Illicit drugs and driving:
An investigation of fatalities and traffic offences in Western Australia

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CURTIN-MONASH ACCIDENT RESEARCH CENTRE

Faculty of Health Sciences

Curtin University

Hayman Road

Bentley WA 6102

Peter Palamara; Michelle Broughton; Fiona Chambers

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Author(s)
Palamara, P.; Broughton, M.; Chambers, F.

Performing Organisation
Curtin-Monash Accident Research Centre (C-MARC)
Faculty of Health Sciences
Curtin University
Hayman Road
BENTLEY WA 6102
Tel: (08) 9266-2304 Fax: (08) 9266-2508
www.c-marc.curtin.edu.au

Sponsor
Road Safety Council of Western Australia
c/- Office of Road Safety
Main Roads Western Australia
1 Adelaide Terrace
PERTH WA 6000

Abstract
The prevalence and characteristics of illicit drug related driving in Western Australia was investigated through the analysis of the records of drivers and riders fatally injured in the period 2000-2012 and drivers and riders charged with a Section 64AC offence (illicit substance in oral fluid), 2008-2012. Approximately 23% of fatally injured drivers/riders tested positive to one or more illicit substances with the annual rate of detection unchanged for the full study period, with some preliminary evidence of a decline from 2008. The odds of testing positive was significantly higher for males, those aged under 40 years; those driving without a valid licence; those testing positive to alcohol in the range 0.05gm%-0.149gm%, and those using benzodiazepines with and without opioids. Around 4% of drivers and riders undertaking a roadside oral fluid test 2008-2012 were charged with a Section 64AC offence. The annual offence rate significantly increased over the period. Offending was highest in males, younger age drivers/riders, and in the metropolitan area and select metropolitan police districts. A number of recommendations were provided covering issues such as data sharing, changes to the roadside oral fluid testing program, penalties, and research.

Keywords
Illicit drugs, motor vehicle crashes, motor vehicle driver and motorcycle rider fatalities; traffic offences

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ABBREVIATIONS

The following abbreviations are used throughout the report:

BAC - Blood Alcohol Concentration

CNS - Central Nervous System

DUD - Drug Use Disorder

DUI - Driving Under the Influence

DUID - Driving Under the Influence of Drugs

DWI - Driving While Intoxicated/Impaired

gm% - grams of alcohol per 100 millilitres of blood

MDMA – Methylenedioxymethamphetamine

MRWA – Main Roads Western Australia

RRDT - Random Road-side Drug Testing

THC - Δ^9-Tetrahydrocannabinol

WAPOL - Western Australia Police

EXECUTIVE SUMMARY

Introduction

Evidence continues to accumulate of the impairing nature of illicit drugs on driving and the prevalence of use among crash and non-crash involved drivers. The prevalence of illicit substances among drivers varies with the type of substance and whether the driver was involved in a crash. For example, illicit substances of all types have been detected in up to 33% of fatally injured drivers with cannabis being the most frequently detected substance. Among non-crash involved drivers, between 4%-18% self-report having driven after using illicit drugs, while up to 5.5% of drivers subject to a roadside oral fluids test have tested positive. Research has also identified that certain drivers have a higher risk of illicit drug-driving, including males, younger age persons and those that engage in other on-road risk behaviours such as failing to wear a seat-belt, drink-driving, and unlicensed driving.

In Western Australia, the most comprehensive investigation to date of the involvement of illicit drugs among fatally injured drivers was for those killed during the period 1995-1999. More recently, the Road Safety Council of Western Australia in 2008 commenced the annual reporting of the involvement of illicit drugs among fatally injured drivers. These annual analyses are however, limited to descriptive details such as the type of substance, age group and gender, road user status, and day of week. Consequently they fail to provide a detailed understanding of the trend and pattern of illicit drug involvement over time and associated driver and crash type risk factors.

The aim of this study was to investigate the problem of illicit drug-driving in Western Australia using two sources of data: Western Australia Police (WAPOL) reports of the crashes and toxicology findings of fatally injured drivers/riders, and, WAPOL records of drivers/riders charged with illicit drugs in oral fluids offences. The specific objectives of the study were to:

1. Report the prevalence, trend and characteristics of illicit drug related motor vehicle driver and motorcycle rider fatalities over the period 2000-2012.
2. Statistically model the driver/rider and crash risk factors for an illicit drug involved fatality.
3. Report the prevalence, trend and characteristics of Section 64AC offences of the Western Australian Road Traffic Act (*Driving with prescribed illicit drugs in oral*

fluids) associated with Western Australian Polices' roadside drug testing program for prescribed illegal substances (e.g., THC, methylamphetamine, MDMA) during the period 2008-2012.

4. Statistically model the driver/rider risk factors for offence recidivism and multiple illicit substance use.

Method

Ethics approvals were obtained from both Curtin University and WAPOL prior to the application and release of de-identified fatal injury crash and traffic offence data by WAPOL.

Fatal injury crash dataset

The toxicology records of motor vehicle drivers and motorcycle/moped riders killed during the period 2000-2012 were extracted from the ChemCentre's Laboratory Information Management System and forwarded to the WAPOL Traffic Policy Unit to be linked with fatal crash records. The de-identified linked toxicology and crash records were subsequently returned to the Curtin-Monash Accident Research Centre (C-MARC). Examples of the information contained in the linked fatality record included:

- Road user status (motor vehicle driver; motor cycle rider)
- Driver/rider gender, age, license status (full, provisional, cancelled, suspended, no valid licence)
- Date, time, day, and location of the crash (WA region, police district, suburb, post code, street name)
- Features of the crash (lighting, road curvature, road use movement, crash type)
- Name and quantity of substance detected by the ChemCentre, including alcohol, prescribed illicit substances, other illegal substances, and pharmaceuticals.

Traffic offence dataset

Section 64AC of the Road Traffic Act 1974 is specific to the attempt to or act of driving a 'motor vehicle while a prescribed illicit drug is present in the person's oral fluid or blood' (page 104). Section 64AC offences specifically relate to the detection of three prescribed substances: THC (related to the use of cannabis), methylamphetamine (e.g., ice, crystal meth, crank) and MDMA (e.g., ecstasy). These offences most commonly result from WAPOL's roadside oral fluids testing program which commenced in October 2007 and is conducted in conjunction with Random Breath Testing bus operations.

WAPOL's Breath and Drug Operations supplied aggregated operational level data on the number of roadside oral fluid tests conducted each year of operation for the period 2008-2012. Section 64AC offence data from this program was provided by the Traffic Policy Unit using extractions from the 'Briefcase' system. All information that could result in the identification or re-identification of a driver/rider was deleted before being supplied to C-MARC for analysis. Examples of the information contained in this dataset are as follows:

- Driver age and gender
- Date of offence
- Location of offence (WA region, police district, suburb, postcode, road name)
- Cozart test (WAPOL) result (THC, Methylamphetamine, MDMA)
- ChemCentre test result (THC, Methylamphetamine, MDMA)

Data management and analysis

Linked fatality and traffic offence data was supplied by WAPOL as .csv files and read into SPSS (Vers. 22) for cleaning, coding, and restructuring to create relevant variables for analysis. The data was analysed using descriptive and multivariate techniques to address the aforementioned research objectives. The main outcome variables of interest were:

- Binary classification of the fatal crash as involving an illicit substance=1 or no illicit substance=0.
- Annual rate of detection of an illicit drug among fatally injured drivers/riders per 100,000 motor vehicle driver licences issued in Western Australia.
- The type and number of illicit substances detected in fatally injured drivers/riders.
- Annual rate of Section 64AC offences per 100,000 motor vehicle driver licences issued in Western Australia and per 1,000 roadside oral fluid tests conducted.
- Binary classification of drivers/riders as repeat/recidivist=1 or single=0 Section 64AC offenders for the period.
- The type and number of illicit substances detected for drivers/riders charged with a Section 64AC offence for the period.

Key findings of the analysis of driver and rider fatal injuries and illicit drugs

A total of n=1,375 linked WAPOL and ChemCentre fatal injury records were analysed, representing approximately 90% of the n=1,523 motor vehicle drivers and motor cycle riders reportedly killed 2000-2012 on Western Australian roads.

One or more illicit substances were detected in 22.7% (n=312) of fatally injured drivers/riders. This equates to a rate of 22.46 fatally injured driver/riders testing positive per 100,000 motor vehicle driver licences issued in Western Australia for the period 2000-2012. The annual rate of detection of an illicit substance in fatally injured drivers/riders did not significantly vary over the period but was found to significantly decline during the period 2008-2012 which coincides with the introduction of the roadside oral fluids testing program in late 2007.

Of the 383 positive results for an illicit substance, THC was the most frequently detected substance (64.8%). The annual proportion of positive tests for THC did not significantly vary over the period.

Nearly one-third of positive tests were for methylamphetamine (26.6%), MDMA (5.7%) and heroin, cocaine and benzylpiperazine (2.9% combined). The annual proportion of positive tests for methylamphetamine was found to significantly vary over the period, with the proportion in 2007 being three times higher than expected.

The majority (80%) of drivers/riders who tested positive did so for one illicit substance only, with 17% and 2.6% testing positive to two and three illicit substances respectively. The most frequently detected combination of illicit substances was THC and methylamphetamine (13.6% of drivers/riders testing positive).

Thirty-four percent of all fatally injured drivers/riders were found to have a Blood Alcohol Concentration level of ≥0.050gm%, of which 30% tested positive for an illicit substance. Approximately 45% (n=140) of drivers/riders who tested positive for an illicit substance were found to have a BAC ≥0.050gm%.

In total, around 47% of all fatally injured drivers/riders were potentially impaired due to alcohol (i.e., ≥0.050gm%) only, illicit drugs only, or a combination of alcohol and illicit drugs.

A greater proportion of fatally injured male drivers/riders (24.3%) than females (16.7%) tested positive for an illicit substance.

An illicit substance was more frequently detected among fatally injured drivers/riders aged 17-24 years (28.6%) and 35-39 years (34.5%) compared with those aged 40-49 years (14.5%), 50-59 years (10.3%) and 60+ years (0.6%).

Fatally injured drivers of motor cars (22.8%), trucks (20.6%), and riders of motorcycles (22.6%) were equally likely to test positive for an illicit substance.

A greater proportion of fatally injured drivers/riders without a valid licence (46%) tested positive for an illicit substance compared with those validly licensed (18.9%) at the time of the crash.

Of the non-illicit substances other than alcohol, benzodiazepines (9.9%) and opioids (12.5%) were most commonly detected among drivers/riders testing positive for an illicit substance compared with those who did not (4.5% and 11.8% respectively).

Drivers/riders fatally injured on metropolitan roads were more likely to test positive for an illicit substance compared with those crashing on rural roads: 25.6% *versus* 20.3%

Of the various metropolitan and regional police districts, the frequency of detection of an illicit substance among fatally injured drivers/riders was highest for North West Metropolitan (34.3%); South East Metropolitan (30.8%); Kimberley (30%) and South West regional (28.1%).

Drivers/riders involved in a single vehicle crash (25%) were more likely to test positive for an illicit substance compared with those involved in a multiple vehicle crash (19.3%).

The detection of an illicit substance among fatally injured drivers/riders did not significantly vary by day of week; crashes involving illicit drugs were only slightly higher on Fridays (26.5%) and Saturdays (26.5%) compared with that across all days of the week (22.7%).

A greater proportion of fatally injured drivers/riders crashing during the hours 18:00-05:59 (28.7%) tested positive for an illicit substance compared with those crashing 6:00-17:59 hours (17.7%).

Twenty-five percent of drivers/riders fatally injured on crashes on curves tested positive for an illicit substance compared with 21% for drivers/riders crashing on straight sections of road.

Multiple logistic regression modelling of the outcome of illicit drug use against the various *driver/rider* and *crash* factors produced a statistically significant model (adjusted for region of crash). Five driver/rider only factors were independently associated with statistically significant increased odds of a driver/rider testing positive for an illicit drug:

- Gender: Males OR=1.56, 95%CI 1.07-2.28, $p < 0.05$
- Age: ≤ 40 years OR=4.13, 95%CI 2.86-5.91, $p < 0.001$
- Licence status: No valid licence OR=2.80, 95%CI 1.97-3.96, $p < 0.001$
- Alcohol: BAC 0.050-0.079gm% OR=2.10, 95%CI 1.01-4.40, $p < 0.05$; BAC 0.080-0.149gm% OR=2.01, 95%CI 1.29-3.11, $p < 0.01$
- Benzodiazepine-Opioid use: benzodiazepines only OR=2.71, 95%CI 1.35-5.49, $p < 0.01$; benzodiazepines in combination with opioids OR=3.45, 95%CI 1.52-7.82, $p < 0.01$.

Key findings of the analysis of Section 64AC traffic offences

In the period January 2008 to December 2012 a total of 43,176 roadside oral fluid tests for illicit drugs were conducted by WAPOL. The number of oral fluid tests conducted annually was found to significantly vary over the period, with a lower than expected number of tests undertaken in 2009 and 2011 compared with other years.

Section 64AC offence data from this program for 1,630 drivers accruing a total of 1,724 offences were extracted from the WAPOL Briefcase system and analysed. Based on this data, approximately 4% of drivers tested during 2008-2012 were subsequently charged with a Section 64AC offence.

Linear regression of the relationship between year of testing and annual offence rates showed a statistically significant increase in the annual rate of offending drivers per 1,000 oral tests conducted but a non-significant increase for the annual rate of offending per 100,000 motor vehicle driver licences issued.

Drivers aged 25-39 years (56.9%) and 15-24 years (21.8%) accounted for the majority of offending drivers for the period. This was consistent across each year of the period.

Males accounted for around eight in ten offending drivers for the period and across each year of the period.

Around nine in ten Section 64AC offences for the period occurred in the metropolitan area. This was consistent across each year of the period except for 2008 when around 21% of offences occurred in Regional WA.

In the metropolitan region, the greater proportion of offending drivers for the period was detected in the South-East (30%), West (13.2%) and Central (12.8%) police districts.

Around 95% of drivers charged during the period were single offenders, with males 2.4 times more likely than females to be recidivist (repeat) offenders (OR=2.40, 95%CI 1.09-5.27, $p < 0.05$).

Around seven in ten Section 64AC offences for the period related to the detection of one prescribed substance only, most commonly methylamphetamine, which rose significantly from 54.7% of all offences in 2008 to 74% in 2012.

The most common multiple prescribed illicit substance detection was methylamphetamine in combination with THC, accounting for 21.9% of offences for the period.

Multiple logistic regression modelling of the factors associated with the detection of multiple versus a single prescribed illicit substance for a Section 64AC offence (adjusted for region of offence) showed statistically significant higher adjusted odds for the following factors:

- Gender: Males OR=1.69, 95%CI 1.22-2.33, $p < 0.01$
- Age: 15-24 years OR=2.17, 95%CI 1.57-3.02, $p < 0.001$; 25-39 years OR=3.87, 95%CI 2.75-5.44, $p < 0.001$.
- Year of offence: 2008 OR=2.17, 95%CI 1.50-3.02-3.96, $p < 0.001$; 2009 OR=3.87, 95%CI 2.75-5.44, $p < 0.001$; 2010 OR=1.52, 95%CI 1.10-2.12, $p < 0.05$.

Discussion

The proportion of fatally injured Western Australian drivers/riders investigated in this study testing positive to one or more illicit substances (22.7%) was reasonably consistent with that reported elsewhere. Some preliminary evidence was found to suggest that the annual rate of illicit drug involved fatalities had significantly declined from 2008, which corresponds to first full year of the roadside oral fluid testing program introduced in October 2007.

In the main, the illicit drug problem among fatally injured drivers/riders in Western Australia appears to be a single rather than poly illicit drug issue and one that mostly involves cannabis. This finding is consistent with other research and is not surprising given that cannabis is the most widely used illicit drug in Australia and that usage is reportedly higher in

Western Australia compared with most other jurisdictions. The high incidence of THC among fatally injured drivers/riders contrasts however, with the finding of a high prevalence of methylamphetamine detections for Sections 64 AC offenders.

The findings of this study also demonstrate that the risk of driver impairment due either to alcohol or illicit drugs or a combination of the two is substantial – around one in two fatally injured drivers/riders. The increased likelihood of driver impairment due to a 'cocktail' of legal and illegal substances was further underscored by the finding of an increased likelihood of illicit drug use among fatally injured drivers/riders who tested positive for the use of known crash risk psychoactive pharmaceuticals (i.e., benzodiazepines and opioids). Consequently, more must be done to detect and deter the combined use of alcohol and illicit drugs and other legal but impairing drugs.

The finding that male and younger age drivers/riders and those that engage in other on-road risk behaviour such as driving under the influence of alcohol and unlicensed driving were significantly more likely to test positive for illicit drugs also highlights the need to develop countermeasures that acknowledge and address the inter-related nature on-road risk behaviours, particularly among high risk groups such as males and younger age drivers.

Most recently, recommendations have been made to the WA state government to increase the number of roadside oral fluid tests to deter usage of and detect the three prescribed substances of THC, methylamphetamine and MDMA among WA drivers/riders. The findings of this investigation support this recommendation as the number of roadside tests had remained relatively stable over the period 2008-2012 against a corresponding increase in the number of motor vehicle driver licences issued. Evidence of a significant increase in the annual rate of drivers/rider committing a Section 64AC offence against a relatively static program of testing suggests that WAPOL is becoming more strategic and targeted in their selection of driver/riders for testing (i.e., increased focus on specific rather than general deterrence), or alternatively, that the prevalence of illicit drug use among drivers/riders is increasing. Either way the annual number of oral fluid tests should be increased to improve both the specific and general deterrence of drug-driving.

Of concern also is the finding that certain roadside testing and confirmatory analytical practices are unintentionally obfuscating our understanding of two issues and their deterrence. These issues include the prevalence of illicit substance use in combination with

alcohol, and, the prevalence of the combined use of the three prescribed substances. WAPOL's roadside drug testing policies and practices must change to address these issues.

As per the finding for fatally injured drivers/riders, the illicit drug problem among non-crash involved drivers/riders appears to be a single-substance problem, but in this case methylamphetamine rather than THC. This finding supports that of previous research. WA's standing in Australia as having the highest proportion of recent users of illegal methylamphetamine/amphetamine adds further weight to the need to counter the use of this substance among drivers.

Like the findings for fatally injured drivers/riders, analysis of the Section 64AC offences highlighted the risk that males and younger age drivers/riders present for drug impaired driving. The finding from these two data sources and our understanding of the relationship between gender and age and other road risk behaviours such as drink-driving, speeding and non-use of seat-belts reaffirms the need to develop effective countermeasures that are targeted to these 'at risk' groups and addresses the co-related nature of their on-road risk behaviours.

A number of issues potentially limit the findings of this investigation. These relate to the completeness of the supplied datasets of fatally injured drivers/riders and Section 64AC offences; the lack of opportunity to link driver licensing information with both fatality and Section 64AC records to retrieve other demographic and relevant driver history data, and the lack of opportunity to link crash records with associated hospital admission records (for driver/riders who did not die at the scene of the crash) to determine what treatment drugs were administered post-crash.

Recommendations

Data and Research

1. That WA Police and the ChemCentre work toward the sharing and use of a common, unique case identifier for traffic related deaths to facilitate future linkages of their respective data.

2. That WA Police and the ChemCentre negotiate the supply of information on the presence of illicit substances for fatally injured road users to Main Roads WA for inclusion in their Integrated Road Information System database of police reported road crashes.

3. That future research into illicit drug related driving seek to link crash and toxicology data with Department of Transport and Health Department of WA data (in and out patient).

4. That a program of research be established to investigate the prevalence of illicit drug use among non-fatally injured drivers admitted to hospital.

Policy and Practice

5. That the Western Australian government increase the number of roadside oral fluid tests in the metropolitan and particularly the non-metropolitan areas.

6. That the Western Australian government undertake the selective oral fluid testing of drivers/riders who exceed their prescribed limit of Blood Alcohol Concentration.

7. That the Western Australian government reinstate the practice of confirmatory testing of both methylamphetamine and THC where there is preliminary evidence for doing so, and not just methylamphetamine as a first-choice option.

8. That a stakeholder forum be established to discuss the benefits of introducing mandatory drug-use treatment programs for repeat Section 64AC offenders.

KEY FINDINGS

Illicit drugs in fatally injured drivers and motorcycle riders

- 22.7% of drivers and motorcycle riders fatally injured during the period 2000-2012 tested positive to one or more illicit substances including THC, methylamphetamine, MDMA, cocaine, heroin, and benzylpiperazine.
- The annual rate per 100,000 Motor Vehicle Driver Licences issued significantly declined during the period 2008 to 2012 - which coincides with the introduction of roadside oral fluid testing - but did not significantly vary during the period 2000 to 2007.
- THC was the most commonly detected illicit substance followed by methylamphetamine.
- While most fatally injured drivers and riders who tested positive did so for one illicit substance only, nearly half had some alcohol in their system with 45% returning a Blood Alcohol Concentration level ≥0.05gm%.
- The likelihood of a fatally injured driver and rider testing positive for an illicit substance was significantly higher if they were male, under 40 years of age, driving without a valid licence, returned a BAC level in the 0.05gm% to 0.149gm% range, and tested positive for benzodiazepines use alone or in combination with opioids.

Section 64AC Traffic Offences for Illicit drugs in Oral Fluids

- Approximately 4% of roadside screening tests for illicit drugs in oral fluids conducted 2008 to 2012 resulted in a Section 64AC offence.
- The annual Offence rate per 1,000 tests significantly increased over the period though the rate per 100,000 Motor Vehicle Driver Licences issued did not significantly vary.
- Methylamphetamine and methylamphetamine in combination with THC were most commonly detected illicit substances at roadside.
- Males, those under 40 years of age, and those tested in metropolitan Perth accounted for the majority of driver/rider Section 64AC offences over the period and in each year of the period. Around three in ten Section 64AC offences involving methylamphetamine alone and in combination with THC occurred in the South-East metropolitan policing district.

- Around three in ten Section 64AC offending drivers/riders tested positive to multiple illicit substances, with the likelihood of doing so highest for males, those under 40 years of age, and those tested during the period 2008 to 2010.
- Consultation with Western Australian Police over the findings of the analysis of Section 64AC offence data suggests that the current oral fluid testing program is best described as 'targeted' rather than 'random'.
- Consultation revealed that WAPOL limits their oral fluid testing program at random breath testing operations to drivers/riders who are *not* in breach of their prescribed BAC level.
- Consultation also identified that a WAPOL-initiated change in policy for confirmatory drug testing by the ChemCentre is the likely reason why the detection of multiple illicit substances significantly declined post 2010.
- The identified enforcement and testing practices undermine the roadside oral fluid testing program's ability to validly and reliably estimate the prevalence of illicit drugs, their combined use, and use in conjunction with alcohol in the population of non-crash involved drivers/riders.

