An analysis of single-vehicle fatality crashes in Australia at various Blood Alcohol Concentrations

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Abstract

In Australia, approximately 30% of road deaths are associated with drivers having an illegal blood alcohol concentration (BAC), with evidence that over the past decade this proportion has increased. It is important to identify and understand the characteristics of drivers most at risk for driving with high BAC levels, and consequently are at increased risk of crash involvement. The aims of the following analysis were to examine the characteristics of single vehicle fatality crashes in Australia from 2000-2006. Of particular interest was the presence and level of alcohol among drivers, . Specifically, we aimed to determine the differences in demographic and crash characteristics of drivers (i.e., age, gender, combined drug use) based on BAC level. The Australian Fatal Road Crash Database (FRCD) comprised 3557 single-vehicle crashes which resulted in the death of 2256 drivers and 1234 passengers in the period 2000 to 2006 inclusive. Approximately 54% of single-vehicle driver fatalities where the BAC was known recorded a BAC > 0.0 g/100ml, with 34% of fatally injured drivers exceeding a BAC of 0.15 g/100 ml. The findings highlight clear patterns and characteristics of alcohol-related crashes, and give important insights into the demographic profile of intoxicated drivers. Of note was the use of illicit drugs such as cannabis, but also prescription drugs, such as anti-depressants. This research has important implications for how we tackle the drink-driving problem in Australia, particularly in relation to high-BAC drivers.

Background

Worldwide the harmful effect of alcohol has been established as a causal factor in more than 60 major types of diseases and injuries, which result in approximately 2.5 million deaths per year (World Health Organization, 2009). Data from survey studies, simulator studies and on-road driving studies have demonstrated that alcohol can lead to decrements in cognitive and physical functioning that can impair driving performance at blood alcohol concentrations (BACs) as low as 0.03 (Moskowitz, Burns, Fiorentino, Smiley, & Zador, 2000). Intoxicated drivers are more likely to demonstrate difficulties with divided attention, recognition and processing of visual stimuli, general information processing and deciding whether or not to drive (Breitmeier, Seeland-Schulze, Hecker, & Schneider, 2007; Filtness, Rudin-Brown, Mulvihill, & Lenne, 2013; Lenné et al., 2010; Lenné, Triggs, & Redman, 1999). Table 1 presents a list of important driving-related skills that can be compromised as a consequence of alcohol intake.

There is strong evidence of a dose dependent relationship between BAC level and risk of having a crash (McLean, Holubowycz & Sandow, 1980), however there is considerable international variation legal BAC limits (World Health Organization, 2013). For instance, BAC legal limits range from 0.02 in Sweden, 0.03 in Japan, 0.05 in Australia, and can be as high as 0.08 in some states of the United States. The literature concerning the crash risk for injury and dose of alcohol consumption is sparse, and typically research studies have focused on cut-offs either side of the BAC legal limit rather than on incremental levels. Recently, Taylor and Rhem (2012) conducted a systematic review of fatal and non-fatal alcohol-related crashes and suggested that there was an OR of 1.75 for each 0.02 rise in BAC greater than zero. Phillips and Brewer (2011) analysed data from 1994-2008 using the Fatality Analysis Reporting System (FARS) and found that there was a strong relationship between BAC, speeding, crash severity and restraint use. The analysis also demonstrated that excessive speeding is associated with BAC levels as low as 0.02 and 0.03.

Table 1: Neurocognitive and Physical Deficits related to Driving

- Impulsivity and dysregulation
- Short term memory
- Visual search and scanning
- Executive function deficits (i.e. forward planning, focusing attention, filtering information, disinhibition, monitoring and regulating self-action)
- Perceptual-motor speed

(Adapted from Austroads, 2012)

In order to develop targeted countermeasures, it is important to identify drivers who are most at risk for driving with high BAC levels, and hence are consequently at an increased risk of crash involvement. Data pertaining to the characteristics of drivers involved in fatal alcohol-related crashes is limited, particularly with respect to BAC level. It is however well established that alcohol-related crashes coincide with social drinking times, occur more frequently at night-time, on weekends (Gainsford, Fernando, Lea, & Stowell, 2006; Leal, King, & Lewis, 2008) and involve drivers with high BACs who are less likely to wear a seatbelt (Phillips & Brewer, 2011; Tsai, Anderson, & Vaca, 2010).

