The Real Risk Of Being Killed When Driving Whilst Impaired By Cannabis

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1. Abstract
Until recently, Australian studies of drivers killed have only identified drivers who were cannabis users by measuring Carboxy-THC, which can remain detectable in body fluids for weeks after cannabis use. Since impairment after cannabis use only persists for hours, the bulk of the cannabis users identified by Carboxy-THC would not be impaired, and responsibility studies did not show an increased risk of an accident for this group. These studies identified drivers who had consumed cannabis, not necessarily drivers who were impaired by cannabis.

However, 4 years of results have now been obtained from studies that identified drivers who tested positive to the impairing constituent in cannabis, Delta-9-THC. This has allowed identification of drivers who were impaired by cannabis at the time of their death. These results indicate that there is a high risk of being killed when driving whilst impaired by Delta-9-THC.

The important finding is that drivers who test positive to Delta-9-THC and have no other psychotropic drug or alcohol present have a relative risk (as shown by odds ratios) of 6, which can be compared to drug and alcohol free drivers, who have an odds ratio of 1. In 4.3% of the 544 fatalities, cannabis was the only drug present, the driver was fully responsible for or contributed to their own death, and the levels of Delta-9-THC were sufficiently high to indicate that the driver was impaired.

Whereas past studies have identified that cannabis combined with other psychotropic drugs such as alcohol have significantly raised accident risk; these new studies indicate a high accident risk for drivers who had used only cannabis (as measured by Delta-9-THC). These findings have important implications for public policy, since cannabis users perceive that cannabis is a "safe" drug in terms of driving and cannabis use within society is increasing.

2. Introduction
There have been road safety studies involving cannabis, which have indicated serious accident risks for drivers, however there have also been many other studies which have failed to show any adverse effects. This inconsistency is partly clarified when the distinction is made between studies that identify drivers who have consumed cannabis and studies that identify drivers who are impaired by cannabis.

To identify this latter group of drivers who are impaired by cannabis there are special challenges, which are difficult to overcome. However recent studies involving 4 years of fatalities in NSW have

indicated that not only is there a high risk associated with driving whilst impaired by cannabis, but also cannabis related deaths are an important factor in road trauma.

3. Materials and Methods

The material presented is based on the research studies, which have been part-sponsored by VicRoads, a Government Transport Authority in the State of Victoria in Australia. These studies have been undertaken as part of the VicRoads Road Safety Program, which includes drug-impaired driving and covers epidemiological research into driver crashes and surveys of at-risk road users. The results of this research are published in Government reports and scientific journals and are used to develop countermeasures.

4. Results and Discussion

4.1. Cannabis and Accident Risk

Laboratory studies have been reviewed by Starmer and Mascord et al. (1994), Henderson (Henderson 1994), Robbe (Robbe 1994) and Berghaus and Scheer et al. (1995).

Berghaus and Scheer conclude "smoking of marijuana causes to a more or less obvious extent impairment of every performance area connected with the safe driving of a vehicle". Simpson (Simpson 1986) reviewed the conflicting evidence relating to cannabis use and road safety and estimated that the percent driving after using marijuana varied from 1 to 4 in the driving population, from 7 to 22 in the injured drivers and from 8 to 37 in fatalities. Krüger and Schulz et al. (1995) suggested that alcohol was 7 times, medications 2.5 times and illicit drugs 15 times more common in impaired, injured and fatally injured drivers than in the general driving population. Christophersen and Beylich et al. (1995) estimated the risk of involvement in an injury causing accident while driving under the influence of cannabis to increase by about a factor of 10 - comparable to increase in risk associated with 0.10% BAC. Robbe (1998) found that the combination of 200 micrograms per kilogram of Delta-9-THC and a BAC of 0.04% produced impairment equivalent to that associated with a BAC of 0.14% when alcohol is used alone.

4.2 Delta-9-THC

It is only fatality studies where the driver has died at the time of the crash that should be used to estimate the real risk of driving whilst impaired by cannabis. The reasons for this are given below and it is also important that the samples are appropriately stored prior to analysis.