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1 INTRODUCTION

1.1 Background

Around 1.24 million deaths and 20 to 50 million injuries yearly are due to road crashes (WHO, 2013). Road crash deaths have been steadily decreasing in Australia since 2001 (WHO, n.d.). However, in Western Australia (WA) the road crash fatality rate remains high at 7.5/100,000 of the population (Office of Road Safety, 2013). Impaired driving, particularly driving under the influence of alcohol, contributes substantially to road crashes worldwide. High Blood Alcohol Concentration (BAC) is closely linked with an increased likelihood of causing or being involved in a fatal or injurious crash. Driving under the influence of illicit drugs also contributes to the road crash fatality rate. However, while it is well known that alcohol plays a clear role in fatal crashes, the involvement of drugs in road crashes is more complex in nature and their role in driver impairment, crashing and injuries is less clear. For example, the presence of illicit drugs in crash involved drivers does not necessarily mean the crash was caused by the drug. For most illicit drugs there is insufficient evidence to accurately describe the effect of a particular level of the substance on driving performance.

Two sources of information are generally used to investigate and report on illicit drug-driving. The first is road-side drug testing. Current road-side drug testing (RDT) practice in Australia determines the presence or absence of cannabis, amphetamines or ecstasy in oral fluid samples (Boorman & Owens, 2009; Wilson, 2012). As mentioned previously, the presence of any of the detectable drugs is indicative of recent use but not necessarily impairment. Victoria was the first Australian state to implement RDT in 2004, after which other Australian states including WA, followed. Amendment of the *WA Road Traffic Act 1974* in 2007 deemed driving under the influence of methylamphetamine, Methylenedioxymethamphetamine (MDMA or ecstasy) and Δ^9-tetrahydrocannabinol (THC) to be an offence (Wooley & Baldock, 2009). In Australia, RDT is a three step process. The initial drug screen detects the presence of any of the three detectable drugs within six minutes or so of screening an oral fluid sample. If the result is positive, a further sample is taken and screened at the breath and drug bus (Boorman & Owens, 2009; Wooley & Baldock, 2009). Finally, if this result is positive, the oral fluid sample (or in some cases a blood sample) is taken and sent to a laboratory for

further analysis. Samples that test positive lead to a driving with prescribed illicit drugs in oral fluid or blood conviction on the offender's record (Boorman & Owens, 2009; Wooley & Baldock, 2009). New legislation introduced in 2007 in Western Australia meant that if police suspect that a driver is impaired by drugs, they can perform a standardised road-side assessment. If positive, urine and blood samples can be collected and sent for toxicological analysis. A positive result could lead to a drug impaired driving conviction on the offenders record (Wooley & Baldock, 2009).

The second method used to investigate illicit drug-driving is the examination of crash fatality records. In Australia, Drummer and colleagues have conducted research using coroners' records and laboratory data to perform culpability analyses (Drummer et al., 2004) and to identify the incidence of drugs in fatally injured drivers (Drummer et al., 2003). In the WA component of these studies, data was obtained from the Perth Coroner's Office on drivers killed in road crashes between 1990 and 1992 and from 1995 to 1999. These data were then matched with records from the toxicology section of the Chemistry Centre. The most recent WA data set to be analyses included 757 fatally injured drivers. The study provided an insight into illicit drug driving in the 90's. However, since then, no study has examined in detail the contemporary state of illicit drug-driving in WA and the trend in this behaviour over the last decade or more.

1.2 Aims of the Study

The aim of this study was to investigate the problem of illicit drug-driving in Western Australia using two sources of data: Western Australian Police reports of the crashes and toxicology findings of fatally injured drivers/riders, and, WAPOL records of drivers/riders charged with illicit drugs in oral fluids offences. The specific objectives of the study were to:

1. Report the prevalence, trend and characteristics of illicit drug related motor vehicle driver and motorcycle rider fatalities over the period 2000-2012.
2. Statistically model the driver/rider and crash risk factors for an illicit drug involved fatality.
3. Report the prevalence, trend and characteristics of Section 64AC offences of the Western Australian Road Traffic Act (Driving with prescribed illicit drugs in

oral fluids) associated with Western Australian Polices' roadside drug testing program for prescribed illegal substances (e.g., THC, methylamphetamine, MDMA) during the period 2008-2012.

4. Statistically model the driver/rider risk factors for offence recidivism and multiple illicit substance use.

It should be noted that this study was not intended to be a statistical analysis of the culpability/responsibility of crashing drivers/riders who test positive for an illicit substance such as that undertaken by Drummer et al. (2004). This was beyond the scope of the study.

2 METHODS

2.1 Ethics approval

This research was undertaken with the approval of the Human Research Ethics Committee of the School of Public Health, Faculty of Health Sciences, Curtin University (approval SPH-60-2012). Application for all data was made to the Western Australian Police and approved by that organisation for release and use.

2.2 Literature search and retrieval

A review of the scientific literature published in Australia and elsewhere was undertaken. A literature search of databases including Medline, ProQuest, Current Contents, Google Scholar, Scopus, and Factiva was undertaken using 'key words' to retrieve local, national and international publications (scientific journal articles, reports, books, conference papers) relevant to the topic.

2.3 Definitions used in the report

In this report, a drug is classified according to the *WA Road Traffic Act 1974*:

- A drug which the *Misuse of Drugs Act 1981* applies; or
- A substance that is included in the *Poisons Act 1964* Schedule 4; or
- A substance (other than alcohol) that, when consumed or used by a person, deprives the person (temporarily or permanently) of any of the person's normal mental or physical faculties.

The main focus of this report is on those drugs which are currently routinely tested for by WAPOL. These prescribed substances include Cannabis (showing as THC), methylamphetamine and MDMA (ecstasy).

For this study, an illicit drug-related crash is defined as one where ChemCentre toxicology records for the fatally injured driver/rider confirm the presence of THC, methylamphetamine, MDMA (ecstasy) or any other substance the ChemCentre subsequently advised to be 'illegal' or prohibited. The level of the detected substance was of no consequence for the categorisation.

An illicit drug-related traffic offence is defined by the charging of a driver under Section 64AC of the Western Australian Road Traffic Act (*driving with prescribed illicit drugs in oral fluids*). Western Australia's 'zero tolerance' laws for these

substances means that the level of the detected drug is irrelevant to the prosecution of a driver. Furthermore, the detection of more than one prescribed substance does not alter the offence or the penalty.

2.4 Toxicology, crash and traffic offence data

2.4.1 Fatally injured driver/rider toxicology and crash data

The Coroners Act 1996 (WA) provides for the investigation of the death of motor vehicle drivers and riders. Part of this investigation includes the conduct of a toxicological assay of the driver/rider's stomach contents and blood to determine the presence of both licit (e.g., alcohol, caffeine, prescription medications) and illicit substances (e.g., Cannabis). This work is undertaken on behalf of the Coroner by the ChemCentre (formerly known as the Chemistry Centre). The toxicology records of motor vehicle drivers and motorcycle/moped riders killed during the period 2000-2012 were extracted from the ChemCentre's Laboratory Information Management Systems and forwarded to Western Australian Police to be linked with details of the fatal crash. As ChemCentre records do not share a unique identifying number with WAPOL's fatal crash records, the linkages were conducted by WAPOL staff of the Traffic Policy Unit (ST) using the name, age, and address of the driver and the date of the crash. De-identified linked toxicology and crash records were subsequently returned to the Curtin-Monash Accident Research Centre. Only those crash records defined as 'in scope' by WAPOL, that is, occurring on a gazetted road or public access road and excluding those deemed to be due to factors such as suicide or a health-related condition (e.g., heart attack) were subsequently analysed. Examples of the information contained in the linked fatality record are as follows:

- Road user status (motor vehicle driver; motor cycle rider)
- Driver/rider gender, age, license status (full, provisional, cancelled, suspended, no valid licence)
- Date, time, day, and location of the crash (WA region, police district, suburb, post code, street name)
- Features of the crash (lighting, road curvature, road use movement, crash type)
- Name and quantity of substance detected by the ChemCentre, including alcohol, prescribed illicit drugs and other illegal substances, and pharmaceuticals.

For the purpose of defining the fatality as illicit drug involved or otherwise, the ChemCentre (RH) collaborated with the investigators (PP) to classify all detected substances as 'illicit' or 'licit' and categorised each substance into broad drug groups (e.g., stimulants, benzodiazepines, opiates, anti-depressants etc.).

2.4.2 Traffic offence data resulting from roadside oral fluid testing

The Road Traffic Act 1974 WA contains two sections related to drugs and driving. The first, Section 63AB, relates to driving while impaired by drugs. This section is not specific to illicit substances per se; rather, the focus is on the impairment that can be attributed to a particular drug, irrespective of its legality. These offences were not the subject of this investigation.

Section 64AC of the Act is specific to the attempt to or act of driving a 'motor vehicle while a prescribed illicit drug is present in the person's oral fluid or blood' (page 104). This section of the Act does not require WAPOL to determine that the driver/rider was incapable of proper control of their vehicle as is the requirement in Section 63AB, but only that the illicit drug was present in oral fluid or blood. A second or subsequent offence will result in the driver being disqualified from holding or obtaining a driver's licence. These offences are the subject of this investigation.

Section 64AC offences most commonly result from WAPOL's roadside drug testing program that was introduced in 2007. This program is specifically geared toward the detection of THC (related to the use of cannabis), methylamphetamine (e.g., ice, crystal meth, crank) and MDMA (e.g., ecstasy). If the initial saliva test is positive for THC or methylamphetamine, the driver is then requested to undertake a confirmatory saliva test (known as Cozart testing). If this test proves positive, a saliva sample is then sent to the ChemCentre for confirmatory testing and the identification of the illicit substance. Drivers are only charged once the ChemCentre confirms the presence of at least one of THC, methylamphetamine or MDMA. The level of the detected substance or the number of substance detected is irrelevant to the laying of a charge.

Application was made to WAPOL for all Section 64AC traffic offences occurring during the period 2008-2012. Data from two sources were subsequently supplied.

Firstly, the Breath and Drug Operations unit (TS) supplied aggregated operational level data on the number of roadside oral fluid tests conducted per year of operation. Secondly, the Traffic Policy Unit (ST) extracted Section 64AC offence data from the WAPOL 'Briefcase' system. Multiple offences for drivers were identified through an applied 'case number'. All information that could result in the identification or re-identification of a driver/rider was deleted before being supplied to C-MARC for analysis. Examples of the information contained in this dataset are as follows:

- Driver age and gender
- Date of offence
- Location of offence (WA region, police district, suburb, postcode, road name)
- Cozart test result (THC, Methylamphetamine, MDMA)
- ChemCentre test result (THC, Methylamphetamine, MDMA)

2.5 Data management and analysis

Linked fatality and traffic offence data was supplied by WAPOL as .csv files and read into SPSS (Vers. 22) for cleaning, coding, and restructuring to create relevant variables for analysis. The data was analysed using descriptive and multivariate techniques to address the aforementioned research aims. The main outcome variables of interest were:

- Binary classification of the fatal crash as involving an illicit substance=1 or no illicit substance=0
- Annual rate of detection of an illicit drug among fatally injured drivers/riders per 100,000 motor vehicle driver licences issued in Western Australia
- The type and number of illicit substances detected in fatally injured drivers/riders
- Annual rate of Section 64AC offences per 100,000 motor vehicle driver licences issued in Western Australia and per 1,000 roadside oral fluid tests conducted
- Binary classification of drivers/riders as repeat/recidivist=1 or single=0 Section 64AC offenders for the period
- The type and number of illicit substances detected for drivers/riders charged with a Section 64AC offence for the period

2.6 Structure of the report

Chapter Three of the report provides a review of the literature related to drugs and driving. In Chapter Four, the results of the analysis of linked fatal crash and toxicology records are presented. This is followed in Chapter Five with the presentation of the results of the analysis of Section 64AC traffic offence data. Chapter 6 concludes the report with a discussion of the findings of both analyses and the presentation of recommendations for future research, policy and practice related to illicit drugs and driving.

3 LITERATURE REVIEW

Driving under the influence of illicit drugs is a significant road safety issue worldwide. There are many factors which contribute to and exacerbate the illicit drug driving problem, such as poly-drug use and driver attitudes and risk perceptions. By understanding these factors, recommendations can be more accurately targeted to the problem at hand. Firstly, the effects of illicit drugs on driving are discussed.

3.1 The effects of illicit drugs on driving

Experimental studies examine the effects of illicit drugs on driving performance using driving simulator technology, which is a safe and effective way of examining the effects of specific drugs alone or in combination. Many studies have reported on the negative impact of THC on driving behaviours such as reaction-time, attention, tracking, time and distance perception, steering, speed and lateral positioning (see Kelly, Darke & Ross, 2004 for a review), although the effects of ecstasy on driving performance are less clear. While some evidence suggests ecstasy can produce psychomotor and cognitive impairment (Kelly et al., 2004), others have found that a single low dose of ecstasy improved road-tracking performance but decreased car-following performance compared to the placebo group (Ramaekers, Kuypers, & Samyn, 2006). The low dose of ecstasy used for the study to remain ethical is unlikely to reflect the dose used by regular or recreational users of the drug and may not be an accurate representation of the actual driving performance deficits that would be expected. Drivers using compensatory behaviour to counter the effects of the drug are also a limitation of simulator studies and could explain some of the inconsistencies.

Ecstasy and many other illicit drugs are often used in conjunction with alcohol (Barrett, Gross, Garand, & Pihl, 2005). The effects of ecstasy and alcohol combined have not been shown in driving simulator studies. However, a recent double-blind, placebo-controlled simulator study by Downey et al. (In press) showed that the combined effects of alcohol and cannabis significantly compromise driver performance, particularly at night-time. Ramaekers, Robbe, and O'Hanlon (2000) also reported significantly compromised driving ability when alcohol and cannabis were combined, even when low levels of both alcohol and drugs were present.

Further research is needed to identify if this is also the case for other illicit drug/alcohol combinations.

3.2 Factors contributing to the problem

3.2.1 Combining drugs and alcohol

It is generally accepted that illicit drugs of any kind will negatively impact driving ability, particularly when combined with alcohol. As poly-drug use is often reported by drug users (Barrett et al., 2005; Kuypers, Samyn, & Ramaekers, 2006; Laumon, Gadegbeku, Martin, Marie-Berthe, & The S. A. M. Group, 2005), this is a significant concern for road safety due to the increased crash risk caused by combinations of illicit drugs and alcohol. A study conducted in the USA using a large sample of fatally injured drivers reported 20% of drivers were positive for multiple drugs, including alcohol (Brady & Li, 2012). Poly-drug use was particularly high in Native Americans and varied significantly depending on driver characteristics. Therefore, the high prevalence of poly-drug use in the USA may be different to other demographics.

3.2.2 Risk perception

Perceptions of driving impairment also contribute to the illicit drug driving problem, particularly as some drug users believe that they become better drivers under the influence of drugs (Forward, 2010). In a cohort of drug users in Australia, one third of those that had driven under the influence of cannabis, ecstasy or methylamphetamine believed that the drug had no effect on their driving ability, 16% - 19% believed the drug slightly improved their driving ability and 1% - 3% believed it was quite improved (Matthews et al., 2009). In Queensland, a similar belief was observed in drug users (Davey, Davies, French, Williams, & Lang, 2005). In Western Australia, 59% of injecting drug users who had driven a vehicle in the past six months reported that illicit drug consumption had no impact on their driving ability (Rainsford & Lenton, 2012). It is interesting to note that 35% - 44% of participants believed that DUID was likely or very likely to result in a traffic accident, whereas 76% - 87% agreed with the same statement for driving under the influence of alcohol (Matthews et al., 2009; Swift, Jones, & Donnelly, 2010), a perception prevalent amongst the general population (Kelly et al., 2004). Further analysis indicated that those who had not DUID were more likely to rate the

likelihood of having a traffic accident whilst under the influence of drugs to be likely or very likely ($p < .001$) (Matthews et al., 2009). Broadly speaking, there is a perception that illicit drugs are believed to have less of an impact on driving ability than alcohol amongst both illicit drug users and the general population.

3.2.3 Recidivism

Previous arrests for DUI are strongly linked with recidivism (Impinen et al., 2009), while those with a DWI conviction in the previous three years were more likely to be involved in drug-related fatal crashes (Brady & Li, 2012). In fact, it has been reported that those who drive under the influence of drugs have higher recidivism rates than those who drive under the influence of alcohol. In the questionnaire component of the US NRS study, 47 daytime drivers indicated that they have been arrested for DUI alcohol or drugs in the past 12 months and 28.9% of these were drug positive when oral fluid was tested (Lacey et al., 2009). 234 night time drivers also indicated that they had been arrested for DUI alcohol or drugs in the past 12 months (Lacey et al., 2009); 29.1% of these had a drug positive oral fluid sample (Lacey et al., 2009). Overall, drivers who answered 'yes' to having been arrested for DUI in the past 12 months were more likely to test positive for illegal drugs than any other drug category (i.e. medications) (Lacey et al., 2009). Frequent drug drivers accounted for 53.3% of those who reported at least one driving conviction (Albery, Strang, Gossop, & Griffiths, 2000) compared with those who never or sometimes drove after taking illicit drugs in the past 12 months.

3.2.4 Summary of factors contributing to the problem

It is important to be aware of the factors contributing to DUID so that treatment, reinforcement and education programs can be tailored to target those at high risk of DUID. Recidivism levels are high in those who DUID and perceptions of impairment whilst driving under the influence of drugs are generally consistent, where drivers who had driven under the influence of drugs believed that the drugs had little to no effect on their driving ability. This increases the likelihood that they are likely to drive whilst under the influence of an illicit drug, alone, or combined with alcohol.

3.3 Prevalence and incidence of illicit drugs and driving

3.3.1 Sources of information

Two sources of information were used to document the incidence and prevalence of illicit drug driving: self-report surveys/questionnaires and roadside data, which includes traffic offence rates and crash rates. These sources of information come with their own unique methodological limitations. The majority of studies which document the prevalence of illicit drug driving rely on self-report, which is subject to some bias and therefore decreases the reliability and validity of such data. With roadside data, if a driving offence is attributed to alcohol in the first instance, drivers are not typically tested for the presence of illicit drugs, which may also provide an underestimation of the prevalence of illicit drug driving, and more-so poly-drug use, which is known to be common. Methodological issues related to the use of crash data are generally limited to two factors; the time period between blood sampling and the actual crash, and whether an illicit drug is listed in the crash data if alcohol is deemed as over the limit in the first instance.

To present the nature of the illicit drug driving problem fully, it is necessary to first describe illicit drug use in the general population.

3.3.2 General population

In Australia, household surveys are conducted annually by the Australian Institute of Health and Welfare (AIHW) to report on, amongst other things, illicit drug use in the general population. Overall, results show that illicit drug use increased in 2010 mainly due to the increase in cannabis use since 2007 (9.1% to 10.3%), cocaine use (1.6% to 2.1%) and hallucinogen use (0.6% to 1.4%). Respondents reported the following regarding cannabis use in the twelve months preceding the survey (2011a):

- 20.9% of people who had used cannabis in the previous twelve months used the drug once a week or more; and
- 34.6% used the drug once or twice.

Overall, cannabis use was highest in the Northern Territory (16.5%) and Western Australia (13.4%). Ecstasy use was second only to cannabis and was used by 3% of people in the past 12 months (AIHW, 2011a). However, ecstasy use significantly

decreased between 2007 and 2010, in comparison to cannabis (AIHW, 2011a), an opposite trend to that seen in Europe and the United States (UNODC, 2012). Furthermore, one in ten of those ever having used ecstasy in the 20 - 29 year age group (in which use was highest), had used the drug in the previous 12 months (AIHW, 2011a). State-wide, Western Australia had the highest ecstasy use rate (AIHW, 2011a).

In Australia, methylamphetamine use decreased from 9.8% to 6.8% between 2007 and 2010 for males aged between 20 - 29 years, however this age group were still the most prevalent users (AIHW, 2011a). Similar to ecstasy use, Western Australia had the highest use rate for methylamphetamines (AIHW, 2011a). Cocaine, hallucinogens and inhalants have varied patterns of global use. In Australia the use of heroin, hallucinogens, ketamine, GHB and inhalant drugs were small (AIHW, 2011a). However, there was a statistically significant increase in the use of hallucinogens between 2007 and 2010 (AIHW, 2011a), no change in the use of heroin, ketamine or GHB and negligible changes in the use of inhalants.

3.3.3 Young people

University students are a common study population used for illicit drug studies due to the high incidence of drug use within the student population. While somewhat lower rates of DUID have been reported in the student population, (16 - 17% of university students in the mid-Atlantic region) (Arria, Caldeira, Vincent, Garnier-Dykstra, & O'Grady, 2011), prevalence is still higher than that reported in the general population. In Ontario, Canada, 19.7% of students interviewed reported driving within one hour after cannabis consumption (Adlaf, Mann, & Paglia, 2003). One study involving 331 university students in Queensland Australia found that 55% had used drugs in their lifetime, 30.8% of which had done so in the last 12 months, with marijuana being the most common drug of choice (Armstrong, Wills, & Watson, 2005). An additional 14.6% had driven whilst under the influence of both alcohol and drugs combined (Armstrong et al., 2005).

3.3.4 Drug users

Although population surveys indicate drug driving prevalence is not particularly high and often varies in the general population, self-report studies often bring attention to concerning rates of driving under the influence of illicit drugs (DUID) in

high-risk populations, such as, for example, recent and/or out of treatment drug users. Out-of-treatment illicit drug users in the United Kingdom reported high levels of drug driving; 81.7% had driven under the influence of drugs, most commonly whilst under the influence of heroin or cannabis (Albery et al., 2000). In three studies involving Australian drug user populations, as many as 88% of the study participants had reported driving whilst under the influence of an illicit drug in the past 12 months (Darke, Kelly, & Ross, 2004; Davey et al., 2005; Jones, Donnelly, Swift, & Weatherburn, 2006). It was not uncommon for these populations to participate in drug driving monthly (59% (Darke et al., 2004), or even weekly (26.9%) (Jones et al., 2006). The prevalence of illicit drugs is relative to the population studied, e.g., the study by Jones et al. (2006) consisted primarily of recent cannabis users. The broader recruitment strategy used in the study by Davey et al. (2005) was reflected in more varied drugs of choice used by drivers: 41% had driven whilst under the influence of amphetamines while 42% and 21% had driven under the influence of heroin and ecstasy in the past 12 months, respectively (Davey et al., 2005).

