779	0.0182	1.202
Alcohol abuse	0.0670	0.1011	0.5075	
Alcohol dependence	0.2478	0.1021	0.0152	1.281
Alcohol pathology	-0.2763	0.1239	0.0258	0.759
Motor Vehicle Driver (n=242)				
male	0.0336	0.1483	0.8204	
age	-0.0331	0.0042	0.0001	0.967
Aboriginality	-0.3126	0.2000	0.1181	
rural	0.1521	0.1925	0.4294	
remote	0.1177	0.1824	0.5188	
Alcohol abuse	0.3593	0.2240	0.1087	
Alcohol dependence	0.0712	0.2385	0.7654	
Alcohol pathology	-0.4030	0.3048	0.1861	
Motorcycle Rider (n=102)				
male	2.9389	0.7150	0.0001	18.895
age	-0.0791	0.0087	0.0001	0.924
Aboriginality	-1.3447	0.3894	0.0006	0.261
rural	-0.1316	0.3402	0.6989	
remote	0.6470	0.2447	0.0082	1.910
Alcohol abuse	1.0772	0.3668	0.0033	2.926
Alcohol dependence	0.8381	0.3971	0.0348	2.312
Alcohol pathology	0.9140	0.3732	0.0143	2.494
Pedestrian (n=311)				
male	0.3116	0.1381	0.0241	1.366
age	-0.0116	0.0037	0.0018	0.988
Aboriginality	1.5477	0.1370	0.0001	4.701
rural	-0.4126	0.1943	0.0337	0.662
remote	-0.3627	0.1513	0.0165	0.696
Alcohol abuse	-0.0858	0.2097	0.6825	
Alcohol dependence	0.4434	0.1999	0.0265	1.558
Alcohol pathology	-0.4124	0.2312	0.0756	

* only risk ratios significantly different from 1.0 are listed

5. DISCUSSION

The aim of this study was to measure the association between alcohol-related medical conditions and road crashes. A longitudinal analysis of the hospital records in the Health Services Research Linked Database of people first admitted to hospital for an alcohol-related medical condition between 1980 and 1997 in Western Australia was conducted.

Information on all contacts with the hospital system in Western Australia for the 41,537 people in the study was available, however, the database does not provide the complete picture as hospital events prior to 1980 and after 1997 were not included. The data presented in this report are limited and examine only the first and last alcohol admissions and the last crash admission.

The number of admissions per year fluctuated between about 4,500 and 5,500, with an increase between 1993 and 1996 to about 7,000 to 8,000 with a return to about 5,000 in 1997. The reason for this increase is unclear but may be due to changes in coding or in hospital admission policies. Those admitted to hospital for an alcohol-related condition had a mean of 7.4 admissions to hospital for all conditions, and 2.4 admissions for an alcohol-related condition. For those who had at least one road crash admission, the average number of crash admissions was 1.2.

The most common diagnoses at first admission for an alcohol condition were found to be alcohol abuse and alcohol dependence. For the 37.2% with more than one alcohol admission, between the first and last admission there was a decrease in the proportion with a diagnosis of alcohol abuse, and an increase in the proportion with alcohol dependence or conditions caused by pathological change (eg. liver cirrhosis).

Those who were admitted only once for an alcohol-related condition were generally younger than those admitted more than once. The younger age groups were more often associated with a diagnosis of alcohol abuse and the older groups with dependence. Three quarters of those admitted to hospital were male, and while the majority of people resided in the Perth metropolitan area, those living in the remote areas of Western Australia were over represented. Aboriginal people also appeared over represented. These findings support previous research that has identified the

characteristics of alcohol-related road crashes (eg. Ryan et al, 1996; Rosman et al, 1999, Dunbar et al, 1985).

Of those who also had a road crash admission (4,875, 11.7%), 23.6% had a crash admission after their first alcohol-related admission, and 44.5% had a crash admission before their first alcohol admission. There were 31.9% who were diagnosed as having an alcohol-related condition while in hospital for injuries resulting from a crash.