* Upon inhalation, Delta-9-THC is rapidly absorbed from the lungs into the blood stream, with peak blood concentrations being reached within 8 minutes of commencing smoking (Huestis and Henningfield et al. 1992). However these highest blood concentrations of Delta-9-THC decline rapidly, falling to about 5-10 per cent of their initial level within the first hour, so with surviving drivers the time between crash and when the drivers blood sample in taken in hospital is critical. The time required to distribute half of the administered dose of Delta-9-THC from the blood into fatty tissues is about 30 minutes (Chiang and Barnett 1984). Hence, within approx 2 hours the crash level of Delta-9-THC has been reduced by approximately 90%, and delays of 2 hours between crash and the blood being taken in hospital do occur regularly.

* In addition to the above challenges of obtaining a timely driver's blood sample, which has Delta-9-THC levels representative of the crash level, there are also the challenges of preventing the decay of the actual Delta-9-THC chemical during the storage time between sampling and analysis. This storage time may be days, weeks, or even months for confirmation analysis. Drummer and Chu (1999) has recently estimated the important factors in this storage and has concluded that significant losses of Delta-9-THC occur when blood is stored at the normal laboratory storage temperature of –20 °C (over 50% at 8 weeks), whereas when blood is stored at –60 °C only marginal losses are observed.

4.3. Australian Studies of Cannabis and Accident Risk

Drummer (Drummer 1994) has used prevalence studies and Responsibility (Culpability) Analysis (Drummer 1994), (Drummer, Gerostamoulos et al. 1998) to estimate the role of drugs in road trauma. The prevalence of drugs in Australian drivers killed in 1995 and 1996 was on average 27%. This was an increase of 5% from a similar study in 1990-1993, mainly due a greater prevalence of cannabis use. In the three Australian States with non-selective test procedures, the most prevalent drug was cannabis, ranging from 12.2% in Victoria to 16.5% in Western Australia. The range for stimulants was 2.1% to 3.8%, benzodiazepines 2.1% to 4.4% and opioids 2.1% to 4.9%.

However these above cannabis results only identify drivers who have consumed cannabis, not necessarily drivers who are driving whilst impaired by cannabis. Inactive metabolites of cannabis such as Carboxy-THC only show that the driver used cannabis at some time in the past. Impairment lasts for only several hours after cannabis use, whereas the inactive metabolite can be detected for several days or weeks. Accordingly, only measurements of the impairing substance Delta-9-THC should be used in relative risk calculations.

Drummer and co-workers (Drummer and Gerostamoulos 1998), (Drummer and Caplehorn et al. 1999) have now reported on the presence of the active ingredient of cannabis, Delta-9-THC in NSW fatalities for the years 1995 to 1998. The first of these NSW reports (Drummer and Gerostamoulos 1998) found that all THC driver fatalities were culpable with an average blood concentration of 19 ng/mL (range 7 to 42 ng/mL) which is within the range at which cannabis impairs (Berghaus et al, 1995 ; Krüger and Berghaus, 1995).
It is important to note that concentrations of both Delta-9-THC and Carboxy-THC will be twice as high in plasma as in whole blood, due to the effects of binding to plasma proteins (Mason and McBay, 1985; Peat, 1989).
This 1995-1996 data from NSW was limited to cases that were obtainable from the metropolitan Coroners Courts in Glebe and Westmead, Sydney. The capture rate was high, however, as 73 % of driver results were useable.
In 1999 Drummer and co-workers (Drummer andCaplehorn et al. 1999) reported on the 1997-8 NSW data, which was collected statewide with the intention of removing possible metropolitan bias. To ensure the sample was representative, the results for drivers who died later in hospital and whose post-mortem body samples were taken too long after the crash to provide relevant toxicology, were excluded, as were all suicides and natural deaths. Drummer found that
" Alcohol positive drivers showed a significant increase in responsibility (OR=7.6, 95% CI 1.8-33), as did drivers with psychotropic drugs (OR 4.8, 95% CI 1.1-21). Importantly there were 16 fatalities in which Delta-9-THC was detected as the sole psychotropic drug. The blood values ranged from 5 to 100 ng/mL, with a median of 12 ng/mL. Fifteen drivers were culpable and one was contributory."