Other populations which have been investigated in the literature in terms of drug driving prevalence include dance event attendees and police detainees, both of which report high levels of illicit drug driving (Duff & Rowland, 2006; Poyser, Makkai, Norman, & Mills, 2002).

3.3.5 Drivers

General population surveys such as the 2011 Substance and Mental Health Services Administration (SAMHSA) survey conducted in America showed that 4.2% of respondents had driven under the influence of illicit drugs in the past year (SAMHSA, 2011). In Australia, the number of people driving a vehicle whilst under the influence of illicit drugs decreased significantly in 2010 but driving was still the most commonly performed illicit drug-related activity (18%, or 1 in 5 people) (AIHW, 2011b). Further, the AAMI Young Driver Index report for 2012 stated that 7% of young drivers in Australia admit to driving after having taken illicit drugs (AAMI, 2012).

A more reliable method to determine the prevalence of illicit drug driving is random roadside drug testing. A study in Scotland, Great Britain tested the oral fluid of randomly selected drivers passing through high accident sites (Wylie, Torrance, Seymour, Buttress, & Oliver, 2005). Analysis revealed that 16.8% of drivers tested positive for one drug. Of this group, 84.7% used a single drug, while 15.3% were cases of poly-drug use (Wylie et al., 2005). Similarly, the 2007 US National Roadside Survey (NRS) involved randomly stopping drivers at 300 locations across 48 US states (Lacey et al., 2009). Oral fluid testing revealed that overall, 16.3% of drivers tested positive for illicit drugs (Lacey et al., 2009). Much lower rates of illicit drug detection were reported in Queensland Australia: 3.5% of the 781 motorists in the sample whose oral fluid was tested were positive for at least one drug (Davey et al., 2005). Cannabis (n=13 drivers) and amphetamines were most commonly detected (n=11 drivers) (Davey et al., 2005). Another Australian study of illicit drugs in the oral fluids of over 13,000 randomly selected drivers in Victoria found that 2.4% tested positive for methylamphetamine, THC or MDMA (Drummer et al., 2007). The majority of positive tests for drivers of all vehicle types were for methylamphetamine followed by MDMA. These findings likely underestimate the prevalence of illicit drugs in this group of randomly selected drivers since drivers who initially tested positive for alcohol were not drug tested.

Other studies evidencing drug detection rates as high as 96% have been reported in Victoria (Chu et al., 2012). Methylamphetamine was the most commonly found drug (77%), with 42% of drivers testing positive for THC and 17% positive for MDMA (Chu et al., 2012). The high level of drug positive results in the oral fluid samples sent for laboratory testing shows the high reliability of roadside drug testing for the main target drugs, which were, as expected the most prevalent drugs in all 853 samples (Chu et al., 2012).

There are three instances where drivers' bodily fluids are routinely tested for the presence of illicit drugs: where there is suspicion of DUI (direct police observation); where a driver presents to an emergency department due to a road traffic accident; and/ or where a driver is fatally injured in a road traffic accident. The following sections of the report document the prevalence of illicit drugs in each of the three scenarios, locally, nationally and elsewhere.

3.3.6 Drivers suspected of driving under the influence

Two recent studies have shown high levels of illicit drug use in drivers suspected of DUI. A large-scale toxicological analysis of blood and urine samples tested for n=22,777 drivers apprehended for suspected DUID in Sweden during 2001 to 2004 found that at least one banned substance was present in 80-85% of cases (A. Holmgren, Holmgren, Kugelberg, Jones, & Ahlner, 2007). The high level of drugs found in blood and urine samples of those drivers apprehended for suspected DUI reflects the increased vigilance of the Swedish police in apprehending DUI drivers. Similarly in Switzerland, 89% of blood samples analysed from drivers suspected of DUID had at least one psychoactive substance present, with cannabis and alcohol being the two most commonly detected substances (Senna et al., 2010). González-Wilhelm (2007) also reported on the prevalence of certain substances amongst drivers suspected for DUID. As can be seen in Table 3.1, the most commonly detected illicit drug was cannabinoids, second only to alcohol (González-Wilhelm, 2007).

Table 3.1 Prevalence of substances in suspected DUI drivers

	Population	
Substance	Drivers primarily suspected of DUI alcohol (%)	Drivers primarily suspected of DUI drugs (%)
Alcohol	88.1-95.5	25.8-49.2
Cannabinoids	2.4-13.8	26.1-59.3
Cocaine	0.0-3.3	1.4-12.5
Opiates	0.0-1.4	7.2-26.0
Amphetamines	0.0-2.7	4.6-21.1

(Modified from: González-Wilhelm, 2007)

In the study by Senna et al. (2010) which investigated drug prevalence in Switzerland after the introduction of zero tolerance laws, drivers who were apprehended by police due to some form of erratic driving behaviour or tested at roadside accounted for 64.6% of DUID cases (Senna et al., 2010). At least one psychoactive substance was found in 94% of cases overall, although there was no separate prevalence reported for accident versus non-accident related drug driving (Senna et al., 2010).

A study conducted across England and Wales of 295 drivers suspected to be drug impaired found that cocaine was the most prevalent illicit drug, present in 92 blood samples or 31.2% (Burch, Clarke, Hubbard, & Scott-Ham, 2013). However, its metabolite, benzoylecgonine, was also included in this calculation. Therefore cocaine was not quantified alone, which should be considered upon interpretation of this result. Other illicit drugs which were found in blood samples were amphetamines, which were detected in 39 samples and MDMA, which was detected in 8 samples (Burch et al., 2013).

There is some information on drivers apprehended by the police for suspected DUI in Australia. Research conducted on a sample of Western Australian drivers in 1996 showed that of the 513 drivers apprehended, 78 (15.2%) were positive for cannabis, 19 (3.7%) were positive for opioids and 25 (4.9%) were positive for stimulants (Poyser et al., 2002). This is significantly lower than studies conducted internationally. However, the study was conducted in 1996 and drug testing has come a long way since then. It is unlikely that the study accurately reflects the current state of those DUID in WA and further research is warranted to investigate this.

As expected, the prevalence of drugs in drivers apprehended for suspected DUI is high, particularly in countries where zero-tolerance laws have been implemented. The prevalence of drivers suspected of DUI is much lower in Australia than internationally, although recent research in WA regarding this issue is lacking.

3.3.7 Crash involved drivers

3.3.7.1 Crash risk

It is well known that young drivers, particularly males and drivers under the influence of alcohol and various medications are at an increased risk for a road traffic crash. In illicit drug road safety research, early crash studies have highlighted an increased likelihood of drivers under the influence of illicit drugs as being culpable (Drummer et al., 2004; Laumon et al., 2005). Marijuana users in particular are more than twice as likely to be involved in a motor vehicle crash (Ashbridge, Hayden, & Cartwright, 2012; Li et al., 2011). Further, Bedard, Dubois, and Weaver (2007) reported that drivers that tested positive for cannabis alone had a 29% increased risk of driving in such a way as to contribute to a crash, compared to those

who were not under the influence of cannabis. However, one study reported no association between cannabis use alone and an increased crash risk (Movig et al., 2004). Due to many influencing factors a causal relationship is difficult to determine, particularly with high rates of poly-drug use reported in the literature. Poly-drug users are at a six-fold increased risk of vehicle crashes requiring hospitalisation, and those under the influence of drug and alcohol combinations also have a higher risk level compared with singular drug or alcohol use alone (Brookhuis, Waard, & Samyn, 2004; Drummer et al., 2004; Kelly et al., 2004; Movig et al., 2004; Schulze, Schumacher, Urmeew, & Auerbach, 2012).

Other crash-culpability studies, such as Kuypers, Legrand, Ramaekers, and Verstraete (2012), reported an odds ratio (OR) for any concentration of cannabis between 1>5 ng/mL to be statistically significant ($p < .001$). They also reported that the concentration at which crash risk was significantly increased was 2 ng/mL. For amphetamines, the same study reported an OR of 54.82 ($p < .001$) for the risk of a crash (Kuypers et al., 2012). Odds ratios for multiple drugs have also indicated an increased crash risk (Kuypers et al., 2012). For example, the DRUID project reported an aggregated estimate of 18.51 (CI: 10.84 – 31.63) for the likelihood of being killed when positive for multiple drugs (Schulze et al., 2012). Large variations in confidence intervals reflect large variances between countries from which data was aggregated.

3.3.7.2 Non-fatal crashes

The prevalence of illicit drugs in non-fatal crashes is often investigated when injured drivers present to a hospital emergency departments or trauma units due to some form of injury sustained due to a road traffic accident. The analysis of blood samples drawn from the driver is most common, but samples of urine, oral fluid and sweat are sometimes also examined. This was the case in Spain where 387 drivers presenting to an emergency department due to a road traffic crash were analysed for the presence of psychoactive substances (Santamariña-Rubio et al., 2009). Results showed that cannabis was second to alcohol in being the most prevalent substance used by those who were injured in road traffic accidents. Seventeen percent of men and 3.8% of women had used the drug within the past 6 hours (Santamariña-Rubio et al., 2009). Cocaine was also prevalent, where 7.2% and 3.8% of men and women

respectively were positive for the drug (Santamariña-Rubio et al., 2009). Given the relatively small sample size of this study, results should be interpreted with some caution.

Also in Europe, Mura et al. (2003) investigated the prevalence of drugs and alcohol in injured drivers presenting to emergency departments in six university hospitals. Blood samples of 900 drivers and 900 controls were analysed and the results showed that among drivers and controls who tested positive for cannabis, 60% were positive for THC alone, while 32% were positive for both THC and alcohol (Mura et al., 2003). The overall prevalence of THC alone and with other substances was 9.5% for drivers and 2.2% for controls (Mura et al., 2003). Case-control studies are limited in the illicit drug driving literature and Mura's study may also be limited because the controls may not be an accurate representation of the general driving population. However, the study does provide evidence that there is a positive relationship between these substances, alone or in combination, and an increased risk for a crash.

Investigation of the presence of illicit drugs in seriously injured drivers across six European countries (Belgium, Denmark, Finland, Italy, Lithuania and the Netherlands) found that 45 samples were positive for amphetamine, 36 samples were positive for cocaine and 68 samples were positive for THC (Legrand, Isalberti, et al., 2013). The prevalence range of amphetamines was 0.1% - 4.2%. Cannabis prevalence ranged from 0.5% to 7.6% across the six countries. Cannabis was overall the most common illicit drug (Legrand, Isalberti, et al., 2013). Studies involving multiple countries highlight well the individual prevalence rates of illicit drugs and the variation between closely related countries (such as those in Europe). This highlights the difficulties in directly comparing prevalence rates and determining an accurate overall prevalence rate for illicit drugs, when the variability is so large across closely related countries.

An early study conducted in Canada investigating alcohol and drug use in drivers presenting to a trauma unit between 1986 and 1989 again reported that cannabinoids were the most prevalent drugs, accounting for 14.6% of injured drivers who were screened for drugs (Stoduto et al., 1993). Cocaine was also present in 5.5% of injured drivers (Stoduto et al., 1993). In America, an early study of drivers admitted to trauma units at two centres in 1990 reported that 132 patients (22.6%) had a

positive urine drug screen and cocaine was the most commonly found illicit drug, found in 51 patients (8.7%) (Orsay, Doan-Wiggins, Lewis, Lucke, & Ramakrishnan, 1994). Another study also conducted in the USA found that 13.8% of injured drivers presenting to trauma centres tested positive for cannabis or marijuana (Waller et al., 1997) but the majority did not have alcohol or drugs present.

Australian studies have the advantage over those conducted internationally in that they have substantially larger sample sizes. Both studies included in this review, one conducted in Victoria and one conducted in South Australia had sample sizes of 1714 and 2500 respectively, and reported on the prevalence of drugs in injured drivers. In Victoria, the prevalence of THC in injured drivers presenting to a trauma unit was 9.8% (Drummer et al., 2012). In South Australia, the most prevalent illicit drug type was cannabinoids (7.1%) which was second to alcohol (8.6%) (Longo, Hunter, Lokan, White, & White, 2000a). However, 75% of the study population tested negative for both alcohol and drugs (Longo et al., 2000a). Although the sample is large and representative, collection methods used for blood samples included a substantial delay between the time of the crash and the collection of the blood sample. Therefore, there would have been some change in blood-related constituents which may have influenced the high level of non-alcohol and non-drug use in injured drivers reported in this study.

3.3.7.3 Summary of illicit drug-related injury crashes

Internationally, cannabis undoubtedly stands to be the most prevalent illicit drug in non-fatally injured/ hospitalised drivers. This is consistent with the drug also being the most commonly used drug in the general population. Interestingly, cocaine was also often present in many injured drivers internationally, a drug which is not currently tested at roadside in Australia. Cannabis is the most prevalent illicit drug in drivers presenting to emergency hospital departments or trauma units both internationally and in Australia. The prevalence of cannabis in injured drivers across studies ranged from 7.1% to 13.8%. A summary of the studies investigating the prevalence of illicit drugs in injured drivers/non-fatal crashes is provided in Table 3.2.

Table 3.2 Summary of illicit drugs found in injured drivers

Study location and year	Sample size	Verification	Most common illicit drugs	Reference
Spain, 2005-2006	387	Oral fluid and sweat	Cannabis	(Santamariña-Rubio et al., 2009)
Canada, 37 months	854	Blood and/or urine	Cocaine	(Stoduto et al., 1993)
USA, 1992-1994	894	Blood	Cannabinoids (14.6%) Benzodiazepines (11.2%) Cocaine (5.5%)	(Waller et al., 1997)
France, 2000-2001	900	Blood	Cannabis	(Mura et al., 2003)
Victoria, Australia July-Nov 2009	1,714	Blood	Cocaine	(Drummer et al., 2012)
South Australia, 1995-1996	2,500	Blood	Opiates	(Longo et al., 2000a)

3.3.7.4 Fatal crashes

There is a growing need for the investigation of illicit drugs in fatally injured drivers to allow better understanding of the contribution of illicit drugs to fatal crashes. In most cases, it is not routine practice to test for the presence of illicit drugs and those studies which do investigate the presence of illicit drugs in fatally injured drivers are often subject to variability in methods. Despite these differences, it can be seen from Table 3.2 that cannabis is the most commonly found illicit drug in injured drivers worldwide, although amphetamines are also common in European countries. Early studies estimated that 0.3% - 9.8% of fatally injured drivers tested positive for cannabis (Macdonald et al., 2003), while a more recent systematic review by González-Wilhelm (2007) reported a prevalence of 0.7-13.2%.

Most studies reveal a high prevalence of poly-drug use in illicit drug-related fatal crashes. Gjerde's et al. (2011) analysis of the toxicological results of fatally injured drivers in Norway between 2006 and 2008 found that illicit drugs were present in 10.2% of drivers. Further, 5.1% of fatally injured drivers were positive for alcohol and drugs, while 6.1% tested positive for multiple drugs and no alcohol (Gjerde et al., 2011). Legrand, Gjerde, et al. (2013) investigated the prevalence of illicit drugs in drivers killed in four European countries - Finland, Norway, Portugal and Sweden - between 2006 and 2009. A large sample size of

1118 was analysed. They found that amphetamines were present in 2% - 7% of drivers across the four countries. Cannabis prevalence was 1.3% - 6% (Legrand, Gjerde, et al., 2013). The prevalence for combinations of drugs across the four countries was 0.4% - 8% (Legrand, Gjerde, et al., 2013). A study conducted in the UK reported that 4% of all fatal crashes involved drugs (Clarke et al., 2010). However, toxicological investigations were not always undertaken; therefore this is likely to be an under-representation. In Kuala Lumpur, post-mortem files from 2006-2009 were analysed to determine the prevalence of illicit drug driving (Norlen et al., 2012). Eleven percent of drivers were positive for illicit drugs. Opiates were the most prevalent illicit drug class found in fatally injured drivers (5.4%). Unlike other studies, the prevalence of cannabis in fatally injured drivers was low in comparison (1.02%) (Norlen et al., 2012). A seven year database study conducted in Canada by (Beasley et al., 2011) revealed that 33% of fatally injured drivers who were tested for the presence of illicit drugs were positive. However, drug categories were broad (i.e. Central Nervous System (CNS) stimulants, CNS depressants) and the number of drug tests performed were relatively low compared to tests performed for alcohol (Beasley et al., 2011).

In Australia, a ten year study of 3,398 drivers killed in motor vehicle crashes in Victoria, WA and NSW reported that 23.5% of drivers involved in a fatal crash had drugs present, compromising 13.5% cannabinoids, 4.9% opioids, 8.2% stimulants and benzodiazepines (Drummer et al., 2003). Many of these cases involved poly-drug use, the most prevalent combination was that of illicit drugs and alcohol (9.3%) (Drummer et al., 2003).

3.3.7.5 Summary of the involvement of illicit drugs in fatal crashes

Cannabis contributes largely to illicit drug-related fatal crashes worldwide, although amphetamines also contribute substantially in European countries such as Norway, Sweden and France. Research conducted in 2003 shows that Australia is generally consistent with the high prevalence of cannabis in illicit drug-related fatal crashes.

There are some limitations which should be considered when interpreting illicit drug-related studies in an attempt to present an overview of the relationship between illicit drugs and driving. Presence of many illicit drugs in bodily fluids does not necessarily imply that the driver was impaired at the time of a fatal crash. This is

particularly the case for metabolites of cannabis, which remains in the blood for many hours/days after inhalation or ingestion. In many studies, there are inconsistencies in the recording of drug types although categorisation of drugs into broad categories appears to be for ease of reporting. Also, there is a wealth of studies focused specifically on cannabis than there are studies for any other drug.

3.4 Characteristics of illicit drug related crashes and involved drivers

3.4.1 Crash and environmental characteristics

3.4.1.1 Crash type

Crash type is commonly investigated in regard to single or multiple vehicle involvement. There is conflicting evidence in the literature regarding which crash type drug involved drivers are most commonly involved in. While there is substantial evidence that drivers are significantly more likely to test positive for drugs, alcohol or a combination of the two if involved in a single rather than multiple vehicle crash (Biecheler, Peytavin, the S. A. M. Group, Facy, & Martineau, 2008; Brady & Li, 2012; Cheng et al., 2005; Gjerde et al., 2011; P. Holmgren et al., 2005; Legrand, Gjerde, et al., 2013; Longo, Hunter, Lokan, White, & White, 2000b; Marowitz, 1994; Mura et al., 2003; Orsay et al., 1994; Waller et al., 1997), more recent studies have reported that multiple vehicle crashes more often involved drug drivers (Beasley et al., 2011; Norlen et al., 2012) or that drug drivers were equally represented in both single and multiple vehicle crashes (Mørland et al., 2011; Poulsen et al., 2012).

Although one study has reported an increased risk for injured drivers to be involved in a multiple vehicle crash when THC was found in the blood (Longo et al., 2000a), the evidence around crash type is generally limited to broad observations on whether drugs were involved in the crash or not, as opposed to which specific drugs are linked to certain crash types. This may due to the high prevalence of poly-drug use reported in non-fatally injured and fatally injured drivers and the difficulty in identifying the effects and/or contribution of specific drugs.

3.4.1.2 Vehicle type

In Hong Kong, motorcycles and private cars were the most common vehicle types involved in illicit drug related fatal crashes (Cheng et al., 2005). In Canada, automobiles accounted for 58.2% of fatal crashes involving illicit drugs, while pick-

up trucks, light trucks, motorcycles, vans and bicycles accounted for 11%, 5.9%, 9%, 5%, and 2.7%, respectively. Other vehicles such as buses, mopeds, tractors and heavy vehicles contributed less than 2% each (Beasley et al., 2011). Of the 855 blood samples analysed by Holmgren et al. (2005), car drivers predominated in deceased drivers. Motorcycles were the next most common (Holmgren et al., 2005). In Switzerland, car drivers were the most predominant DUID cases, accounting for 87% of the study population (Senna et al., 2010). Automobile drivers predominated in the study by Orsay et al. (1994), where a resounding 90.7% of those with a positive alcohol or drug screen presenting to the trauma units drove cars. The rest, (9.3%) were motorcyclists (Orsay et al., 1994). A distinction between alcohol impaired and drug impaired drivers was not made. However, 22.6% had a positive drug screen, while 32% were legally drunk, which suggests that drug impaired drivers were less represented in both groups. In Australia, Drummer's study found that in the group testing positive for the highest level THC only (n = 49), there were 35 (71.4%) car drivers, 13 (23%) motorcyclists and one truck driver. (Drummer et al., 2003). In those positive for cocaine or its metabolite, four were car drivers and one was a motorcyclist (Drummer et al., 2003).

As expected, vehicle types most often involved in illicit drug-related crashes are cars, although the involvement of motorcycles is also relatively common, particularly in THC positive fatally injured drivers in Australia.

3.4.1.3 Time and day

In Kuala Lumpur, Norlen et al. (2012) found that most substance-related crashes occurred between 0400 and 0559 hours (20.3%), followed by 0200 and 0359 (19.6%). However, no differentiation was made between alcohol and illicit drugs. This is important to note, as when studies do differentiate between alcohol and illicit drug impairment, different times of the day are often reported depending on the impairment type. For example, a recent report for the Canadian Centre on Substance Abuse found that in fatally injured drivers, 27.3% of combined alcohol and drug use occurred in crashes that between 12am and 6am, whereas drug use alone was most common in fatal crashes which occurred between 6am and 12pm (24.9%) and between 12pm and 6pm (22.8%) (Beasley et al., 2011).

Particularly high levels of substance use have also been reported in fatally injured drivers in European countries where crashes have occurred on weekends and at night. Legrand, Gjerde, et al. (2013) reported that up to 80% of drivers in Finland, Norway and Portugal who were killed in road traffic crashes at night and on the weekend were positive for some form of psychoactive substance. Conversely, in Sweden, 60% of drivers died in crashes also on the weekend and at night, but fatal crashes involving psychoactive substances were more prevalent when the crash occurred during a week night (Legrand, Gjerde, et al., 2013). Another study which is inconsistent with the findings reported in Finland, Norway and Portugal investigated illicit drugs in drivers injured in car crashes on the weekend. They found that of the 211 injured drivers, only 6.6% tested positive for drugs alone (Schepens et al., 1998). It can be seen that there is some variation regarding when illicit drug-related crashes occur, fatal or otherwise. Furthermore, the nature of the illicit drug it is not always specified during these times.