Over this time period, the majority of the 4,875 people were involved in only one crash. About 32.7% of those involved in a road crash were aged 17 to 24 years and 38.3% were aged 30 to 59 years. This group tended to be younger than those not involved in crashes.

The majority of people involved in a road crash resided in the metropolitan area, however, those living in the remote areas of Western Australia were over represented, as were Aboriginal people. While the majority of those who were admitted were motor vehicle drivers (23.7%), a large group were pedestrians (18.3%), and 9.1% were motorcyclists.

When examining factors associated with subsequent crash involvement, differences were found for drivers, motorcycle riders and pedestrians. For all road user groups, those admitted to hospital for an alcohol-related condition at a younger age were more likely to later be involved in a road crash. For each additional year of age, the relative risk decreased by 1% for pedestrians, 3% for drivers, and 8% for motorcycle riders. Aboriginal people were five times more likely to be involved in a pedestrian crash than non-Aboriginal people of the same gender, age and area of residence.

Over the 18 year period, 11.7% (about one in nine) of those admitted to hospital for an alcohol-related medical condition were also involved in a road crash. In comparison, about one in twenty seven people in Western Australia would have been admitted to hospital as a result of a road crash over the same length of time. (This was calculated using data for 1991 when there were 3,266 road crash hospital admissions for a population of about 1.6 million people in Western Australia). This

suggests that those admitted to hospital for an alcohol-related condition were three times more likely to be involved in a road crash than the average Western Australian.

It appears from these findings that since only about one quarter of crash admissions were preceded by an alcohol-related admission, an intervention aimed at reducing crashes and applied to all alcohol-related admissions not associated with a crash would not be practical, as only about 2.5% (23.6% of 11.7%) of such admissions would potentially precede a crash. Such an intervention might be made more specific by concentrating on males, those under 30 years of age, and Aboriginal people. An alternative approach would be to apply an alcohol-related intervention to all young males admitted for a crash. For almost half the crash cases, there was an alcohol-related admission at a later date. A cost effective intervention may be appropriate in these cases. Further research is required to explore the potential of these interventions.

REFERENCES

- Cercarelli, L.R., Hendrie, D., Ryan, G.A., Legge, M. & Kirov, C. (1998). *Road Safety Risk Factors Study: Results From the Fourth Survey*. Perth: Road Accident Prevention Research Unit, The University of Western Australia. Report No. RR62.
- Cercarelli, L.R., Kirov, C., Legge, M. & Rosman, D.L. (1998). *Reported Road Crashes in Western Australia 1997*. Perth: Road Safety Council of Western Australia.
- Cooper, L.M. & Ryan, G.A. (1998). *Drink Driving in Western Australia: Review of Current Situation and Measures to Reduce Drink-Driving Related Crashes*. Perth: Road Accident Prevention Research Unit, The University of Western Australia. Report No. RR70.
- Department of Human Services and Health. (1994). *Rural/Remote Areas Classification*. Canberra: Department of Human Services and Health.
- Dunbar, J.A., Ogston, S.A., Ritchie, A., Devgun, M.S., Hagart, J. & Martin, B.T. (1985). Are problem drinkers dangerous drivers? An investigation of arrest for drinking and driving, serum γ glutamyltranspeptidase activities, blood alcohol concentrations, and road traffic accidents: the Tayside Safe Driving Project. British Medical Journal Clinical Research Ed, 290(6471): 827-830.
- English, D.R., Holman, C.D.J., Milne, E., Winter, M.G., Hulse, G.K., Codde, J.P., Bower, C.I., Corti, B., de Klerk, N., Knuiman, M.W., Kurinczuk, J.J., Lewin, G.F. & Ryan, G.A. (1995). *The Quantification of Drug Caused Morbidity and Mortality in Australia*. Canberra: Commonwealth Department of Human Services and Health.
- Herve, C., Gaillard, M., Roujas, F. & Huguenard, P. (1986). Alcoholism in polytrauma. The Journal of Trauma, 26(12): 1123-1126.
- Holman, C.D.J., Bass, A.J., Rouse, I.L. & Hobbs, M.S.T. (In Press). Population-based linkage of health records in Western Australia: Development of a Health Services Research Linked Database. Australian Journal of Public Health.
- International Classification of Diseases Revision 9 - Clinical Modification (ICD9 CM). (1986). Ann Arbor, Michigan: Edwards Brothers Inc.
- Madden, C. & Cole, T.B. (1995). Emergency intervention to break the cycle of drunken driving and recurrent injury. Annals of Emergency Medicine, 26(2): 177-179.
- Maio, R.F., Waller, P.F., Blow, F.C., Hill, E.M. & Singer K.M. (1997). Alcohol abuse/dependence in motor vehicle crash victims presenting to the emergency department. Academic Emergency Medicine, 4(4): 256-262.
- Mancino, M., Cunningham, M.R., Davidson, P. & Fulton, R.L. (1995). Identification of the motor vehicle accident victim who abuses alcohol: An opportunity to reduce trauma. Journal of Studies on Alcohol, 57(6): 652-658.