4.4 Statistical Significance of the NSW Results
Statistical analysis of the above NSW results that calculated statistical significance using logistic regression was carried out (Wohlers 1999). The logistic model used in the statistical analysis showed no difference between surveys; despite the different capture rates, so the data was pooled. The odds ratios were calculated using the comparison of "fully culpable drivers" against "not fully culpable drivers" and the results showed statistical significance.

Table 1 Relative Risks for Alcohol and Drugs as shown by Odds Ratios with 95% Confidence Limits

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1995 to 1998	**Odds Ratio**	**95% Confidence Limit**
Alcohol only	7.5	3.2 to 21.9
Psychotropic Drugs Only	3.8	1.7 to 10.1
Drugs plus Alcohol	9.2	1.9 to 165.0

The Odds Ratios for drivers with any blood alcohol levels (only) or any Psychotropic drug (only) or any combination being culpable are 7.5, 3.8 and 9.2 times greater than drug/alcohol free drivers,

respectively. In terms of the key issue, which is drivers impaired by cannabis, we need to consider the drivers who have Delta-9-THC and the results for drivers with 'Delta-9-THC only', compared to 'Psychotropic drugs without Delta-9-THC' are shown below.

Table 2 Relative Risks for Psychotropic Drugs (without Delta-9-THC) and for Delta-9-THC as shown by Odds Ratios with 95% Confidence Limits

1995 to 1998	Odds Ratio	95% Confidence Limits
Psychotropic Drugs (No Delta-9-THC) Only	3.4	1.3 to 11.6
Delta-9-THC	6.4	1.3 to 115.7

The Odds Ratios for drivers with 'psychotropic drugs (excluding Delta-9-THC) only' and 'Delta-9-THC only' being culpable are 3.4 and 6.4 times greater than drug/alcohol free drivers are, respectively.

It should be noted that the confidence limits have a wide range which reflects the small numbers involved, however recent results from both Victoria and WA also show the same trends in risks associated with driving whilst impaired by Delta-9-THC (Drummer 1999).

4.5 Delta-9-THC as the Sole Impairing Drug

One of the major findings in the NSW studies is the fact that there are a statistically significant number of driver deaths where Delta-9-THC was the only drug present. The odds ratio for Delta-9-THC is 6.4. The importance of this result is clear when the implications (Lenné and Fry et al. 1999) of a limited recent survey of cannabis users are considered. The survey results show that cannabis users do not recognise cannabis by itself as a risk factor, the majority of respondents felt that cannabis does not impair their driving ability or increase their accident risk. They also plan to use cannabis and drive, and many do not worry about waiting after using cannabis before driving. Furthermore approximately 80% of people surveyed indicated they would be prepared to be driven by others who were affected by cannabis only, and approximately half of the participants said driving while affected by cannabis should be allowed (in the legal sense).

However in NSW, most importantly, in 24 driver fatalities (4.3%), the active constituent Delta-9-THC, was the sole psychotropic drug detected in blood concentrations ranging from 5 to 100 ng/ml. Cannabis-related impairment is regarded as likely for blood Delta-9-THC concentrations above 5 ng/ml (Drummer et al 1998) and twenty-three of these 24 drivers were fully responsible for their fatal crash. The twenty-fourth was classified as having contributory responsibility.

These results indicate relatively high risks of driving when impaired by cannabis, compared to the previous studies of drivers who had consumed cannabis and did not show an elevated risk.

4.6. Impaired Drivers

Berghaus et al.(1995) extensively reviewed cannabis studies and selected 60 studies with a combined total of 1,344 reported observations to develop a ranking order for THC related impairment. Impaired performance levels measured in plasma were listed as follows; Tracking (6 ng/ml), psychomotor skills (8 ng/ml), attention (9 ng/ml), divided attention (11 ng/ml), visual functions (12 ng/ml), simulator/driving (13ng/ml), en-/decoding (15 ng/ml), reaction time (15 ng/ml), all performance areas (11 ng/ml).