In Kuala Lumpur drivers who test positive for substance use, whether alcohol, drugs or both were more likely to have died in a fatal crash which happened on Saturday (20.3%), Sunday (17.5%) or Wednesday (16.1%) (Norlen et al., 2012). In regards to THC specifically, Biecheler et al. (2008) reported that fatal crashes were more likely to occur during weekdays at any time of day, but more likely afternoons, as opposed to drivers who were under the influence of cannabis and alcohol, where crashes occurred on weekends, at night, between the hours of 9pm and 7am, similar to findings reported by (Beasley et al. (2011)) described above. An early study by Waller et al. (1997) found no time and day relationship for crashes where the driver was DUID alone.

Time and day are important crash characteristics to inform best practice for roadside drug testing to apprehend or deter the highest number of illicit drug drivers possible. Studies which are performed during the daytime hours may underestimate the real prevalence of illicit drug driving and crashes, while night time studies, particularly those conducted on the weekend may overestimate.

3.4.1.4 Use of seat-belt

It is not surprising that in general, seat-belt use is lower in drug drivers, which thus increases the risk of a more serious injury in the event of a crash. An early study by

Waller et al. (1997) reported a significant difference in seat-belt use between drivers who had used drugs with or without alcohol (43.3% used a seat-belt) compared to those who used neither alcohol nor drugs (77.8% used a seat-belt) ($p < 0.001$). Two recent studies reported that seat belt use was significantly lower in crashes where the driver tested positive for drugs (Beasley et al., 2011; Romano & Voas, 2011). This is also the case at the roadside: Lacey et al. (2009) found that the prevalence of drugs was significantly higher in those who did not wear a seat belt ($p < .01$). A more detailed look at use of a seat belt by drug class revealed that marijuana users were significantly more likely not to use a seat-belt during the day ($p < .01$) (Lacey et al., 2009). This is consistent with the time/day findings of Biecheler et al. (2008) described above where fatal crashes involving drivers who tested positive for THC were more likely to occur in the afternoons. Orsay et al. (1994) reported that impaired motorists were less likely to use a seat-belt than those who were unimpaired (22.8% and 38.7% respectively). Again, no distinction was made between the kind of impairment (i.e. alcohol or illicit drugs).

3.4.1.5 Speed

In a study conducted by Romano and Voas (2011), 25.5% of those speeding were drug positive compared with 21.2% who were not speeding, a difference that was statistically significant. Speed was also more likely to be noted as a contributing factor to a fatal crash in drivers that tested positive for cannabis (Bedard et al., 2007). The crude odds ratio between DRFs and cannabis was 1.39, meaning that a driver who was positive for cannabis was 1.39 times more likely to have contributed to the fatal crash. The adjusted odds ratio was 1.29 (Bedard et al., 2007). Unfortunately, besides brief mentions in these two studies, there is little further evidence regarding speed and illicit drug-related crashes.

3.4.1.6 Road type

Clarke et al. (2010) reported that impaired crashes are often 'loss of control' crashes occurring on a curve. However, a distinction between drug-related or alcohol-related loss of control crashes was not made. Beasley et al. (2011) reported that curved but level roads accounted for 17.6% of fatal crashes involving alcohol or drugs, and curved roads with a gradient accounted for 12.2% of fatal crashes (Beasley et al., 2011). Drug driving only contributed to a small percentage of the fatalities however,

as police reports only attributed a fatal crash to illicit drugs in 2.6% of cases, compared to 26.9% of cases for alcohol (Beasley et al., 2011). Evidence regarding road type is inconclusive.

3.4.1.7 Crash location

Rural roads (74.9%), freeways (73.6%) and multi-lane roads (74.3%) were the most common crash locations for fatal road crashes in Canada, 2000-2007, which involved illicit drugs (Beasley et al., 2011), while 60% of crashes involving illicit drugs occurred in urban areas in the study conducted by Smink et al. (2005).

3.4.1.8 Summary of crash and environmental characteristics

In summary, there is substantial evidence to suggest that drug drivers are more likely to be involved in single over multiple vehicle crashes and that automobiles are the most commonly involved vehicle type. Illicit drug drivers are significantly less likely than their counterparts to use a seat-belt. There remains however, limited evidence to confirm the role of specific illicit drugs in crash types. Only one study has reported that a specific drug (THC) was more likely to lead to multiple vehicle crashes. Lack of evidence around the contribution of other illicit drugs to crash type may be limited due to the high prevalence of poly-drug use reported in many studies. Lastly, there is little evidence around speed, road type and crash location of illicit drug-related crashes documented in the literature. These areas warrant further research.

3.4.2 Driver characteristics

3.4.2.1 Age and sex

Young people are more likely to engage in risky lifestyle practices than other age groups. In fact, drivers who are both younger (Bogstrand et al., 2011; Orsay et al., 1994) and male (Bogstrand et al., 2011; Orsay et al., 1994; Schepens et al., 1998) are more likely to be impaired. Other research has shown that 8.9% of Americans 12 years of age and older had used illicit drugs in the month preceding the National Survey on Drug Use and Health (SAMHSA, 2011), with 10.1% of 12 - 17 year old youths and 21.5% of 18 - 25 year old young adults being the most common users of cannabis in America (SAMHSA, 2011). Further, 12.7% of people who had reportedly driven under the influence of drugs were in the 18-25 year age group (SAMHSA, 2011). In Australia, those aged between 18 - 29 years were more likely

to report using illicit drugs at a high risk level in the preceding 12 months (AIHW, 2011a).

Given the evidence of the high prevalence of male involvement in risky driving behaviours (Palamara et al., 2012), it is not surprising that males are also more frequently involved in illicit drug driving (Blencowe, Pehrsson, Mykkänen, Gunnar, & Lillsunde, 2012; Legrand, Isalberti, et al., 2013; Poulsen et al., 2012) and road-traffic accidents, both directly and indirectly (Elliott et al., 2009). In a further study by Clarke et al. (2010), fatal crash involved drivers who were found to have used drugs were of a younger age than non-drug involved drivers (28 year of age *versus* 40 years of age) and were also more likely to be male. Other studies have also shown that males involved in injurious or fatal crashes were significantly more likely to test positive for drugs than females (Longo et al., 2000b; Waller et al., 1997), specifically cannabis, or a combination of alcohol and cannabis (Poulsen et al., 2012). Similarly, oral fluid sample testing of randomly selected drivers showed that males were more likely to test positive for drugs than females (Bierness & Beasley, 2010). Interestingly, of the overall sample, more drivers tested positive for drugs (10.4%) than alcohol (8.1%) (Bierness & Beasley, 2010).

In the first two years of Victoria's RRDT program, 76.07% of drivers convicted with a driving under the influence of illicit drugs offence were male, with an average age of 24 years (Boorman & Owens, 2009). Fatally injured drivers in Kuala Lumpur by comparison, were most commonly in the 30-39 year age group (43.3%). However, 20-29 year olds still accounted for (39.7%) of the fatally injured driver records examined (Norlen et al., 2012).

3.4.2.2 License status

Previous research has identified that not holding an appropriate drivers' licence or being unlicensed is a risk factor for involvement in a serious injury crash (Ayuso, Guillén, & Alcañiz, 2010) and risk taking behaviours such as not wearing a seat-belt (Palamara, Kaura & Fraser, 2013) or testing positive for alcohol when involved in a killed or serious injury crash (Palamara, et al., 2013) and all police attended crashes (Palamara, 2013). Unfortunately very few studies of illicit drugs and driving have considered the licensing status of the driver as a risk factor. Most to do so have relied on self-reports of driving after taking an illicit substance rather than objective

evidence. For example, an early Victorian survey of n=76 heroin and amphetamine users found that nearly 10% of respondents self-reported to driving unlicensed, the implication being that they did so at some stage while affected by drugs (Aitken, Kerger & Crofts, 2000).

The exception to self-report studies is the investigation by Boorman and Owens (2009) of Victorian drivers subject to a roadside drug test 2004-2006. The authors noted that approximately 5.2% of drivers processed for an illicit drugs in oral fluids offence were unlicensed, while a further 31% held a valid probationary licence (i.e., licensed less than 5 years).

3.4.2.3 Driving record

It has been reported that drivers who tested positive for cannabis had significantly poorer driving records in the past three years than those who did not test positive (Bedard et al., 2007). Furthermore, according to Bedard et al. (2007), driver-related factors which were significantly different in those who had consumed cannabis to those who had not, included driving too fast (26% vs. 19.7%, $p = 0.001$) and negligent vehicle operation (8.9% vs. 5.6%, $p < 0.001$). Drivers suspected of DUI are often apprehended by the police due to some form of moving traffic behaviour. A register-based study conducted in Finland found that of the 31,963 DUID cases, two out of every three were apprehended by the police due to some form of traffic infringement (Ojaniemi, Lintonen, Impinen, Lillsunde, & Ostamo, 2009), suggesting a possible relationship between DUID and an increased likelihood of traffic offences. Most studies however, are not clear about the type of traffic offence committed.

It is well known that certain traffic offences such as speeding are more likely to result in serious or fatal accidents than others (Ayuso et al., 2010). Drivers under the influence of illicit drugs are more likely to speed and not use a seat belt ($p < .01$) (Romano & Voas, 2011).

The Drug Use Monitoring in Australia (DUMA) 2009-10 report stated that 45% of all police detainees attributed their current detainable offence to some sort of substance use (Sweeney & Payne, 2012). In the report, across all states, 22% of road/traffic offenders attributed their offence to drugs/alcohol. In Perth, this figure

was slightly higher than the average, at 28% (Sweeney & Payne, 2012). In an earlier report on drug use among traffic detainees specifically, self-report data for 555 detainees indicated that 37% had used potentially impairing drugs or medications shortly before their arrest (Poyser et al., 2002). A further 14% reported using both drugs and alcohol (Poyser et al., 2002). A study conducted in 1996 investigated the validity of self-reported traffic violations in a sample of drivers who had been convicted for driving while intoxicated (DWI) (Chang & Lapham, 1996). Of the 274 offenders included in the study, 26% had previous license or registration violations, 20% insurance violations and 12% moving violations, which included running a stop sign or red light, speeding and reckless driving amongst others (Chang & Lapham, 1996). It was found that when compared to court records, offenders tended to under-report their previous arrests (Chang & Lapham, 1996). Though this study was specific to alcohol-related DWI, the information could extend to drug-related DWI. Orsay et al. (1994) also reported that impaired drivers (whether impaired by drugs or alcohol) were more likely to have committed traffic offences related to moving violations.

A few studies have reported findings regarding illicit drug-related traffic offences as part of a larger study. A linked data study conducted in Norway of 3221 patients involved in opioid maintenance treatment, 4,222 convictions were registered against the patients prior to treatment, of which 12.1% were traffic offences (Bukten et al., 2012). In a sample of illicit drug users recruited from the illicit drug database in New Zealand, an overall combined average of 14% had been charged with some form of driving offence (Wilkins, Girling, & Sweetsur, 2008).

C'De Baca, McMillan, and Lapham (2009) reported a relative risk some 13% higher in subjects with a drug use disorder (DUD) for being convicted of a traffic offence, than those without a DUD. Marowitz (1994) investigated a population of individuals arrested for drug violations one year prior to arrest and for the first two years after arrest. Drug arrestees committed 3.04 times as many traffic violations as the general driving population prior to arrest and were involved in 1.66 times as many traffic accidents (Marowitz, 1994).

In summary, young age, male gender (Holmgren, Holmgren, Kugelberg, Jones, & Ahlner, 2008; Kelly et al., 2004; Orsay et al., 1994; Schepens et al., 1998) and a

previous driving under the influence of alcohol (Ashbridge, Poulin, & Donato, 2005) or drugs offence (Ashbridge et al., 2005; Holmgren et al., 2008) are the main characteristics associated with illicit drug-related crashes.

4 FATALLY INJURED MOTOR VEHICLE DRIVERS AND MOTORCYCLE RIDERS, WESTERN AUSTRALIA 2000-2012, AND THE INVOLVEMENT OF ILLICIT DRUGS

This section presents the results of the analysis of ChemCentre toxicology records that were linked with WA Police reported crash records for fatally injured drivers/riders. A total of n=1,375 fatal injury records were analysed, which represents approximately 90% of the n=1,523 motor vehicle drivers and motor cycle riders reportedly killed during 2000-2012 on Western Australian roads[1].

4.1 Frequency of the detection of illicit drugs

Based on the criteria described in Chapter 2 for the classification of a substance as 'illicit', 22.7% (n=312) of fatally injured drivers/riders for whom linked data was obtained tested positive to one or more illicit substances during the period 2000-2012 (Table 4.1). This equates to a rate of 22.46 fatally injured driver/riders testing positive per 100,000 motor driver licences issued in Western Australia for the period 2000-2012[2].

Table 4.1 Annual frequency distribution and rate of fatally injured drivers/riders testing positive to an illicit substance; Western Australia 2000-2012

	Illicit Substance						
	Not Detected		Detected		Total Fatalities		Rate*
Year	n	%	n	%	n	%	
2000	78	78.8	21	21.2	99	100	1.65
2001	68	76.4	21	23.6	89	100	1.63
2002	78	80.4	19	19.6	97	100	1.49
2003	75	80.6	18	19.4	93	100	1.36
2004	75	76.5	23	23.5	98	100	1.71
2005	73	73.0	27	27.0	100	100	1.98
2006	97	83.6	19	16.4	116	100	1.37
2007	96	70.6	40	29.4	136	100	2.70
2008	95	72.5	36	27.5	131	100	2.10
2009	90	78.3	25	21.7	115	100	1.40
2010	95	77.9	27	22.1	122	100	1.61
2011	78	83.9	15	16.1	93	100	0.86
2012	65	75.6	21	24.4	86	100	1.17
2000-2012	**1063**	**76.4**	**312**	**22.7**	**1375**	**100**	**22.46**

*Rate of detection of an illicit substance in fatally injured drivers/riders per 100,000 motor vehicle driver licences issued in Western Australia

[1] Based on data presented in Hill, Marchant, Trafalski and Grant (2007); Thompson and Hill (2010); Bramwell, Hill and Thompson (2014).
[2] Based on the number of licences issued at the midpoint of the period.

The rate (and associated 95% Confidence Interval) of detection of an illicit substance among fatally injured drivers/riders for each year of the study period is charted in Figure 4.1. The relationship between year of fatality and the annual rate of detection of was investigated using simple linear regression following confirmation that the assumptions for this test had been met. For the period, the illicit drug involved fatality rate was not significantly related to year of fatality (F (1,11)=0.54, p=.477), with the unstandardized slope (-0.025) found not to be significantly different from 0 (t= -.736, p=0.477). However, further analysis of the data restricted to the period 2008 to 2012 – which coincides with the introduction of roadside oral fluid testing in October 2007 - revealed a significant decrease in the rate of illicit drug involved fatalities over this period: F (1,4)=16.03, p=.016, unstandardized coefficient -0.319, t= -4.0, p=0.016.

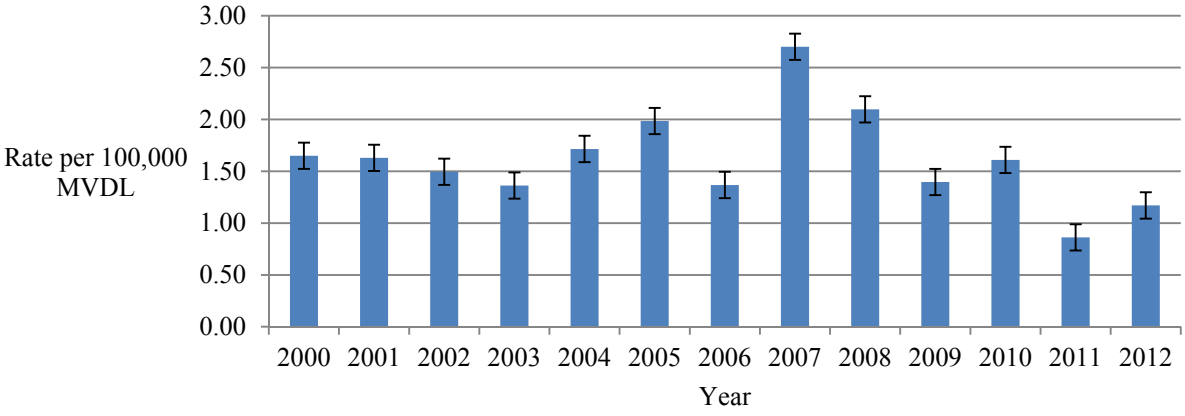

Figure 4.1 Rate of detection of an illicit drug among fatally injured drivers/riders per 100,000 Motor Vehicle Driver Licences issued; Western Australia 2000-2012

4.2 Illicit drugs detected

A total of n=383 positive tests for illicit substances were recorded for the n=312 illicit drug related driver/rider fatalities. As shown in Table 4.2, THC (signifying the past use of cannabis) was the most frequently detected substance accounting for 64.8% of positive tests, followed by methylamphetamine (26.6%) and MDMA (5.7%).

Table 4.2 Frequency distribution of types of illicit substances detected among fatally injured drivers/riders; Western Australia 2000-2012

	Positive Tests	
Illicit Substance	**n**	**%**
Benzylpiperazine	1	0.3
Cocaine	3	0.8
Heroin	7	1.8
MDMA (Ecstasy)	22	5.7
Methylamphetamine	102	26.6
THC	248	64.8
All Positive Tests	**383**	**100**

Analysis of the detection of THC and methylamphetamine by year of fatality showed no significant difference in the proportion observed each year compared with that expected (based on the total number of positive detections for the period) for THC (X^2=16.40 df=12; p=0.17) but a significant variation for methylamphetamine (X^2=41 df=12; $p \leq 0.001$). Detections for methylamphetamine among those fatally injured in 2007 were nearly three times greater than expected (23 *versus* 7.8).

Analysis also showed that the majority (80%) of drivers/riders tested positive to one illicit substance only (see Table 4.3) with 17% and 2.6% testing positive to two and three illicit substances respectively. Approximately 62% of driver/riders who tested positive did so for THC alone. The next most common detections were methylamphetamine alone (14.7%), and THC and methylamphetamine in combination (13.6%). Descriptive statistics for the two most commonly detected illicit substances – THC and methylamphetamine – are presented in Table 4.4.

Table 4.3 Frequency distribution of the detection of single and multiple illicit substances among fatally injured drivers/riders; Western Australia 2000-2012

Detected Substance(s)	n	%
Single Substance		
THC	193	61.9
Methylamphetamine	46	14.7
MDMA	7	2.2
Cocaine	2	0.6
Heroin	2	0.6
Multiple Substances		
THC Meth MDMA Heroin	1	0.3
THC Meth MDMA	4	1.3
THC Meth Heroin	3	1.0
THC MDMA	4	1.3
THC Meth	42	13.6
THC Heroin	1	0.3
Meth MDMA Benzylpip.	1	0.3
Meth MDMA	5	1.6
Meth Cocaine	1	0.3
Total	312	100

Table 4.4 Descriptive statistics for THC and Methylamphetamine detections among fatally injured drivers/riders; Western Australia 2000-2012

	THC ug/L	Methylamphetamine mg/L
Minimum	0.50	0.01
Maximum	46.0	11.0
Median	2.8	0.13
Percentiles		
-25th	1.0	0.05
-50th	2.8	0.13
-75th	5.8	0.44
-95th	19.0	2.8

4.3 Description of fatally injured driver/riders and illicit drugs

4.3.1 Gender

For the period 2000-2012, 24.3% of fatally injured male drivers/riders tested positive for an illicit substance compared with 16.7% of female drivers/riders (Table 4.5).

Calculation of the unadjusted odds showed that males were 60% more likely than females to test positive for an illicit substance (OR=1.60, 95%CI 1.14-2.23, p≤ 0.01).

The proportion of positive tests for THC was similar for males (65%) and females (63.5%). In contrast, females evidenced a slightly higher proportion of positive tests for methylamphetamine (30.2%) and heroin (3.2%) compared with males (25.9% and 1.6% respectively), while males evidenced a slightly higher proportion of positive tests for MDMA compared with females (6.3% versus 3.2%).

Table 4.5 Frequency distribution of the gender of fatally injured drivers/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Gender	**n**	**%**	**n**	**%**	**n**	**%**
Female	249	83.3	50	16.7	299	100
Male	814	75.7	262	24.3	1076	100
All persons	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

4.3.2 Age

The detection of an illicit substance was highest among younger age drivers/riders 17-24 years (28.6%) and 25-39 (34.5%) compared with older age and all age drivers/riders. Compared with drivers aged 40+ years, drivers/riders under 40 years of age were 4.8 times more likely to test positive for an illicit substance (OR=4.83 95%CI 3.45-6.76, p≤ 0.001).

Table 4.6 Frequency distribution of the age of fatally injured drivers/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Age (years)	**n**	**%**	**n**	**%**	**n**	**%**
Under 17	18	78.3	5	21.7	23	100
17-24	270	71.4	108	28.6	378	100
25-39	291	65.5	153	34.5	444	100
40-49	177	85.5	30	14.5	207	100
50-59	131	89.7	15	10.3	146	100
60+	176	99.4	1	0.6	177	100
All persons	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

4.3.3 Road user status

As shown in Table 4.7 the vast majority of fatally injured drivers/riders for whom linked crash and ChemCentre data could be retrieved were drivers of motor cars and riders of motorcycles/mopeds. The proportion of fatally injured drivers/riders testing positive to an illicit substance was similar across car (22.8%) and truck drivers (20.6%) and motorcycle/moped riders (22.6%). Road user status (car, truck, bus and other driver *versus* motorcycle/moped rider) and the detection of an illicit substance were not found to be significantly associated (X^2=.001 df=1; ns).

Table 4.7 Frequency distribution of the road user status of fatally injured driver/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Gender	**n**	**%**	**n**	**%**	**n**	**%**
Motor car driver	787	77.2	233	22.8	1020	100
Motorcycle/moped rider	246	77.4	72	22.6	318	100
Bus and other driver	3	100	0	0.0	3	100
Truck driver	27	79.4	7	20.6	34	100
All persons	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

4.3.4 Licensing status

Licensing status information was available for 89.3% of linked records. Just over eight in ten fatally injured drivers/riders (83.8%) were validly licensed at the time of the crash, the majority of who were full licence holders. Approximately 16% of fatally injured drivers/riders were not validly licensed to drive at the time of the crash because they had never held a licence or because their licence was suspended, cancelled, expired, or inappropriate for the vehicle they were driving/riding at the time of the crash.