McLean, A.J., Holubowycz, O.T. & Sandow, B.L. (1980). *Alcohol and Crashes: Identification of Relevant Factors in this Association*. Canberra: Federal Office of Road Safety. Report No. CR 11.

Papoz, L., Weill, J., L'Hoste, J., Chich, Y., Got, C. & Goehrs, Y. (1986). Biological markers of alcohol intake among 4,796 subjects injured in accidents. British Medical Journal Clinical Research Ed, 292(6530): 1234-1237.

Piette, J.D., Barnett, P.G. & Moos, R.H. (1996). First-time admissions with alcohol-related medical problems: A 10-year follow-up of a national sample of alcoholic patients. Journal of Studies on Alcohol, 59(1): 89-96.

Rosman, D.L., Ferrante, A.M. & Marom, Y. (1998). *Drink-Driving Arrests and Alcohol-Related Crashes: Results From the Linkage of Western Australian Arrest and Crash Records (1987-1995)*. Perth: Road Accident Prevention Research Unit, The University of Western Australia. Report No. RR71.

Ross, H.L. (1993). Prevalence of alcohol-impaired driving: An international comparison. Accident Analysis and Prevention, 25(6): 777-779.

Ryan, G.A., Cercarelli, L.R. & Mullan, N. (1998). *Road Safety in the Rural and Remote Regions of Western Australia*. Perth: Road Accident Prevention Research Unit, The University of Western Australia. Report No. RR64.

Ryan, G.A., Ferrante, A., Loh, N. & Cercarelli, L.R. (1996). *Repeat Drink-Driving Offenders in Western Australia, 1984 to 1994*. Canberra: Department of Transport and Regional Development, Federal Office of Road Safety. Report No. CR 168.

Ryan, G.A., Kirov, C. & Cercarelli, L.R. (1999). *Alcohol-Related Crashes in Western Australia, 1989-1997*. Perth: Road Accident Prevention Research Unit, The University of Western Australia. Report No. RR78.

Sanson-Fisher, R., Redman, S., Homel, R. & Key, W. (1990). Drink driver rehabilitation programs – an Australian perspective. Alcohol, Drugs and Driving, 6(3-4): 133-145.

Soderstrom, C.A., Dischinger, P.C., Smith, G.S., Hebel, J.R., McDuff, D.R., Gorelick, D.A., Kerns, T.J., Ho, S.M. & Read, K.M. (1997). Alcoholism at the time of injury among trauma centre patients: vehicular crash victims compared with other patients. Accident Analysis and Prevention, 29(6): 715-721.