Of particular interest is the comparison of the above values with the "real-world-crash" values for driver deaths expressed in plasma values. The average "real-world-crash" values for 1995/96 driver deaths in NSW when THC was the only psychotropic drug present were on average approximately 38 ng/ml (range 14 to 84 ng/ml). The average "real-world-crash" values for 1997/98 driver deaths in NSW when THC was the only drug present were 24 ng/ml (range 10 to 200 ng/ml).

Berghaus et al.(1995) report that "all performance areas" are affected at 11ng/ml whereas the driver deaths occurred at average values of 38 ng/ml in 1995/96 and 24 mg/ml in 1997/98.

4.7 Countermeasures

Society has now accepted that alcohol is a key causal factor in crashes. In response there are severe penalties for driving whilst impaired by alcohol. The fines and jail penalties increase with higher levels of blood alcohol.

Road safety resources are limited and since alcohol levels have not only an established crash risk but also well known and accepted penalties within Australian society, it is useful to compare the risks associated with Delta-9-THC, when it is the only psychotropic drug present, against the benchmark of alcohol drivers.

When this is done, it is found that Delta-9-THC has been found as the only psychotropic drug present in 4.2% of drivers who were fully responsible for their crash as compared with 24.7 % of driver fatalities who had alcohol in their blood and were also fully responsible for their crash. The relative risks as shown by odds ratios were approximately 6 and 7.5.

However, in contrast to alcohol, which has many tens of millions of dollars invested in alcohol related countermeasures, no significant countermeasure expenditure occurs for Delta-9-THC driving. Furthermore, cannabis users perceive Delta-9-THC as a "safe" drug, and its use within society is increasing.

Krüger (Krüger and Berghaus 1995) reviewed the literature on alcohol and used the results of meta-analysis to integrate Berghaus' results on THC.

These authors stated:
" Taking the global performance, 50% of all observed effects were negative in cases when a BAC value of 0.073% was reached. A plasma concentration of 11 ng/mL THC results in an equivalent deterioration. This value will be reached approximately 1 hour after smoking a standard cigarette containing 10 mg of cannabis".

Krüger and Berghaus conclude that it is very difficult to decide which substance is more dangerous cannabis or alcohol as these substances must cause performance failures in different traffic situations."

In Australia the BAC legal limits for most drivers are set at 0.05%, and are supported by a multimillion-dollar countermeasure system using legislation, enforcement, mass media publicity, education and rehabilitation. In contrast, cannabis has no such countermeasure system.

The scientific arguments concerning the "real" dangers of cannabis will not be easily or quickly resolved. However, the evidence presented by Krüger and Berghaus and the deaths of drivers who were positive to Delta-9-THC alone and no other drug and were fully responsible for their own death indicates that countermeasures for cannabis impaired drivers should be further developed.

The relative fatality risks for drivers who have used only 'Delta-9-THC ' are approximately 6 times greater than for drug/alcohol free drivers. This high relative risk of 6 for drivers who are impaired whilst driving and test postive to Delta-9-THC can be compared with the relative risk of 1 for drivers who consumed cannabis and were tested for Carboxy-THC.

Although the numbers are small and the confidence limits wide, the most important facts are that in 24 drivers who were killed in road crashes, which represents (4.3%) of the 511 driver sample, the only drug these drivers tested positive to was the active constituent of cannabis Delta-9-THC. In every case

the levels were above the blood impairment level of 5 ng/ml and twenty-three of these 24 drivers were fully responsible for their fatal crash. The twenty-fourth was classified as having contributory responsibility.

The fact that similar results to the above NSW findings are now being identified in other states (Drummer 1999) indicates that driving whilst impaired by cannabis is an issue that warrants more research and further countermeasure development.

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