An illicit substance was detected in 46% of fatally injured drivers/riders who were not validly licensed compared with 18.9% of drivers/riders holding a valid licence. Compared with validly licensed drivers, those driving without a valid licence were approximately 3.5 times more likely to test positive for an illicit substance (OR=3.5, 95%CI 2.51-4.89; p≤ 0.001).

Of the group of validly licensed drivers/riders, the detection of an illicit substance was slightly higher among Provisionally licensed drivers (22.9%) compared with Full licence holders (18.5%). Further analysis showed that 19% of the n=147 drivers/riders for who no licensing information was available returned a positive test for an illicit substance.

Table 4.8 Frequency distribution of the licensing status of fatally injured driver/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Gender	**n**	**%**	**n**	**%**	**n**	**%**
No valid licence*	109	54.8	90	46.0	199	100
Valid licence	835	81.1	194	18.9	1029	100
-Full Licence	*734*	*81.5*	*167*	*18.5*	*901*	*100*
-Provisional Licence	*81*	*77.1*	*24*	*22.9*	*105*	*100*
-Learner Licence	*14*	*87.5*	*2*	*12.5*	*16*	*100*
-Extraordinary Licence	*6*	*85.7*	*1*	*14.3*	*7*	*100*
All persons	**944**	**76.9**	**284**	**23.1**	**1228**	**100**

n=147 missing licence status *never held a licence; suspended, cancelled, expired or inappropriate licence

4.3.5 Use of protection: Seat-belts and helmets

Information on the use of a seat-belt or helmet was available for 90% of fatally injured drivers/riders. Approximately 75% of drivers/riders were noted to have used protection. An illicit substance was detected among 21.5% of drivers/riders who used protection compared with 25.6% for those who did not use protection. This relationship was found not to be statistically significant for all drivers/riders (X^2=2.31 df=1; ns) and for the disaggregated groups of drivers of motor cars, truck, and buses (X^2=1.58 df=1; ns) and riders of motorcycle/mopeds (X^2=1.34 df=1; ns).

Table 4.9 Frequency distribution of the use of protection* by fatally injured drivers/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Protection	**n**	**%**	**n**	**%**	**n**	**%**
Worn	728	78.5	199	21.5	927	100
Not worn	229	74.4	79	25.6	308	100
All persons	**957**	**77.5**	**278**	**22.5**	**1235**	**100**

n=140 missing use of protection; * use of a seat-belt by drivers or helmet by motorcycle/moped riders

4.3.6 Use of alcohol

Blood Alcohol Concentration (BAC) level information was available for all but two fatally injured drivers/riders. Approximately 62% of fatally injured drivers/riders returned a BAC level reading of 0.00gm%. Just over a third of drivers/riders (34.2%) returned a BAC level ≥ 0.05gm%, the majority of who were ≥0.150gm%.

Driver/rider BAC category and illicit substance use were found to be significantly associated (X^2=39.94 df=4; p ≤ .001). As shown in Table 4.10, drivers/riders with a BAC in the range 0.08-0.149gm% evidenced the highest proportion of drivers testing positive to an illicit substance (40.6%) followed by those with a BAC in the range of 0.05-0.079gm% (37.5%) and 0.001-0.049gm% (27.3%).

Table 4.10 Frequency distribution of the Blood Alcohol Concentration level of fatally injured drivers/riders and the detection of an illicit substance; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
BAC level (gm%)	**n**	**%**	**n**	**%**	**n**	**%**
0.00	692	81.6	156	18.4	848	100
0.001-0.049	40	72.2	15	27.3	55	100
0.050-.0790	25	62.5	15	37.5	40	100
0.080-0.149	82	59.4	56	40.6	138	100
≥ 0.150	223	76.4	69	23.6	292	100
All persons	**1062**	**77.3**	**311**	**22.7**	**1373**	**100**

n=2 missing BAC level

The unadjusted odds for drivers/riders of varying BAC levels testing positive for an illicit substance is presented in Table 4.11. Compared with drivers/riders recording a BAC of 0.000gm%, drivers/riders with a BAC in the range of 0.050-0.079gm% and 0.080-0.149gm% had significantly greater odds - 2.6 to 3 times respectively - of testing positive for an illicit substance.

Table 4.11 Unadjusted odds for fatally injured drivers/riders testing positive to an illicit substance; by Blood Alcohol Concentration Level, Western Australia 2000-2012

Blood Alcohol Concentration Level (gm%)	Odds Ratio	95% Confidence Interval	Significance
0.000^	1.00		
0.001-0.049	1.66	0.89-3.08	ns
0.050-0.079	2.66	1.37-5.16	< 0.01
0.080-0.149	3.02	2.06-4.43	< 0.001
≥0.150	1.37	0.99-1.89	ns

^ Base level

4.3.7 Use of non-illicit drugs

The proportion of fatally injured drivers/riders testing positive to drugs other than alcohol or those classified as illicit is presented in Table 4.12. Opioids were the most frequently detected group of non-illicit drugs - 12% of all fatalities - followed by anti-depressants (7.3%), benzodiazepines (5.9%) and stimulants (2%). An additional 5.9% of drivers/riders also tested positive to a diverse range of drugs to treat conditions such as heart disease, diabetes and hypertension. Analysis of the association between the presence of each group of non-illicit pharmaceutical drugs and the detection of an illicit substance was found to be significant for the benzodiazepine group only. Fatally injured drivers/riders testing positive for this group of non-illicit drugs were 2.3 times more likely than those who were benzodiazepine negative to test positive for an illicit substance (OR=2.23, 95CI% 1.45-3.73, $p < 0.001$).

Table 4.12 Proportion of fatally injured drivers/riders testing positive for non-illicit drugs by illicit substance detection status; Western Australia 2000-2012

	Illicit Substance					
	Not Detected (n=1063 drivers/riders)		Detected (n=312 drivers/riders)		All (n=1375 drivers/riders)	
Drug Group	n	%	n	%	n	%
Opioids	125	11.8	39	12.5	164	11.9
Benzodiazepines	48	4.5	31	9.9	79	5.7
Anti-depressants	84	7.9	16	5.1	100	7.3
Stimulants	18	1.7	9	2.9	27	2.0
All Other Non-Illicits^	69	6.5	12	3.8	81	5.9

^Excluding alcohol

The combined use of non-illicit drugs was investigated for benzodiazepines and opioids because of their noted complimentary use and effect as Central Nervous System depressants. As shown in Table 4.13, around four in ten drivers testing positive for benzodiazepines alone (41.2%) and in combination with opioids (37.8%) tested positive for an illicit substance.

Table 4.13 Frequency distribution of fatally injured drivers/riders testing positive to benzodiazepines and opioids by illicit substance detection status; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Category	**n**	**%**	**n**	**%**	**n**	**%**
Negative for benzodiazepines and opioids	910	78.0	256	22.0	1166	100
Positive for benzodiazepines only	28	62.2	17	37.8	45	100
Positive for opioids only	105	80.8	25	19.2	130	100
Positive for benzodiazepines and opioids	20	58.8	14	41.2	34	100
Total	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

Calculation of the unadjusted odds showed that fatally injured drivers/riders testing positive to benzodiazepines alone (OR=2.15, 95CI% 1.16-4.0, $p < 0.05$) and in combination with opioids (OR=2.48, 95CI% 1.23-4.99, $p < 0.01$) were 2.2 and 2.5 times respectively more likely to test positive for an illicit substance compared with those who tested negative for both benzodiazepines and opioids.

Table 4.14 Unadjusted odds for fatally injured drivers/riders testing positive to an illicit substance; by benzodiazepine and opioid detection, Western Australia 2000-2012

Category	**Odds Ratio**	**95% Confidence Interval**	**Significance**
Negative for benzodiazepines and opioids ^	1.00	-	
Positive for benzodiazepines only	2.15	1.16-4.0	< 0.05
Positive for opioids only	0.84	0.53-1.33	ns
Positive for benzodiazepines and opioids	2.48	1.23-4.99	< 0.01

^ Base level

4.4 Description of the fatal crash and illicit drugs

4.4.1 Region and Policing District

The detection of an illicit substance was found to be proportionally higher for drivers/riders fatally injured in crashes occurring in metropolitan Western Australia (25.6%) compared with regional Western Australia (20.3%). The former group of fatally injured drivers/riders were 35% (OR=1.35, 95%CI 1.05-1.71, $p < 0.05$) more likely than the latter to test positive for an illicit substance.

Table 4.15 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by region of crash; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Region	**n**	**%**	**n**	**%**	**n**	**%**
Metropolitan WA	465	74.4	160	25.6	625	100
Regional WA	598	79.7	152	20.3	750	100
All persons	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

The detection of an illicit substance was also analysed by the WA Police district of the crash (see Table 4.16). The proportion of drivers/riders testing positive was somewhat higher for fatalities occurring in the North West Metropolitan (34.3%), South East Metropolitan (30.8%), and South West regional (28.1%) districts. However, relative to the Central Metropolitan area, only drivers/riders crashing in the North West Metropolitan area evidenced significantly higher odds of testing positive for an illicit substance (OR=3.39, 95%CI 1.05-10.91, $p < 0.05$).

Table 4.16 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by WA Police district of the crash; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
WA Police District	**n**	**%**	**n**	**%**	**n**	**%**
Metropolitan						
Central Metropolitan	26	86.7	4	13.3	30	100
East Metropolitan	113	75.8	36	24.2	149	100
North West Metropolitan	44	65.7	23	34.3	67	100
Peel Metropolitan	98	75.4	32	24.6	130	100
South East Metropolitan	83	77.6	37	30.8	120	100
South Metropolitan	52	77.6	15	22.4	67	100
West Metropolitan	49	79.0	13	21.0	62	100
Regional						100
Goldfields - Esperance	43	82.7	9	17.3	52	100
Great Southern	112	81.8	25	18.2	137	100
Kimberley	21	70.0	9	30.0	30	100
Mid West-Gascoyne	56	78.9	15	21.1	71	100
Pilbara	62	88.6	8	11.4	70	100
South West	141	71.9	55	28.1	196	100
Wheatbelt	163	84.0	31	16.0	194	100
All Crashes	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

4.4.2 Nature

Information on the nature of the crash was available for 98% of driver/rider fatalities. Aggregating the crash types into multiple *versus* single vehicle crashes (see Table 4.17) showed that fatally injured drivers/riders involved in a single vehicle crash were more likely to test positive for an illicit substance (25%) compared with those involved in a multiple vehicle crash (19.3%). The former group of drivers/riders were around 40% more likely to test positive (OR=1.39, 95%CI 1.06-1.81, $p < 0.05$) when compared with those involved in a multiple vehicle crash. Disaggregating the crash types showed the highest proportion of positive tests for an illicit substance for driver/riders involved in 'non-collision' (24.6%), 'hit object' (25.1%) and 'head on' (23.7%) crashes.

Table 4.17 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by the nature of the crash; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Nature of crash	**n**	**%**	**n**	**%**	**n**	**%**
Multiple Vehicle Crash	**438**	**80.7**	**105**	**19.3**	**543**	**100**
Rear-end	31	86.1	5	13.9	36	100
Head-on	184	76.3	57	23.7	241	100
Sideswipe – same direction	28	77.8	8	22.2	36	100
Right angle	133	87.5	19	12.5	152	100
Right turn thru	62	79.5	16	20.5	78	100
Single Vehicle Crash	**602**	**75.0**	**201**	**25.0**	**803**	**100**
Hit pedestrian	2	100	0	0.00	2	100
Hit animal	3	60.0	2	40.0	5	100
Hit object	468	74.9	157	25.1	625	100
Non collision	129	75.4	42	24.6	171	100
All Crashes	**1040**	**77.3**	**306**	**22.7**	**1346**	**100**

n=29 missing Nature of Crash

4.4.3 Day of week

The frequency distribution of the detection of an illicit substance among fatally injured drivers/riders by day of the week is presented in Table 4.18. Though the proportion of positive detections was somewhat higher on Fridays (26.5%) and Saturdays (26.5%) compared with that for all days of the week (22.7%), day of week and the detection of an illicit substance were not significantly associated (X^2=1.17 df=1; ns).

Table 4.18 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by day of week of the crash; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Day of Week	**n**	**%**	**n**	**%**	**n**	**%**
Monday	110	78.0	31	22.0	141	100
Tuesday	135	77.1	40	22.9	175	100
Wednesday	121	79.1	32	20.9	153	100
Thursday	171	83.8	33	16.2	204	100
Friday	166	73.5	60	26.5	226	100
Saturday	189	73.8	67	26.2	256	100
Sunday	171	77.7	49	21.5	220	100
Weekdays (Mon-Fri)	703	78.2	196	21.8	899	100
Weekend (Sat-Sun)	360	75.6	116	24.4	476	100
All Days	**1063**	**77.3**	**312**	**22.7**	**1375**	**100**

4.4.4 Time of day

A statistically significant association was computed between time of day of fatality and the detection of an illicit substance (X^2=5.97 df=1; $p \leq .05$). A greater proportion of drivers/riders fatally injured in the evening (1800-2359 hours; 25.2%) and late at night (0000-0559 hours; 34.9%) tested positive for an illicit substance compared with those fatally injured in the morning (18.8%) and afternoon (17%). Aggregation of the time of crash to compare night-time with daytime showed that drivers/riders fatally injured 1800-0559 hours were 80% more likely than those injured 0600-1759 hours to test positive for an illicit substance (OR=1.84, 95%CI 1.42-2.38, $p < 0.001$).

Table 4.19 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by time of day of the crash; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Time of Day	**n**	**%**	**n**	**%**	**n**	**%**
0000-0559	149	65.1	80	34.9	229	100
0600-1159	254	81.2	59	18.8	313	100
1200-1759	357	83.0	73	17.0	430	100
1800-2359	297	74.8	100	25.2	397	100
All Times	**1057**	**77.3**	**312**	**22.7**	**1369**	**100**

n=6 missing time of day of crash

4.4.5 Speed zone

Crashes occurring on roads zoned at 60 and 90 km/hour evidenced the highest proportion of fatally injured drivers/riders testing positive to an illicit substance – 26.4% and 30.7% respectively – while crashes occurring in 110 km/hour evidenced the lowest proportion (19.4%) of positive tests for an illicit drug. Speed zone at the location of the crash and the detection of an illicit substance were however not significantly associated (X^2=9.38 df=6; ns).

Table 4.20 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by speed zone for the crash location; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Speed Zone	**n**	**%**	**n**	**%**	**n**	**%**
Up to 50 km/hour	63	77.8	18	22.2	81	100
60 km/hour	134	73.6	48	26.4	182	100
70 km/hour	107	78.7	29	21.3	136	100
80 km/hour	108	74.0	38	26.0	146	100
90 km/hour	61	69.3	27	30.7	88	100
100 km/hour	63	75.9	20	24.1	83	100
110 km/hour	473	80.6	114	19.4	587	100
All Zones	**1009**	**77.4**	**294**	**22.6**	**1369**	**100**

n=72 missing speed zone of crash

4.4.6 Road alignment

A slightly greater proportion of fatally injured drivers/riders crashing on curved section of road tested positive for an illicit substance compared with those crashing on straight sections of road: 25.2% *versus* 21.1% though this was not found to be statistically significant (X^2=3.10 df=1; ns). Further analysis of the relationship with the inclusion of driver/rider BAC level showed that alcohol, but not illicit drug detection status, was significantly and independently associated with an increased likelihood of crashing on curves versus straight. Fatally injured drivers/riders with BAC levels in the range of 0.001-0.49gm% (OR=1.85, 95%CI 1.07-3.20, p <0.05), 0.080-0.149gm% (OR=1.57, 95%CI 1.08-2.28, p < 0.05) and 0.150gm% (OR=2.41, 95%CI 1.83-3.17) were between 1.57 and 2.4 times more likely to crash on a curve section of road versus straight section of road.

Table 4.21 Frequency distribution of fatally injured drivers/riders and the detection of an illicit substance by road alignment for the crash location; Western Australia 2000-2012

	Illicit Substance					
	Not Detected		Detected		Total	
Road Alignment	**n**	**%**	**n**	**%**	**n**	**%**
Curve	398	74.8	134	25.2	532	100
Straight	662	78.9	177	21.1	839	100
All Alignments	**1060**	**77.3**	**311**	**22.7**	**1371**	**100**

n=4 missing road alignment at crash location

4.5 Multivariate analysis of driver/rider fatalities and illicit drugs

The preceding univariate analyses showed that gender, age, licence status, BAC level, the use of CNS depressant drugs (benzodiazepine and opioids) and the region, nature, and time of day of the crash were significantly associated with increased unadjusted odds of a fatally injured driver/rider testing positive to an illicit substance. These variables were subsequently included in a Multivariate Logistic Regression of the detection of an illicit substance.

In the full model time of day, nature of crash, and region of crash were found not to be significantly associated with the increased odds of detection of an illicit substance. Region was nevertheless retained in the model to adjust for the location of the fatality. The multivariate modelling (see Table 4.22 for adjusted odds ratios) showed that driver/rider gender, age, licence status, BAC level, and the use of CNS depressant drugs such as benzodiazepines and opioids were found to be significantly and independently associated with increased odds of a fatally injured driver/rider testing positive for an illicit substance.

Compared with fatally injured female drivers/riders, males were 56% more likely to test positive for an illicit substance (OR=1.56, 95%CI 1.07-2.28, $p < 0.05$). In relation to age, those under 40 years of age were four times more likely than their older age counterparts to test positive for an illicit substance (OR=4.13, 95%CI 2.86-5.91, $p < 0.001$). Fatally injured drivers/riders without a valid licence at the time of the crash were nearly three times more likely than those validly licensed to test positive for an illicit substance (OR=2.80, 95%CI 1.97-3.96, $p < 0.001$). Two levels of driver/rider BAC were found to be associated with a significant increase in the odds of testing positive for an illicit

substance. Drivers/riders with a BAC level in the range of 0.050gm%-0.079gm% (OR=2.10 95%CI 1.01-4.40, P < 0.05) and 0.080gm%-0.149gm% (OR=2.01, 95%CI 1.29-3.11, p < 0.01) were twice as likely as drivers/riders with a BAC of 0.00gm% to test positive for an illicit substance. Lastly, the use of benzodiazepines alone (OR=2.71, 95%CI 1.33-5.49, p < 0.01) and in combination with opioids (OR=3.45, 95%CI 1.52-7.82, p < 0.01) increased the odds of testing positive for an illicit substance between 2.7 and 3.4 times respectively.

Table 4.22 Multivariate Logistic Regression of fatally injured drivers/riders testing positive for an illicit substance; Western Australia 2000-2012

Variable	Odds Ratio	95% Confidence Interval	Significance
Driver/Rider Gender			
-Female^	1.00	-	
-Male	1.56	1.07-2.28	< 0.05
Driver/Rider Age			
-40+ years^	1.00	-	
-< 40 years	4.13	2.86-5.91	< 0.001
Driver/Rider Licence Status			
-Valid licence^	1.00	-	
-No valid licence	2.80	1.97-3.96	< 0.001
Driver/Rider BAC level			
-0.000 gm%^	1.00	-	< 0.01
-0.001-0.049 gm%	1.15	0.59-2.42	ns
-0.050-0.079 gm%	2.10	1.01-4.40	< 0.05
-0.080-0.149 gm%	2.01	1.29-3.11	< 0.01
-≥ 0.150 gm%	0.89	0.61-1.29	ns
Benzodiazepine and Opioid Use			
-Negative for benzodiazepines and Opioids^	1.00	-	< 0.01
-Positive for benzodiazepines only	2.71	1.33-5.49	< 0.01
-Positive for opioids only	1.18	0.70-1.98	ns
-Positive for both benzodiazepines and opioids	3.45	1.52-7.82	< 0.01

^ Base level. Adjusted for Region of crash.

5 DRUG DRIVING TRAFFIC OFFENCES, WESTERN AUSTRALIA 2008-2012

This section presents the results of the analysis of Section 64AC offences. WA Police undertook 43,176 roadside oral fluid sample screenings for prescribed illicit drugs during the period January 1st 2008 to 31st December 2012. The dataset for the analysis of resulting offences was limited to 1,630 drivers/motorcycle riders charged with a total of 1,724 Section 64AC offences (as retrieved from the WA Police 'Briefcase' system). Because of administrative and/or evidence related reasons not all drivers/riders who test positive for a prescribed illicit substance are necessarily charged with a Section 64AC offence.

5.1 Descriptive statistics for roadside oral fluid screenings for illicit drugs

The number of roadside screenings conducted annually, the proportion resulting in a Section 64AC offence, and the annual offence rates per 1,000 tests and per 100,000 motor vehicle driver licences issued is presented in Table 5.1. The observed number of roadside screenings for each year of the period significantly varied from that expected based on the total number for the period (X^2=483.04 df=4; p ≤ .001). The number of screenings was lowest in 2009 and 2011.

Table 5.1 Descriptive statistics for roadside oral fluid screenings for illicit drugs; Western Australia 2008-2012

	Roadside Screenings		Section 64AC Offences		Offence Rate	
Year	**n**	**%**	**n**	**%**	**Screenings^**	**MVDL#**
2008	9,325	21.6	307	3.3	32.92	17.89
2009	7,496	17.4	235	3.1	31.35	13.12
2010	9,711	22.5	331	3.4	34.09	19.73
2011	7,598	17.5	355	4.6	46.72	20.41
2012	9,046	21.0	496	5.4	54.83	27.64
2008-2012	**43,176**	**100**	**1724**	**4.0**	**177.53**	**102.77**

* As retrieved from the WA Police 'Briefcase' system. ^per 1,000 oral fluid screenings undertaken; #per 100,000 Motor Vehicle Driver Licences issued in WA

On average, 326 drivers were charged and 345 offences were committed per year for the period. For the period 2008-2012, approximately 4% of roadside screenings resulted in the issue of a Section 64AC offence. The relationship between year of oral fluid testing operation and the annual offence rate was investigated using simple linear regression following confirmation that the assumptions for this test had been met. The offence rate

per 1,000 roadside screenings was significantly associated with the year of operation (F (1,3)=14.08, p=0.03), with the unstandardized slope (5.91) being significantly different from zero (t=3.75, p=0.03). The offence rate per 1,000 roadside screenings in 2012 was approximately 66% higher than that calculated for the first full year of the testing, 2008. In contrast, the annual offence rate per 100,000 motor vehicle driver licences issued was found not to be significantly associated with year of operation (F (1,3)=5.61, p=0.09), with the unstandardized slope (2.67) not being significantly different from zero (t=2.37, p=0.09).

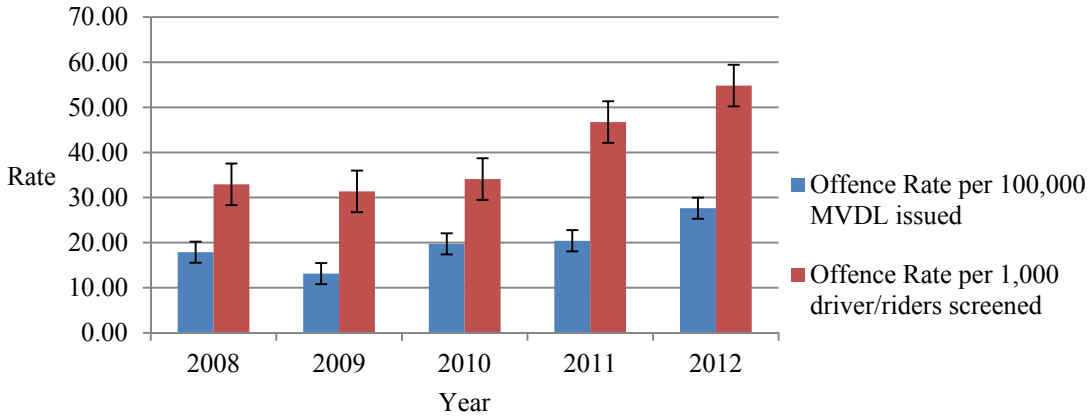

Figure 5.1 Annual Section 64AC offence rate per 1,000 roadside oral fluid screenings and per 100,000 Motor Vehicle Driver Licences issued; Western Australia 2008-2012

Of the n=1630 drivers charged with a Section 64AC offence over the study period, the vast majority (94.6%) were charged with one offence only with a further 5% charged with two offences. A total of six drivers/riders were charged up to three times during the period of investigation. After adjusting for non-significant variables such as the age of the driver at the first offence and the region (metropolitan Perth versus regional WA) of the first offence, males were 2.4 times (OR=2.40, 95%CI 1.09-5.27, $p < 0.05$) more likely than females to be recidivist offenders during the period 2008-2012.

5.2 Description of Section 64AC offences

5.2.1 Substances detected

Methylamphetamine was the most commonly detected substance, singularly and in combination with other illicit substances, leading to a Section 64AC offence during the period of study. In contrast, THC was more commonly detected in the presence of

methylamphetamine than alone. The relatively greater proportion of detected methylamphetamine in 2011 and 2012 along with the relatively smaller proportion of THC detections in 2008, 2011 and 2012 underlie the statistically significant association between drug test result and year of offence (X^2=251.85 df=24, p <0.001).

Table 5.2 Annual frequency distribution of Section 64AC offences by ChemCentre test result; Western Australia 2008-2012

	Year											
	2008		2009		2010		2011		2012		All Years	
Detected Substance	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Methylamphetamine	168	54.7	73	31.1	194	58.6	257	72.4	367	74.0	1059	61.4
THC	21	6.8	38	16.2	46	13.9	19	5.4	27	5.4	151	8.8
MDMA	7	2.3	8	3.4	0	0.0	1	0.3	3	0.6	19	1.1
Meth/THC	72	23.5	73	31.1	86	26.0	72	20.3	75	15.1	378	21.9
Meth/MDMA	24	7.8	15	6.4	0	0.0	4	1.1	17	3.4	60	3.5
THC/MDMA	6	2.0	12	5.1	1	0.3	0	0.0	3	0.6	22	1.3
Meth/THC/MDMA	9	2.9	16	6.8	4	1.2	2	0.6	4	0.8	35	2.0
All	**307**	**100**	**235**	**100**	**331**	**100**	**355**	**100**	**496**	**100**	**1724**	**100**

Table 5.2 also shows that around seven in ten Section 64AC offences for the study period involved the detection of one illicit substance as opposed to multiple substances. Analysis of the first offence for the period showed that it was no more likely to involve the detection of multiple substances if the driver was a single offender (29.2%) for the period or became a repeat offender (29.5%) during the period. The proportion of offences involving the detection of multiple substances declined to 20.5% for the second (first repeat) offence and to 16.7% for the third (second repeat) and final offence for the period.

Further investigation of this outcome (single *versus* multiple substance detection) by driver details (age, gender), region of offence (metropolitan Perth *versus* regional WA) and year of offence showed all variables except region (which was nevertheless retained in the final model to adjust for location) were significantly related to the detection of multiple substances (see Table 5.3). Compared with females committing a Section 64AC offence, males were 69% more likely to test positive for multiple illicit substances (OR=1.67 95%CI 1.21-2.34, p <0.05). Two levels of driver age were significantly related to an increase in the odds of the detection of multiple illicit substances. Compared with

those aged 50+ years, drivers aged 15-24 years (OR=2.17, 95%CI 1.57-3.02, p < 0.001) were twice as likely to test positive to multiple substances while those aged 25-39 years (OR=3.87, 95%CI 2.75-5.44, p < 0.001) were nearly four times as likely. In relation to year of offence, the odds of the detection of multiple illicit substances was significantly greater for offences occurring during the years 2008 (OR=2.17 95%CI 1.50-3.02, p < 0.001), 2009 (OR=3.87 95%CI 2.75-5.44 p < 0.001) and 2010 (OR=1.52, 95%CI 1.10-2.12, p < 0.05) compared with 2012.

Table 5.3 Multivariate Logistic Regression of the detection of multiple illicit substances associated with Section 64AC offences; Western Australia 2008-2012

Variable	Odds Ratio	95% Confidence Interval	Significance
Driver/Rider Gender			
-Female^	1.00	-	
-Male	1.69	1.22-2.33	< 0.01
Driver/Rider Age			
50+ years^	1.0	-	
40-49 years	1.10	0.78-1.54	ns
25-39 years	3.87	2.75-5.44	< 0.001
15-24 years	2.17	1.57-3.02	< 0.001
Year of offence			
-2012^	1.00	-	
-2011	1.10	0.78-1.55	ns
-2010	1.52	1.10-2.12	< 0.05
-2009	3.87	2.75-5.44	< 0.001
-2008	2.17	1.50-3.02	< 0.001

^ Base level. Adjusted for region of offence

5.2.2 Offender Gender

For the period of investigation males accounted for a significantly greater proportion – around eight in ten - of Section 64AC offences (X^2=791.31 df=1, p <0.001) (see Table 5.4). Small, though non-statistically significant, variations were noted in the proportion of offending males and females for each year of the period.

Table 5.4 Annual frequency distribution of Section 64AC offences by offender gender; Western Australia 2008-2012

	Gender					
	Male		Female		All Persons	
Year	**n**	**%**	**n**	**%**	**n**	**%**
2008	268	87.3	39	12.7	307	100
2009	202	86.0	33	14.0	235	100
2010	267	80.7	64	19.3	331	100
2011	305	85.9	50	14.1	355	100
2012	404	81.5	92	18.5	496	100
All Years	**1446**	**83.9**	**278**	**16.1**	**1724**	**100**

Even though methylamphetamine was the most commonly detected substance across all drivers, a statistically significant association was found between the type of substance detected and gender (X^2=24.9 df=6, p < 0.001). Females were more likely to test positive for methylamphetamine (74.1%) than males (59%), while a greater proportion of offences for males compared with females involved the detection of THC (9.5% *versus* 4.7%) and methylamphetamine in combination with THC (23.2% *versus* 15.5%).

5.2.3 Offender Age

The frequency distribution of the age of offenders is presented in Table 5.5. For the period of investigation offenders aged 25-39 years accounted for a significantly greater proportion – around 57% - of Section 64AC offences (X^2=1062.44 df=3, p <0.001). Whilst some variation was noted from year to year in the distribution of the age of offenders, year of offence and offender age were found not be significantly associated.

Table 5.5 Annual frequency distribution of Section 64AC offences by offender age; Western Australia 2008-2012

	Age (years)									
	15-24		25-39		40-49		50+		All Persons	
Year	n	%	n	%	n	%	n	%	n	%
2008	60	19.5	179	58.3	58	18.9	10	3.3	307	100
2009	49	20.9	140	59.6	37	15.7	9	3.8	235	100
2010	70	21.1	187	56.5	62	18.7	12	3.6	331	100
2011	91	25.6	200	56.3	53	14.9	11	3.1	355	100
2012	105	21.2	275	55.4	97	19.6	19	3.8	496	100
All Years	**375**	**21.8**	**981**	**56.9**	**307**	**17.8**	**61**	**3.5**	**1724**	**100**

Type of substance detected and age of driver were found to be significantly associated (X^2=84.23 df=18, p <0.001). This finding should be treated with caution however, because of the relatively high proportion of expected cell counts (28.6%) less than 5. Notwithstanding this cautionary note, drivers aged 15-24 years were less likely to test positive for methylamphetamine compared with those aged 25+ years: 53.9% versus an average of 64.1% across older age driver groups. In contrast, a greater proportion of younger age drivers compared with older age drivers tested positive for MDMA (ecstasy): 3.5% versus an average of 0.2% across older age driver groups. Finally, proportionally more drivers aged 25-39 years (23.4%) and 40-49 years (22.8%) tested positive for methylamphetamine in combination with THC compared with those aged 15-24 years (18.4%) and 50+ years (14.8%).

5.2.4 Region and District of offence

The frequency distribution of the Region and WA Police District of Section 64AC offences during the period 2008-2012 are presented in Tables 5.6 and 5.7 respectively. As can be seen, around nine in ten offences for the period occurred in the metropolitan Perth region. This proportion significantly varied over the period (X^2=58.35 df=4, p <0.001). Most notably, in 2008 the proportion of offences occurring in regional WA was substantially higher (20.8%) compared with the range of 6.3% to 7.9% for other years of the period.

Table 5.6 Annual frequency distribution of Section 64AC offences by Region; Western Australia 2008-2012

	Region					
	Metropolitan WA		Regional WA		All	
Year	**n**	**%**	**n**	**%**	**n**	**%**
2008	243	79.2	64	20.8	307	100
2009	217	92.3	18	7.7	235	100
2010	305	92.1	26	7.9	331	100
2011	332	93.5	23	6.5	355	100
2012	465	93.8	31	6.3	496	100
All Years	**1562**	**90.6**	**162**	**9.4**	**1724**	**100**

Analysis of the relationship between region of offence and type of substance detected was found to be statistically significant (X^2=20.12 df=6, p <0.01). Compared with offences in the metropolitan region, regional WA offences evidenced a lower proportion of detections for methylamphetamine alone (49.4% *versus* 62.7%) and a higher proportion of detection for THC alone (17.3% *versus* 7.9%).

The distribution of offences by metropolitan and regional WA police districts, by year of offence, is presented in Table 5.7. Offences occurring in police districts across regional WA were not analysed in any details because of their small number. Excluding these offences, a statistically significant relationship was found between year of offence and metropolitan police districts (X^2=81.28 df=24, p <0.001). Across the period, the greatest proportion of offences was recorded in the South-East metropolitan district followed by the West metropolitan district (13.2%). The Central, East, Peel and West metropolitan districts evidenced increasing proportion of offences over the years, particularly during the period 2011-2012.

The relationship between metropolitan policing district and detected substance could not be reliably analysed because of the very high percentage (36.7%) of cells with expected offence counts less than 5. It was nevertheless observed that 30% of all offences involving the detection of methylamphetamine (n=979) and methylamphetamine in combination with THC (n=339) occurred in the South-East metropolitan district, nearly three times that recorded for other districts.

Table 5.7 Annual frequency distribution of Section 64AC offences by WA Police District; Western Australia 2008-2012

	Year											
	2008		2009		2010		2011		2012		All Years	
District	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Metropolitan												
Central Metropolitan	44	22.0	27	13.5	32	16.0	33	16.5	64	32.0	200	100
East Metropolitan	17	9.7	21	12.0	41	23.4	22	12.6	74	42.3	175	100
North West Metropolitan	38	19.6	34	17.5	34	17.5	48	24.7	40	20.5	194	100
Peel Metropolitan	19	11.0	19	11.0	24	13.9	57	32.9	54	31.2	173	100
South East Metropolitan	84	18.1	61	13.1	98	21.1	106	22.8	116	24.9	465	100
South Metropolitan	16	10.7	27	18.1	40	26.8	26	17.4	40	26.8	149	100
West Metropolitan	25	12.1	28	13.6	36	17.5	40	19.4	77	37.4	206	100
Regional												
Goldfields-Esperance	19	48.7	0	0.0	1	0.3	6	15.4	13	33.3	39	100
Great Southern	4	30.8	0	0.0	1	0.3	2	15.4	6	46.2	13	100
Kimberley	4	30.8	0	0.0	0	0.0	0	0.0	0	0.0	4	100
Mid West-Gascoyne	9	34.6	2	7.7	7	26.9	3	11.5	5	19.2	26	100
Pilbara	5	20.0	7	28.0	6	24.0	6	24.0	1	4.0	25	100
South West	12	42.9	4	14.3	4	14.3	5	17.9	3	10.7	28	100
Wheatbelt	11	40.7	5	18.5	7	25.9	1	3.7	3	11.1	27	100
All Districts	**307**	**17.8**	**235**	**13.6**	**331**	**19.2**	**355**	**20.6**	**496**	**28.8**	**1724**	**100**

6 DISCUSSION

The objectives of this investigation were to report the prevalence and pattern of illicit drug related motor vehicle driver and motorcycle rider fatalities over the period 2000-2012 and to model the risk factors for these illicit drug involved fatalities. Second to this, the investigation sought to report on the prevalence and pattern of Section 64AC offences of the Road Traffic Act (*Driving with prescribed illicit drugs in oral fluids*) for the period 2008-2012 and to identify risk factors for repeat offending and multiple illicit substance use. A discussion of the findings in relation to these objectives is provided in following sections, along with recommendations for further research and the implications of the findings for drug-driving related policy and enforcement.

6.1 Driver/Rider Fatalities

This study analysed linked toxicology and fatal injury crash records for 90% of drivers/riders fatally injured on Western Australian roads during the period 2000-2012. Around 23% of the investigated drivers/riders tested positive to one or more of six illicit substances for the period 2000-2012. This proportion is not too dissimilar to that reported by Morland et al. (2011) and others.

The findings in this study also show that the annual rate of detection of illicit drugs in fatally injured drivers/riders per 100,000 motor vehicle driver licences issued in Western Australia did not significantly vary over the entire period but was found to significantly decline over the period coinciding with the introduction of roadside oral fluid testing: 2008 to 2012. The latter finding provides some very preliminary evidence of an association between the oral fluid testing program and a reduction in illicit drug related driver/rider fatalities. The finding will be explored in a future project using additional data and more sophisticated analytical techniques such as segmented regression to provide a more rigorous investigation of the effect of the roadside oral fluid testing program on illicit drug related fatalities (see Palamara & Chow, 2015).

In the main, the illicit drug problem among fatally injured drivers/riders in Western Australia appears to be a single rather than poly illicit drug issue and one that mostly involves cannabis. The three prescribed illicit drugs - THC, methylamphetamine and MDMA –accounted for 97% of positive tests for the period, though THC accounted for two-thirds of the 383 positive detections. Indeed, fatally injured drivers/riders were 2.5

times more likely to test positive for THC compared with the next most frequently detected illicit substance, methylamphetamine. The higher prevalence of THC compared with other illicit substances is reasonably consistent with that reported in other Australia studies of drivers (see Drummer et al. 2003; Drummer et al. 2012) and other road users killed (see Fitzharris et al., 2007).

This study found that 18% of all fatally injured drivers/riders tested positive for THC. This proportion is consistent with that reported by Drummer et al. (2007) for Victorian drivers killed in 2004 but higher than that reported by Drummer et al. (2003) in a larger study of Australian drivers fatally injured during the period 1990-1999. Between 10.9% and 15.6% of drivers killed during that period tested positive for THC. In contrast, Morland et al's. (2011) investigation of Norwegian drivers killed during the period 2000-2001 reported that THC was presented in 4.8% of drivers. More recently, Drummer et al. (2012) reported that 9.8% of drivers admitted to hospital in Victoria from 2009 onwards tested positive for THC. Notwithstanding the variation in these findings, it is clear that THC is the most prevalent illicit substance among fatally injured drivers.

The higher prevalence of THC in this study underscores cannabis use as a major risk factor for the impairment of drivers on Western Australian roads. It raises questions regarding the level of use of cannabis within the community compared with elsewhere and the potential exposure of drivers and their risk of crashing. In relation to this, results from the 2010 National Drug Strategy Household Survey (AIHW, 2011a) found that cannabis is the most commonly used illicit drug in Australia (around10.3% of the survey respondents) with Western Australia ranked second for use of cannabis at 13.4% of the population aged 14+ years. The survey also noted that cannabis use by Western Australians in the 12 months prior to the survey had significantly increased from that surveyed in 2007. Estimating the crash risk associated with the use of cannabis is however difficult, since the prevalence of use among non-crash involved drivers cannot be reliably determined because current WAPOL roadside testing practice are not entirely random and drivers who test positive for alcohol are excluded from oral fluid testing.

Indeed some authors have expressed concern for an increasing exposure of non-crash involved drivers to cannabis. This was based on evidence of a 58% increase in the mean THC concentrations measured between 2000 and 2010 for Norwegian drivers apprehended by police (Vindenes, Strand, Kristofferesen, Boix & Morland, 2013).

Whether this phenomenon applies to Western Australian drivers cannot be readily answered from the Section 64AC offence data (non-crash involved drivers) analysed in this study since it did not include the level of THC detected. Changes in the policy and practice of testing the oral fluids of drivers/riders post 2010 (see below) also mean that this data cannot be used to reliably determine annual variation in the exposure of drivers to cannabis. In regard to fatally injured drivers/riders however, the proportion testing positive for THC in this study was found not to be significantly related to year of crash. Further to this, ancillary one way analysis of variance (using the Welch t-test for unequal variances and unequal sample sizes) of the annual mean concentration level of THC for fatally injured/drivers was found not to be statistically significant. Taken together, these results suggest that the detection of cannabis among fatally injured drivers/riders at least has remained unchanged over time. Other data from the household surveys of drug use reported by the AIHW (2011a) suggests however, that there is significant potential for an increase in the exposure of WA drivers to cannabis because of its use within the community.

THC was not only the most commonly detected single illicit substance but was also detected in 88% of drivers who tested positive for multiple illicit substances. In the vast majority of these cases THC was detected in combination with methylamphetamine (76% of multiple illicit substance fatalities), a finding which is generally consistent with that reported elsewhere in Australia (see Drummer et al., 2003). The combined use of such substances can greatly impair driving ability due to their respective adverse effects on central nervous system activity (NCIP 2009). The problem is further exacerbated when drivers combine the multiple illicit substances with legal but impairing substances such as alcohol and pharmaceuticals such as benzodiazepines and opioids, such as those detected in this study. The finding that nearly 50% of fatally injured drivers/riders in this study tested positive for alcohol and illicit drugs alone or in combination highlights the importance of comprehensive measures for surveillance and deterrence of multiple substance use.

The high prevalence of THC among fatally injured drivers/riders, along with the findings from laboratory and simulator studies of the detrimental effects of cannabis on various psychomotor and driving performance skills (see NCIP 2009), underscores the concern that cannabis use represents a significant source of risk for crash involvement and injury.

While Western Australia, like many other jurisdictions, enforces a zero tolerance policy for cannabis use (i.e., any level of THC in a driver is illegal), other jurisdictions like Norway have established a 'numerical threshold' for this illicit substance and others, including some legal pharmaceuticals (Canadian Centre on Substance Abuse, 2014). The implementation of non-zero 'per se' laws for cannabis such as those that apply for alcohol is based on the premise that research has been able to reliably identify a particular level or concentration at which a driver's skills and abilities are impaired (Canadian Centre on Substance Abuse, 2014). Based on a meta-analysis of numerous investigations of THC and crash involvement, Grotenhermen et al. (2007) have suggested that serum THC concentrations in the range of 7-10 ng/ml (equivalent to 7-10 ug/L) could be as impairing as a BAC of 0.05gm% and might serve as a lower legal limit for driving under the influence legislation for this substance. More recently, the Canadian Centre on Substance Abuse (2014) has suggested that the 'per se' law level could be as low as 3-5 ng/ml. Based on the lower level of these identified thresholds up to 53% of the 305 drivers testing positive for THC (alone and in combinations with other illicit substances) in this study would not be categorised as 'impaired'. At this stage however, there is insufficient reason or evidence to warrant Western Australia rejecting zero tolerance for a higher threshold of THC.

One of the major aims of the investigation of the fatal crash data was to profile illicit drug involved drivers/riders and to identify relevant risk factors. A number of significant factors were identified at the univariate level, many of which remained significant in the multivariate analysis. Like most other studies of illicit drug-related fatal crashes, drivers of motor cars accounted for the majority (75%) of illicit drug involved fatalities, followed by motorcycle/moped riders (23%). There was no evidence to suggest that the latter group of fatally injured road users were more likely to test positive for an illicit substance.

Previous studies have reported mixed findings in relation to the involvement of illicit substances in single versus multiple vehicle crashes. Though drivers/riders involved in the latter type of crash were 40% more likely in this study to test positive for an illicit substance, crash type was not retained in the final multivariate model which included other statistically significant road user and crash related factors. This was most likely due to the very strong association of BAC with the detection of an illicit substance, which is

also a noted risk factor for single vehicle killed and serious injury crash (see Palamara et al., 2013).

Drivers/riders fatally injured in crashes in the Perth metropolitan region versus rural WA were significantly more likely to test positive for an illicit substance. This finding contrasts with the higher incidence of illicit drug related crashes on rural roads reported in the study by Beasley et al. (2011) but is consistent with a higher incidence of illicit drug related crashes on urban roads reported by Smink et al. (2005). However, after adjusting for other significant illicit drug related driver and crash risk factors (e.g., age, gender, license status, and other impairing substances) the location of the fatal injury crash was found not to be significantly related to the risk of illicit drug involvement. Reasons for the higher proportion of the involvement of illicit drugs in metropolitan based crashes observed at the univariate level in this study could include population demographics related to drug use (i.e., greater number of younger age persons residing in metropolitan WA) and the increased availability of illicit drugs in the metropolitan area.

Further analysis of the distribution of illicit drug involved fatalities by WA Police district revealed significant variation within and across metropolitan and regional areas. For example, within the metropolitan area, the North-West (34.3%) and South-East (30.8%) districts evidenced the highest proportions of illicit drug involved fatalities, while proportions were relatively higher in the Kimberly (30%) and South-West (28.1%) districts in regional WA. In absolute numbers and as a proportion of the total number of illicit drug involved fatalities for the period, the South-West regional district (17.6% of all illicit drug related fatalities) and the South-East metropolitan district (12% of all illicit drug related fatalities) would appear to be districts of concern. Whether this is related to a higher level of illicit drug use within these communities compared with others or differences in the level of policing related to drug use in these communities is a matter of speculation and requires further investigation. For example, the aforementioned geographic distribution of illicit drug related fatal crashes could be investigated with reference to sub-populations residing in these locations that are known to have a higher risk of illicit drug use, particularly cannabis. Examples of such sub-populations include unemployed persons, students, those who are single, and those of Indigenous status (see AIHW, 2011a).

The relationship between time and day of week of the crash and illicit drug involvement was mixed. Unlike other studies which have noted a somewhat higher prevalence of illicit drug involvement on weekend days (e.g., Norlen et al. 2102), this relationship was not found to be statistically significant despite evidence of slightly higher prevalence on Fridays (26.5%) and Saturdays (26.2%). In comparison, time of day of the crash – 1800 to 0559 hours - was found to be associated with an 80% increase in the likelihood of the detection of an illicit substance among fatally injured drivers/riders. It is difficult to compare this finding with those of other studies of this variable because they also included other substances, such as alcohol, in their reporting of illicit drug related crashes around this time period. For example, Beaseley et al. (2011) noted that around 27.3% of drivers fatally injured between midnight and 6.00am tested positive for alcohol and drug use, while 24.9% tested positive to only drug use between midday to 6.00pm. Like crash type (single *versus* multiple vehicle), time of day of the fatality was not significant in the multivariate model, most likely because crashes later in the evening/early morning are also known to be strongly associated with higher BAC levels (see Palamara et al., 2013).

Other studies have provided some evidence to suggest that up to a quarter of drivers who speed test positive to illicit drugs (Bedard et al., 2007). However, this study was unable to investigate the relationship between speed at the time of the crash and the involvement of an illicit substance. Western Australia's police reported crash data does not include reliable evidence of the involvement of speeding. The only other recorded speed-related crash information is the speed zone at the location of the crash, which was not found to be significantly associated with the detection of an illicit substance in the fatally injured driver/rider.

The findings of this study and others (e.g., Beasley et al., 2011) fail to provide sufficient and consistent evidence of an increased risk of crashing on curved rather than straight section of road for drivers who test positive for an illicit substance. Rather, additional analyses in this study showed that alcohol, after controlling for the presence of illicit substances which was non-significant, was significantly associated with an increased likelihood (between 1.57 and 2.4 times depending on the level of BAC) of the fatal crash occurring on a curve rather than straight section of road. Other studies (see Palamara,

Broughton & Fraser, 2013 for a review) have similarly shown that alcohol increases the risk of a run off road crash on a curve

This study similarly did not find evidence to confirm that drivers/riders who test positive to illicit substances are less likely to wear a seat-belt or use a helmet because of some common basis in risk taking. This contrasts with the findings of Beasley et al. (2011), Romano and Voss (2011) and Lacey et al. (2009), all of whom reported an increased likelihood of illicit drug affected drivers not wearing a seat-belt.

The most significant findings of the risk factors associated with the detection of an illicit substance among fatally injured drivers/riders were provided through the multivariate modelling. These findings are particularly meaningful because the risk associated with any one factor was quantified while controlling for its significant covariates. In this investigation driver age, gender, licensing status, alcohol, and the presence of certain non-illicit substances (e.g., benzodiazepines with and without opioids) were independently predictive of the increased likelihood of a fatally injured driver/rider testing positive for an illicit substance. The increased odds of testing positive for an illicit substance for male drivers/riders, those under 40 years of age, and those driving without a valid licence is consistent with the findings of previous research into illicit drug involved fatalities. As a rule, drivers with these characteristics are generally more likely to be involved in killed and serious injury crashes and to engage in risk taking behaviours such as speeding and drink driving. Such drivers obviously represent high priority target groups for measures to counter drug-driving as well as other problem behaviours. This is particularly so for driver age as fatally injured drivers less than 40 years of age in this study were over four times more likely to test positive for an illicit substance.

Alcohol featured very strongly in this study's findings and reaffirms the concern that this 'legal' substance, alone and in association with other impairing substances, is a major crash risk factor. In this study, 34% of fatally injured drivers/riders returned BAC levels ≥0.05gm%. This is significantly higher than the 23% who tested positive for an illicit substance. The higher prevalence of alcohol compared with that for illicit drugs is consistent with the findings of other investigations (e.g., Morland et al 2011; Drummer et al 2003; Drummer et al., 2012). Importantly, the findings in this study clearly demonstrate that alcohol and illicit drugs are found in combination among fatally injured

drivers/riders: driver/riders with a BAC level of 0.05gm% to 0.140gm% were 2.66 to three times more likely to test positive for an illicit substance. When considered together, nearly 47% of all fatally injured drivers/riders in this study were at risk of impairment because they tested positive to either alcohol alone (i.e., ≥ 0.05 gm%), illicit drugs alone, or alcohol and illicit drugs in combination.

The preceding finding highlights a troubling cocktail of substance use and potential impairment which is further exacerbated by the multivariate findings of an independent significant effect of benzodiazepine and opioid use in conjunction with illicit drugs. The detection of benzodiazepines, either alone or in conjunction with opioids, among fatally injured drivers/riders significantly increased the odds (between 2.7 and 3.5 times) of testing positive for an illicit substance. The use of both benzodiazepines (e.g., Barbone et al., 1998; Morland et al., 2011; Meuleners et al., 2011; Poulsen et al., 2012;) and opioids (Meuleners et al., 2011) in their own right have been shown to be associated with a significant increase in the risk of crashing among drivers of various ages. However, their use in association with illicit drugs and even alcohol has the potential to amplify the risk of crashing. Fortunately, most drivers who tested positive for benzodiazepines and/or opioid use did not test positive for an illicit substance and fewer again returned a BAC level ≥ 0.05 gm%. In all, around 6% of all fatally injured drivers/riders tested positive for a combination of benzodiazepines and/or opioids, illicit drugs and alcohol (i.e., BAC level ≥ 0.05 gm%), a combination that is highly likely to impair the judgement and skill of a driver/riders.

Why fatally injured drivers/riders in this study testing positive for benzodiazepines alone and in combination with opioids had a significantly increased risk of testing positive for an illicit substance is open to interpretation. Unfortunately it cannot be determined from the data whether these substances were being used legally or abused in combination with illicit drugs. It is also not known whether these drugs were present in the driver at the time of the crash or whether their presence is somehow related to whatever treatment they received if they had been hospitalised prior to death. Further research is required to address this issue.

6.2 Illicit drugs detected through roadside random drug testing

Western Australia's roadside random drugs testing program to detect prescribed illicit substances (e.g., THC, methylamphetamine, MDMA/ecstasy) in oral fluids formally commenced in October 2007 and for the period 2008-2012 has charged approximately 3.7% of tested drivers/riders with a Section 64AC offence. This is slightly higher than the 2.4% reported by Drummer et al. (2007) from the random roadside testing of over 13,000 Victorian drivers back in 2004. It must be borne in mind however, that WAPOL's oral fluid testing program is not truly random and as such is likely to yield a higher proportion of positive tests compared with programs that are truly random.

Though limited years of data were provided for analysis, it does show that the number of roadside oral fluid tests conducted over the period 2008-2012 has remained relatively stable despite a corresponding increase in the number of motor vehicle driver licences issued over the same period. Not so surprisingly then, the annual offence rate per 1,000 tests conducted was found to have significantly varied over the period, with the 2012 rate being some 66% higher than at the beginning of the period (2008). One interpretation of this finding is that WA driver/rider exposure to the three prescribed substances has substantially increased without a corresponding increase in the amount of enforcement. An alternative and perhaps more plausible explanation is that WA Police are being more strategic in the use of their limited testing resources and are targeting drivers/riders who have a higher likelihood of returning a positive test. Either way, Cameron's (2012) extensive review of drug driving enforcement in WA concluded that enforcement and deterrence should be enhanced through a cost-effective increase in the number of roadside oral fluid tests in vicinity of 90,000 to 160,000 per annum. He also recommended that testing continue through the highly visible Random Breath Testing bus operations because other jurisdictions had found this procedure to be effective in reducing the incidence of drug-driving and because it may enhance the general deterrence of drug-driving.

Though the period of investigation was limited to just five years, the findings showed the vast majority of drivers were not repeat offenders. The maximum number of Section 64 offences committed by any one driver was three. Further years of data might provide a more accurate understanding of the problem of repeat offending, particularly since a driver's chances of being caught during the period was rather small given the number of

tests conducted. Consistent with other research (e.g., Holmgren et al., 2008), this study found that males were 2.4 times more likely than females to be recidivist Section 64AC offenders and to account for the greater proportion (83.9%) of all drug-driving offences.

While younger age drivers/riders were not significantly more likely to be repeat offenders, drivers aged 15-24 years and 25-39 years accounted for the greater proportion of offences for the period. In addition, drivers in these age groups were two to four times more likely to test positive for multiple illicit substances than those aged 40+ years. Again, these findings are consistent with other evidence citing younger age drivers as more likely to repeat drug-drive (e.g., Holmgren et al., 2008) and consistently more likely to engage in on-road risk taking behaviours such as drink-driving, failing to use seat-belts, and speeding (see Palamara et al., 2013).

The increased likelihood of offending by males and younger age drivers/riders is consistent with the identified increased risk for males and younger age drivers/riders who are fatally injured and non-crash involved drivers who test positive for an illicit substance (see Drummer et al., 2007; Drummer et al., Poulsen et al., 2012). This is not an altogether surprising finding given the volume of empirical evidence showing that Western Australian males and younger age persons have a significantly higher likelihood of engaging in on-road and other health related risk behaviours (see Palamara et al., 2013; Palamara, Molnar et al., 2013).

The study also highlighted some significant findings in relation to multiple illicit substance use. Around seven in ten offenders tested positive to only one prescribed illicit substance, similar to that observed for fatally injured drivers/riders. However, unlike that observed for fatally injured drivers/riders, methylamphetamine and not THC was the most commonly detected substance. Alone it accounted for 61.4% of positive tests and 27.4% in combination with other illicit substance, mostly THC. The seven in ten drivers/riders who tested positive to one substance only is somewhat comparable to the 85% of randomly selected drivers in Glasgow who tested positive to one illicit drug only (Wylie et al., 2005). In contrast to the findings of this study where methylamphetamine was the most commonly detected substance, MDMA (escstasy) was most commonly detected in the study reported by Wylie et al. (2005).

Those who drive while affected by multiple substances represent a significant road safety problem. While this study has highlighted the problem of poly illicit substances among fatally injured drivers/riders and non-crash involved drivers/riders, the reliability of the latter finding is potentially undermined by a change in policy at the end of 2010 regarding which substances the ChemCentre are required to initially test for when samples from roadside testing are sent for analysis. As reported in the logistic regression of multiple substance use by Section 64AC offenders, the odds of drivers/riders testing positive to multiple illicit substances was significantly higher in the years 2008-2010 but not 2011 (compared with 2012). Discussions with the ChemCentre (personal communication with R. Hansson 2014) regarding this finding revealed that from 2011 onwards, oral fluid samples were no longer consistently and routinely tested for all three illicit substances (methylamphetamine, THC and MDMA) even where there was preliminary evidence for doing so as was the case in previous years. From 2011 onwards, ChemCentre testing initially focused on the detection of methylamphetamine. If the sample tested positive further tests for other substances were not routinely undertaken. This change in policy essentially limits the detection of multiple illicit substances and our understanding of the prevalence of drivers affected by multiple illicit substances.

Notwithstanding this change of policy, the offence data demonstrates a noteworthy pattern of results that underlines recent concern over the increased prevalence in the manufacture, availability and use of amphetamine-type drugs/methylamphetamine in the wider community. The Australian Institute of Criminology (Macgregor & Payne, 2011) noted that methylamphetamine use among police detainees significantly increased 2010-2011 compared with previous years, with users reporting that both the quality and availability of the drug had also improved. The Australian Crime Commission (2014) also noted in their annual report of illicit drug data that border detections for amphetamine-type substances increased in 2012/2013 and were the highest on record. They also noted that detections in 2012/2013 of clandestine laboratories for the manufacture (and subsequent availability) of substances such as methylamphetamine were the second highest number in the past decade. These findings highlight the likelihood that amphetamine/methylamphetamine availability and use will be an on-going risk factor for road crashes and injury.

The roadside drug testing operations data for the period strongly implies that very little roadside random drug testing took place in the non-metropolitan regions of WA over the period of investigation. Less than one in ten offences analysed were recorded in regional Western Australia. This low number realistically limits the veracity of the conclusions that can be drawn about illicit drug-driving among non-crash involved drivers/riders in that region. However, if this figure is somewhat representative of the level of roadside drug testing undertaken outside metropolitan Perth during this time, it would appear to represent an 'under-enforcement' of the potential problem given that just under 43% of fatally injured drivers/riders that tested positive for an illicit substance during the period 2008-2012 crashed on regional WA roads. On this basis there is good reason to argue for a substantial increase in the number of roadside oral fluid tests in the non-metropolitan area.

On the other hand, the findings for the metropolitan region - read in conjunction with those for driver/rider fatalities - provide a somewhat better evidence base for understanding the geography of drug-driving across metropolitan Perth. Despite the absence of knowledge in this study of the total number of roadside tests undertaken in each metropolitan district, the South-East metropolitan district appears to be a particular problem area for drug driving given the 30% of all metropolitan offences and 23% of metropolitan area illicit drug involved driver/rider fatalities recorded in this district. This district was also found to account for under a third of all offences in the metropolitan area involving methylamphetamine and methylamphetamine in combination with THC. It would be beneficial to investigate how other intelligence on the illicit drug problem for this area (e.g,, detections of clandestine laboratories; arrests for supply, sell, possession) are related to the road safety related indices of illicit drug involved fatalities and drug-driving offences.

Another caveat that should be noted in the use of Section 64AC data to understand the prevalence of illicit drug driving, is that roadside drug testing is typically undertaken in tandem with roadside testing for alcohol as part of WAPOL's 'Booze Bus' program. This may limit which drivers/riders are 'randomly' selected for oral fluids testing. WAPOL have advised that once a driver/rider is found to have exceeded the legal BAC limit for their licence class they are automatically excluded from oral fluids testing for an illicit substance. This is because the penalty for an alcohol offence is greater than that for an

illicit drug offence and secondly, because of the additional cost involved in drug testing the driver who is already subject to a penalty. Given the very strong association between illegal BAC levels and illicit drug use reported in this study for fatally injured drivers/riders, there is a high likelihood that a good proportion of drivers who test positive for alcohol at an RBT point will have used an illicit substance but not be detected or charged. Victoria Police recognise the increased potential for impairment from a combination of alcohol and illicit substances and will from 2015 drug test the majority of drivers who test positive for alcohol. This practice will be supported by the introduction of a special class of offence for the combined use of alcohol and illicit drugs (personal communication with Superintendent Neville Taylor and Inspector Martin Boorman, October 2014). WAPOL should similarly adopt this practice and the new 'combined impairment' offence.

6.3 Limitations of the study

A number of issues limit the validity and reliability of the findings presented in this report. In relation to fatally injured drivers/riders, data were retrieved for 90% of drivers/riders killed on Western Australian road during the study period. It is not known whether the inability to retrieve data on all drivers/riders was due to errors in the extraction of relevant records from the ChemCentre or that no records were available for these fatalities because blood or fluid samples were not sent for analysis. Drivers/riders that die following admission to hospital and treatment may not necessarily have samples taken for screening (R. Hansson personal communication 2014). The number of deaths this scenario applies to could not be determined in this study but could be determined if crash and ChemCentre records were linked with WA Health Department records of hospital admission.

The findings in relation to certain illicit substance and other legal drugs may not necessarily represent the level of the drug present in the driver at the time of crash, or even if the drug was present at all at the time of the crash. This is because we were unable to determine if the driver died at the roadside or in hospital following treatment or what treatment (e.g., drugs) they received. The timing of the driver/rider's death means that ChemCentre reports may not always represent the most accurate information in relation to what substances – illicit or otherwise – and level of substance was present in the driver/rider at the time of the crash. The accuracy of this information depends on the

elapsed time between the crash and the driver/rider's death, what drugs were administered in the course of treatment before death if the driver/rider was taken to hospital, and the relevant half-life of the substance detected. The relevance of these factors to the findings presented in this study cannot be determined without recourse to an investigation of coronial and hospital treatment records. Previous investigations of drug related road fatalities in Australia (e.g., Fitzharris et al., 2007) have attempted to address such issues by segmenting the analysis by location of death: roadside versus hospital. In that particular study 29% of road user deaths in 2004 occurred in hospital.

There are similarly a number of issues that limit the findings in relation to Section 64AC offences. Firstly, it is likely that Section 64AC offence data does not provide the most accurate estimate of the prevalence of illicit drugs in non-crash involved drivers. This is because the WAPOL program of roadside oral fluid testing appears to be targeted toward drivers who meet criteria related to an increased likelihood of illicit drug use. In addition, the practice of not drug testing drivers who test positive for alcohol will likely exclude some drivers who would otherwise test positive for illicit drugs. A number of records related to positive tests for an illicit substance were also excluded from the analysis because they lacked complete data, namely ChemCentre results for the offences.

The findings in relation to offending drivers were largely restricted to gender and age. No information was available from the WAPOL 'Briefcase System' on vehicle type driven/ridden at the time of the offence or the licensing status of the driver/rider. The investigation would have yielded further information on risk factors if driver/rider licensing records for offending driver/riders and those fatally injured could have been retrieved and cross matched to determine the relationship between drug driving offending and fatal crash involvement. That had been an objective of the research but timeliness issues overrode the possibility of doing so.

6.4 Recommendations

The following recommendations related to data and research and policy and practice are offered for consideration.

Data and Research

One of the difficulties encountered during the study was the linking of ChemCentre records with WA Police crash records. WA Police and the ChemCentre do not share a

unique numerical identifier, such as a crash record number or driver licence number (in the case of drivers/riders). The linkage process was consequently undertaken with some difficulty using the fatally injured driver's name, age, and details of the crash.

That WA Police and the ChemCentre work toward the sharing and use of a common, unique case identifier for traffic related deaths to facilitate future linkages of their respective data.

Research into Western Australia's police reported road crashes most commonly uses data retrieved from the Integrated Road Information System managed by Main Roads WA. This dataset contains information supplied by the ChemCentre on the Blood Alcohol Concentration level of fatally injured drivers but no information relating to the detection of illicit substances. Illicit substances are - like alcohol - a potentially significant cause of driver impairment, and as this research has highlighted they are strongly associated with the use of alcohol. Information on the detection of illicit substances among fatally injured drivers/riders (and other road users) should consequently be included in the police reported crash dataset maintain by MRWA. This would provide road safety researchers with a more complete understanding of the presence of impairing substances without having to make additional, time consuming requests for data.

That WA Police and the ChemCentre negotiate the supply of information on the presence of illicit substances for fatally injured road users to Main Roads WA for inclusion in their Integrated Road Information System database of police reported road crashes.

For pragmatic reasons this research was unable to retrieve and link Department of Transport (licensing and traffic offence) records of fatally injured drivers/riders. Consequently, we have no understanding of how licensing and offence histories may be used to identify drivers/riders who are at risk of illicit drug-involved fatal crashes and how such information might be used to better manage these drivers.

This research similarly did not link crash records with Health Department of WA records of treatment that fatally injured drivers/riders *may have* received on admission to hospital prior to their death. The availability of this information would be useful. It would potentially help account for a proportion of fatally injured drivers/riders for whom no ChemCentre record could be linked (as no samples were sent for testing upon admission) or explain/clarify the detection of certain substances, illicit and otherwise (based on treatment received and time when sample was taken.

That future research into illicit drug related driving seek to link crash and toxicology data with Department of Transport and Health Department of WA data (in and out patient).

In addition to Recommendation (3) there is a need to undertake research into the prevalence of illicit drugs among drivers who are not fatally injured and admitted to hospital. At present, this prevalence is unknown in Western Australia.

That a program of research be established to investigate the prevalence of illicit drug use among non-fatally injured drivers admitted to hospital.

Policy and Practice

There are a number of reasons to recommend an increase in the number of roadside oral fluid tests conducted by WAPOL across the metropolitan and non-metropolitan area. Based on data for the period 2008-2012, the number of tests conducted has remained relatively stable and has not increased in line with the growth that has occurred in WA's population and the number of motor vehicle driver licences issued. An increase in enforcement is particularly required for the non-metropolitan area which has to date received minimal roadside oral fluid testing enforcement but evidenced nearly half of all illicit drug related driver/rider deaths. Other data which shows that the recent use of illicit drugs such as cannabis and methylamphetamine/methamphetamine in WA is somewhat higher relative to other Australian jurisdictions also suggests that Western Australia's roadside oral fluids enforcement program should be bolstered.

That the Western Australian government increase the number of roadside oral fluid tests in the metropolitan and particularly the non-metropolitan areas.

The current WAPOL practice is not to conduct an oral fluids drug test on a driver at a random breath testing operation if the driver first returns a BAC level exceeding their permitted level. Given the identified relationship between alcohol and illicit drug use, albeit amongst fatally injured drivers/riders, the failure to subject some drivers/riders with an illegal BAC to an oral fluids test will result in the lack of detection and underestimation of the prevalence of drivers/riders who use alcohol in conjunction with illicit drugs and thus increase their level of impairment.

That the Western Australian government undertake the selective oral fluid testing of drivers/riders who exceed their prescribed limit of Blood Alcohol Concentration.

This investigation noted that the incidence of Section 64AC offending drivers testing positive to multiple illicit substances declined significantly in 2011 and 2012 compared with 2008-2010. WAPOL and the ChemCentre have advised that the decline was most likely due to the decision to limit the initial testing of samples to methylamphetamine since this is the most commonly detected illicit substance in oral fluids. If positive, no further tests would be conducted even when Cozart testing indicated the presence of THC. This practice and the existing Road Traffic Act for illicit substances in oral fluids (which does not provide an additional penalty for more than one prescribed substance) undermines the deterrence of multiple illicit substance use by drivers. Further to this, the practice undermines the utility of the offence data as source of information on multiple substance use by drivers and riders.

That the Western Australian government reinstate the practice of confirmatory testing of both methylamphetamine and THC where there is preliminary evidence for doing so, and not just methylamphetamine as a first-choice option.

Though the number of recidivist Section 64AC offenders was found to be relatively small for the period of investigation, there is reason nevertheless to consider additional measures to not only deter but to better manage the drug use behaviour of repeat offenders. This could be accomplished through mandatory drug-use treatment programs for repeat offenders.

That a stakeholder forum be established to discuss the benefits of introducing mandatory drug-use treatment programs for repeat Section 64AC offenders

REFERENCES

AAMI. (2012). Young driver index: Author.

Adlaf, E. M., Mann, R. E., & Paglia, A. (2003). Drinking, cannabis use and driving among Ontario students. *Canadian Medical Association Journal, 168*, 565-566.

Aitken, C.; Kerger, M. & Crofts, N. (2000). Drivers who use illicit drugs: Behaviour and perceived risks. *Drugs: Education, Prevention and Policy*, *7*, 29-50.

Albery, I. P., Strang, J., Gossop, M., & Griffiths, P. (2000). Illicit drugs and driving: Prevalence, beliefs and accident involvement among a cohort of current out-of-treatment drug users. *Drug and Alcohol Dependence, 58*, 197-204.

Armstrong, K. A., Wills, A. R., & Watson, B. C. (2005). *Psychosocial influences on drug driving in young Australian drivers*. Paper presented at the Proceedings Australasian Road Safety Research Policing Education Conference, Wellington, New Zealand.

Arria, A. M., Caldeira, K. M., Vincent, K. B., Garnier-Dykstra, L. M., & O'Grady, K. E. (2011). Substance-related traffic-risk behaviors among college students. *Drug and Alcohol Dependence, 118*, 306-312.

Ashbridge, M., Hayden, J. A., & Cartwright, J. L. (2012). Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. *British Medical Journal, 344*, 1-9.

Ashbridge, M., Poulin, C., & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident Analysis and Prevention, 37*, 1025-1034.

Australian Bureau of Statistics [ABS]. (2010). Australian Social Trends. Author.

Australian Institute of Health and Welfare [AIHW]. (2011a). 2010 National drug strategy household survey report. Canberra, ACT: Author.

Australian Institute of Health and Welfare [AIHW]. (2011b). Drugs in Australia 2010 - Tobacco, alcohol and other drugs. Canberra, ACT: Author.

Ayuso, M., Guillén, M., & Alcañiz, M. (2010). The impact of traffic violations on the estimated cost of traffic accidents with victims. *Accident Analysis and Prevention, 42*, 709-717.

Barbone, F.; McMahon, A.; Davey, P.; Morris, A.; Reid, I.; McDevitte, D. & MacDonald, T. (1998). Association of road traffic accidents with benzodiazepine use. *The Lancet, 335*, 1331-1336.

Barrett, S. P., Gross, S. R., Garand, I., & Pihl, R. O. (2005). Patterns of simultaneous polysubstance use in Canadian rave attendees. *Substance Use and Misuse, 40*, 1525-1537.

Beasley, E. E., Beirness, D. J., & Porath-Waller, A. J. (2011). A comparison of drug and alcohol involved motor vehicle driver fatalities. Ottawa, ON: Canadian Centre on Substance Abuse.

Bedard, M., Dubois, S., & Weaver, B. (2007). The impact of cannabis on driving. *Canadian Journal of Public Health, 98*, 6-11.

Biecheler, M.-B., Peytavin, J.-F., the S. A. M. Group, Facy, F., & Martineau, H. (2008). SAM survey on "drugs and fatal accidents": Search of substances consumed and comparison between drivers involved under the influence of alcohol or cannabis. *Traffic Injury Prevention, 9*, 11-21.

Bierness, D. J., & Beasley, E. E. (2010). A roadside survey of alcohol and drug use among drivers in British Columbia. *Traffic Injury Prevention, 11*, 215-221.

Blencowe, T., Pehrsson, A., Mykkänen, S., Gunnar, T., & Lillsunde, P. (2012). Cannabis findings in drivers suspected of driving under the influence of drugs in Finland from 2006 to 2008. *Forensic Science International, 217*, 107-112.

Bogstrand, S. T., Normann, P. T., Rossow, I., Larsen, M., Mørland, J., & Ekeberg, Ø. (2011). Prevalence of alcohol and other substances of abuse among injured patients in a Norwegian emergency department. *Drug and Alcohol Dependence, 117*, 132-138.

Boorman, M., & Owens, K. (2009). The Victorian legislative framework for the random testing drivers at the roadside for the presence of illicit drugs: An evaluation of the characteristics of drivers detected from 2004 to 2006. *Traffic Injury Prevention, 10*, 16-22.

Brady, J. E., & Li, G. (2012). Prevalence of alcohol and other drugs in fatally injured drivers. *Addiction*, [E-pub ahead of print].

Bramwell, J., Hill, D. & Thompson, P. (2014). *Reported road crashes in Western Australia 2012*. Perth, Western Australia: Road Safety Council of Western Australia.

Brookhuis, K., Waard, D., & Samyn, N. (2004). Effects of MDMA (ecstasy), and multiple drugs use on (simulated) driving performance and traffic safety. *Psychopharmacology, 173*, 440-445.

Bukten, A., Skurtveit, S., Gossop, M., Waal, H., Stangeland, P., Havnes, I., & Clausen, T. (2012). Engagement with opioid maintenance treatment and reductions in crime: a longitudinal national cohort study. *Addiction, 107*, 393-399.

Burch, H. J., Clarke, E. J., Hubbard, A. M., & Scott-Ham, M. (2013). Concentrations of drugs determined in blood samples collected from suspected drugged drivers in England and Wales. *Journal of Forensic and Legal Medicine, 20*, 278-289.

Cameron, M. (2012). *Development of a strategy for enhanced drink and drug driving enforcement in Western Australia*. Unpublished report to the WA Office of Road Safety. Melbourne, Victoria: Camcomp Partners P/L.

Canadian Centre on Substance Abuse (September 2014). Policy brief: Drug per se laws. Downloaded from www.ccsa.ca.

C'De Baca, J., McMillan, G. P., & Lapham, S. C. (2009). Repeat DUI offenders who have had a drug diagnosis: Are they more prone to traffic crashes and violations? *Traffic Injury Prevention, 10*, 134-140.

Chang, I., & Lapham, S. C. (1996). Validity of self-reported criminal offences and traffic violations in screening of driving-while-intoxicated offenders. *Alcohol and Alcoholism, 31*, 583-590.

Cheng, J. Y., Chan, D. T., & Mok, V. K. (2005). An epidemiological study on alcohol/drugs related fatal traffic crash cases of deceased drivers in Hong Kong between 1996 and 2000. *Forensic Science International, 153*, 196-201.

Chu, M., Gerostamoulos, D., Beyer, J., Rodda, L., Boorman, M., & Drummer, O. H. (2012). The incidence of drugs of impairment in oral fluid from random roadside testing. *Forensic Science International, 215*, 28-31.

Clarke, D. D., Ward, P., Bartle, C., & Truman, W. (2010). Killer crashes: Fatal road traffic accidents in the UK. *Accident Analysis and Prevention, 42*, 764-770.

Darke, S., Kelly, E., & Ross, J. (2004). Drug driving among injecting drug users in Sydney, Australia: prevalence, risk factors and risk perceptions. *Addiction, 99*, 175-185.

Davey, J., Davies, A., French, N., Williams, C., & Lang, C. P. (2005). Drug driving from a user's perspective. *Drugs: Education, Prevention, and Policy, 12*, 61-70.

Downey, L. A., King, R., Papafotiou, K., Swann, P., Ogden, E., Boorman, M., & Stough, C. (In press). The effects of cannabis and alcohol on simulated driving: Influences of dose and experience. *Accident Analysis and Prevention*, [In Press].

Drummer, O. H., Gerostamoulos, J., Batziris, H., Chu, M., Caplehorn, J., Robertson, M. D., & Swann, P. (2004). The involvement of drugs in drivers of motor vehicles killed in Australian road traffic crashes. *Accident Analysis and Prevention, 36*, 239-248.

Drummer, O. H., Gerostamoulos, J., Batziris, H., Chu, M., Caplehorn, J. R., Robertson, M. D., & Swann, P. (2003). The incidence of drugs in drivers killed in Australian road traffic crashes. *Forensic Science International, 134*, 154-162.

Drummer, O.H., Gerostamoulos, J., Chu, M., Swann, P., Boorman, M. & Cairns, I. (2007). Drugs in oral fluid in randomly selected drivers. *Forensic Science International*, *170*, 105-110.

Drummer, O. H., Kourtis, I., Beyer, J., Tayler, P., Boorman, M., & Gerostamoulos, D. (2012). The prevalence of drugs in injured drivers. *Forensic Science International, 215*, 14-17.

Duff, C., & Rowland, B. (2006). 'Rushing behind the wheel': Investigating the prevalence of 'drug driving' among club and rave patrons in Melbourne, Australia. *Drugs: Education, Prevention, and Policy, 13*, 299-312.

Elliott, S., Woolacott, H., & Braithwaite, R. (2009). The prevalence of drugs and alcohol found in road traffic fatalities: a comparative study of victims. *Science and Justice, 49*, 19-23.

Forward, S. (2010). Motives behind risky driving - driving under the influence of alcohol and drugs. Sweden.

Gjerde, H., Christophersen, A. S., Normann, P. T., & Mørland, J. (2011). Toxicological investigations of drivers killed in road traffic accidents in Norway during 2006–2008. *Forensic Science International, 212*, 102-109.

González-Wilhelm, L. (2007). Prevalence of alcohol and illicit drugs in blood specimens from drivers involved in traffic law offenses. Systematic review of cross-sectional studies. *Traffic Injury Prevention, 8*, 189-198.

Holmgren, A., Holmgren, P., Kugelberg, F. C., Jones, A. W., & Ahlner, J. (2007). Predominance of illicit drugs and poly-drug use among drug-impaired drivers in Sweden. *Traffic Injury Prevention, 8*, 361-367.

Holmgren, A., Holmgren, P., Kugelberg, F. C., Jones, A. W., & Ahlner, J. (2008). High re-arrest rates among drug-impaired drivers despite zero-tolerance legislation. *Accident Analysis and Prevention, 40*, 534-540.

Holmgren, P., Holmgren, A., & Ahlner, J. (2005). Alcohol and drugs in drivers fatally injured in traffic accidents in Sweden during the years 2000–2002. *Forensic Science International, 151*, 11-17.

Impinen, A., Rahkonen, O., Karjalainen, K., Lintonen, T., Lillsunde, P., & Ostamo, A. (2009). Substance use as a predictor of driving under the influence (DUI) rearrests. A 15-year retrospective study. *Traffic Injury Prevention, 10*, 220-226.

Jones, C., Donnelly, N., Swift, W., & Weatherburn, D. (2006). Preventing cannabis users from driving under the influence of cannabis. *Accident Analysis and Prevention, 38*, 854-861.

Kelly, E., Darke, S., & Ross, J. (2004). A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. *Drug and Alcohol Review, 23*, 319-344.

Kuypers, K. P. C., Legrand, S. A., Ramaekers, J. G., & Verstraete, A. G. (2012). A case-control study estimating accident risk for alcohol, medicines and illegal drugs. *PLoS ONE, 7*, e43496.

Kuypers, K. P. C., Samyn, N., & Ramaekers, J. G. (2006). MDMA and alcohol effects, combined and alone, on objective and subjective measures of actual driving performance and psychomotor function. *Psychopharmacology, 187*, 467-475.

Lacey, J. H., Kelley-Baker, T., Furr-Holden, D., Voas, R. B., Romano, E., Ramirez, A., . . . Berning, A. (2009). 2007 national roadside survey of alcohol and drug use by drivers: Drug results. Washington, DC: National Highway Traffic Safety Administration.

Laumon, B., Gadegbeku, B., Martin, J.-L., Marie-Berthe, B., & The S. A. M. Group. (2005). Cannabis intoxication and fatal road crashes in France: Population based case-control study. *British Medical Journal, 331*, 1371-1374.

Legrand, S.-A., Gjerde, H., Isalberti, C., Van der Linden, T., Lillsunde, P., Dias, M. J., . . . Verstraete, A. G. (2013). Prevalence of alcohol, illicit drugs and psychoactive

medicines in killed drivers in four European countries. *International Journal of Injury Control and Safety Promotion*, 1-12.

Legrand, S.-A., Isalberti, C., der Linden, T. V., Bernhoft, I. M., Hels, T., Simonsen, K. W., . . . Verstraete, A. G. (2013). Alcohol and drugs in seriously injured drivers in six European countries. *Drug Testing and Analysis, 5*, 156-165.

Li, M., DiMaggio, C., Brady, J., Lusardi, A., Tzong, K., & Li, G. (2011). Marijuana use and motor vehicle crashes: A meta-analysis. *American Journal of Epidemiology, 173*, S201-S201.

Longo, M. C., Hunter, C. E., Lokan, R. J., White, J. M., & White, M. A. (2000a). The prevalence of alcohol, cannabinoids, benzodiazepines and stimulants amongst injured drivers and their role in driver culpability: Part I: The prevalence of drug use in drivers, and characteristics of the drug-positive group. *Accident Analysis & Prevention, 32*, 613-622.

Longo, M. C., Hunter, C. E., Lokan, R. J., White, J. M., & White, M. A. (2000b). The prevalence of alcohol, cannabinoids, benzodiazepines and stimulants amongst injured drivers and their role in driver culpability: Part II: The relationship between drug prevalence and drug concentration, and driver culpability. *Accident Analysis and Prevention, 32*, 623-632.

Macdonald, S., Anglin-Bodrug, K., Mann, R. E., Erickson, P., Hathaway, A., Chipman, M., & Rylett, M. (2003). Injury risk associated with cannabis and cocaine use. *Drug and Alcohol Dependence, 72*, 99-115.

Marowitz, L. A. (1994). The relationship between drug arrests and driving risk. Sacramaneto, CA: California Department of Motor Vehicles.

Matthews, A., Bruno, R., Johnston, J., Black, E., Degenhardt, L., & Dunn, M. (2009). Factors associated with driving under the influence of alcohol and drugs among an Australian sample of regular ecstasy users. *Drug and Alcohol Dependence, 100*, 24-31.

Meuleners, L., Duke, J., Lee, A., Palamara, P., Hildebrand, J. & Ng, J. (2011). Psychoactive medications and crash involvement requiring hospitilization for older drivers: A population-based study. J*ournal of the American Geriatric Society*, *59*, 1575-1580.

Mørland, J., Steentoft, A., Simonsen, K. W., Ojanperä, I., Vuori, E., Magnusdottir, K., Christophersen, A. (2011). Drugs related to motor vehicle crashes in northern European countries: A study of fatally injured drivers. *Accident Analysis and Prevention, 43*, 1920-1926.

Movig, K. L. L., Mathijssen, M. P. M., Nagel, P. H. A., van Egmond, T., de Gier, J. J., Leufkens, H. G. M., & Egberts, A. C. G. (2004). Psychoactive substance use and the risk of motor vehicle accidents. *Accident Analysis and Prevention, 36*, 631-636.

Mura, P., Kintz, P., Ludes, B., Gaulier, J. M., Marquet, P., Martin-Dupont, S., . . . Pourrat, O. (2003). Comparison of the prevalence of alcohol, cannabis and other drugs between 900 injured drivers and 900 control subjects: results of a French collaborative study. *Forensic Science International, 133*, 79-85.

Norlen, M., Wahida, A. B., Nurul Kharmila, A., Muhammad Fadhli, M. Y., Sharifah Allyana, S. M. R., & Mohd Shah, M. (2012). Alcohol and drug use among fatally injured drivers in urban area of Kuala Lumpur. Kuala Lumpur: Malaysian Institute of Road Safety Research.

Office of Road Safety. (2013). 2012 fatality and serious injury statistics - overview. Perth, WA: Author.

Ojaniemi, K. K., Lintonen, T. P., Impinen, A. O., Lillsunde, P. M., & Ostamo, A. I. (2009). Trends in driving under the influence of drugs: a register-based study of DUID suspects during 1977-2007. *Accident Analysis and Prevention, 41*, 191-196.

Orsay, E. M., Doan-Wiggins, L., Lewis, R., Lucke, R., & Ramakrishnan, V. (1994). The impaired driver: Hospital and police detection of alcohol and other drugs of abuse in motor vehicle crashes. *Annals of Emergency Medicine, 24*, 51-55.

Palamara, P. (2013). Predictors of alcohol impairment among crash involved drivers and motorcycle riders in Western Australia. Proceedings of the conference for the *International Council on Alcohol and Drugs in Traffic Safety*, Brisbane, 2013.

Palamara, P., Molnar, L., Eby, D., Kopinanthan, C., Langford, J., Gorman, J., & Broughton, M. (2013). Review of young driver risk taking and its association with other risk taking behaviours. Perth, WA: Curtin-Monash Accident Research Centre. RR 09-001.

Palamara, P., Kaura, K., & Fraser, M. (2013). An investigation of serious injury motor vehicle crashes across metropolitan, regional and remote Western Australia. RR 10-001. Perth, WA: Curtin-Monash Accident Research Centre. RR 10-001.

Palamara, P. & Chow, K. (2015). A segmented regression analysis of the effect of changes to drug driving and alcohol traffic legislation and policy on road crashes (report in preparation). Perth, WA: Curtin-Monash Accident Research Centre. RR 13-001.

Poulsen, H., Moar, R., & Troncoso, C. (2012). The incidence of alcohol and other drugs in drivers killed in New Zealand road crashes 2004–2009. *Forensic Science International, 223*, 364-370.

Poyser, C., Makkai, T., Norman, L., & Mills, L. (2002). Drug driving among police detainees in three states of Australia *Canberra, ACT*. Commonwealth of Australia.

Rainsford, C., & Lenton, S. (2012). WA drug trends 2011: Findings from the Illicit Drug Reporting System (IDRS): National Drug Research Institute, Curtin University.

Ramaekers, J. G., Kuypers, K. P. C., & Samyn, N. (2006). Stimulant effects of 3,4-methylenedioxymethamphetamine (MDMA) 75 mg and methylphenidate 20 mg on actual driving during intoxication and withdrawal. *Addiction, 101*, 1614-1621.

Ramaekers, J. G., Robbe, H. W., & O'Hanlon, J. F. (2000). Marijuana, alcohol and actual driving performance. *Human Psychopharmacology, 15*, 551-558.

Romano, E., & Voas, R. B. (2011). Drug and alcohol involvement in four types of fatal crashes. *Journal of Studies on Alcohol and Drugs, 72*, 567-576.

Santamariña-Rubio, E., Pérez, K., Ricart, I., Rodríguez-Sanz, M., Rodríguez-Martos, A., Brugal, M. T., . . . Suelves, J. M. (2009). Substance use among road traffic casualties admitted to emergency departments. *Injury Prevention, 15*, 87-94.

Schepens, P. J., Pauwels, A., Van Damme, P., Musuku, A., Beaucourt, L., & Selala, M. I. (1998). Drugs of abuse and alcohol in weekend drivers involved in car crashes in Belgium. *Annals of Emergency Medicine, 31*, 633-637.

Schulze, H., Schumacher, M., Urmeew, R., & Auerbach, K. (2012). Final report: Work performed, main results and recommendations. Germany.

Senna, M.-C., Augsburger, M., Aebi, B., Briellmann, T. A., Donzé, N., Dubugnon, J.-L., Sutter, K. (2010). First nationwide study on driving under the influence of drugs in Switzerland. *Forensic Science International, 198*, 11-16.

Smink, B. E., Ruiter, B., Lusthof, K. J., Gier, J. J. d., Uges, D. R. A., & Egberts, A. C. G. (2005). Drug use and the severity of a traffic accident. *Accident Analysis & Prevention, 37*, 427-433.

Stoduto, G., Vingilis, E., Kapur, B. M., Sheu, W.-J., McLellan, B. A., & Liban, C. B. (1993). Alcohol and drug use among motor vehicle collision victims admitted to a regional trauma unit: demographic, injury, and crash characteristics. *Accident Analysis & Prevention, 25*, 411-420.

Substance Abuse and Mental Health Services Administration [SAMHSA]. (2011). Results from the 2010 National Survey on Drug Use and Health: Summary of national findings. Rockville, MD: Author.

Sweeney, J., & Payne, J. (2012). Drug use monitoring in Australia: 2009-10 report on drug use among police detainees. Canberra, ACT: Australian Institute of Criminology.

Swift, W., Jones, C., & Donnelly, N. (2010). Cannabis use while driving: A descriptive study of Australian cannabis users. *Drugs: Education, Prevention, and Policy, 17*, 573-586.

United Nations Office on Drugs and Crime. (2012). World drug report 2012. New York, USA: Author.

Vindenes, V., Strand, D.; Kristoffesen, L.; Boix, F.; & Morland, J. (2013). Has the intake of THC by cannabis users changed over the last decade? Evidence of increased exposure by analysis of the blood THC concentrations in impaired drivers. *Forensic Science International*, *226*, 197-201.

Waller, P. F., Blow, F. C., Maio, R. F., Singer, K., Hill, E. M., & Schaefer, N. (1997). Crash characteristics and injuries of victims impaired by alcohol versus illicit drugs. *Accident Analysis and Prevention, 29*, 817-827.

WHO. (2013). Road traffic injuries.

WHO. (n.d.). from http://www.who.int/violence_injury_prevention/road_safety_status/2013/country_profiles/australia.pdf

Wilkins, C., Girling, M., & Sweetsur, P. (2008). Recent trends in illegal drug use in New Zealand, 2005-2007. Findings from the 2005, 2006 and 2007 Illicit Drug Monitoring System (IDMS). Centre for Social and Health Outcomes Research and Evaluation: Massey University, NZ.

Wilson, L. A. (2012). Exploring illicit drug use and drug driving as edgework. *Current Issues in Criminal Justirce, 24*, 223-240.

Woolley, J. E., & Baldock, M. R. J. (2009). *Review of Western Australian drug driving laws.* Adelaide, South Australia: Centre for Automotive Safety Research. CASR 064.

Wylie, F. M., Torrance, H., Seymour, A., Buttress, S., & Oliver, J. S. (2005). Drugs in oral fluid: Part II. Investigation of drugs in drivers. *Forensic Science International, 150*, 199-204.