At the individual level, evidence from case-control studies have shown that drivers aged less than 21 years are at an increased risk for crashes regardless of BAC level (Peck, Gebers, Voas, & Romano, 2008). It can be argued that younger drivers are at greater risk at lower BAC levels due to their inexperience and propensity to engage in other risk taking behaviours. Younger drivers are also more likely than older age groups to engage in binge drinking. A population based longitudinal study in Canada demonstrated that binge drinking was predictive of younger driver (12-29 years) motor vehicle crash injuries, while medication use was predictive of crash injuries for middle aged drivers (30-60 years) (Vingilis & Wilk, 2008). However, not all studies have found that young drivers are over-represented in crashes involving high BAC levels (Leal et al., 2008; Moskowitz et al., 2000).

There is a substantial amount of research to indicate that drivers with drink driving offences are likely to have had, or to suffer from an alcohol-related disorder (Ferrante, Rosman, & Marom, 2001; Lapham, Stout, Laxton, & Skipper, 2011; McCutcheon et al., 2011; Peck, Arstein-Kerslake, & Helander, 1994). Furthermore, there is evidence to suggest that drink driving offenders with BAC's $\geq$ .15 are typically older than offender drivers with BAC levels < .15 (Leal et al., 2008). More recently, an alternative view has been put forward proposing that a large proportion of drink drivers are normative drinkers who engage in episodic or 'binge' drinking (Flowers et al., 2008; Furr-Holden, Voas, Lacey, Romano, & Jones, 2011; Lacey et al., 2011). However, the majority of these studies were conducted in America and Australian data is lacking.

While alcohol-impaired driving has received wide research attention in relation to driver performance and driver crash risk, there is limited understanding of how other drugs (i.e, psychotropic or recreational drugs) impact on driver safety. In Australia, while alcohol continues to be the main contributor to impaired driving, other drugs can negatively impact driver capabilities, increase crash risk, and increase likelihood of driver responsibility, particularly when combined with alcohol (Drummer et al., 2004; Ogden & Moskowitz, 2004). Drivers with drug driving offences are more likely to suffer from substance abuse and dependence compared to the general population (Lapham et al., 2001), and the increase of mental health conditions in the general population has coincided with a rise in prescription medications such as benzodiazepines. A study conducted in Victoria, Australia, found benzodiazepines were the most common drug used by impaired drivers (Ch'ng et al., 2007). Similarly, Gerostamoulus et al. (2002) analysed blood samples of 41 apprehended drivers in Victoria in 1996, and also found benzodiazepines were the most frequently used drug (64%) followed by opioids (43%) and tetrahydrocannabinol (THC)

(30%). In a longitudinal study conducted by Callaghan et al. (2013), individuals with drug or substance abuse disorders were recruited from hospitals and followed for 16 years. The rate of fatalities from motor vehicle crash injuries over the follow up period was significantly higher for the cohort compared to the general population indicating an increased mortality risk for drug users. The impact of mental health conditions, medication and drug driving is a challenging and complex issue that requires significant attention. This issue will be explored further in a separate study.

Objectives and Aims

The primary objective of the study was to explore the demographic and crash characteristics of alcohol-related single vehicle crashes. In particular, we aimed to determine the differences in crash characteristics of drivers (i.e., age, gender, road user impairment, combined drug use) based on blood alcohol concentrations. The crash characteristics relating to the road environment, posted speed limit and locality were also of interest and analysed according to BAC level.

Methods

Study Population

The study was a retrospective analysis of all fatal motor vehicle crashes that occurred on Australian roads in the period 2000 to 2006 inclusive.

Database

The database used was the Australian Fatal Road Crash Database (FRCD). The FRCD represents a national census of all deaths that occur on public roads in Australia. The basis for the database is police-reported crashes, as every unnatural death must be reported to the Police in the jurisdiction where the death occurs. The FRCD draws together a number of disparate information sources concerning the road crash and all associated occupants, including those that survived.

The FRCD is integrated with the *National Coroners Information System* (www.ncis.org.au/) and thus relies on Coronial records of each death. For each death, the cause of death is specified by the investigating Coroner. Specific reports for each crash and associated death include: police report of the crash; vehicle inspection report; autopsy report; toxicology report (for alcohol and other drugs, medications); other specialist reports, including Police Major Collision Squad Investigations, and the Coronial Inquest Brief/Report where an inquest was undertaken.

The FRCD includes 231 variables and includes specific information concerning the crash, the person, and the involved vehicle. At the time of the research, data was available for the period 2000 to 2006 inclusive. Only the drivers of cars and 4WDs were included in this study.

Access to the FRCD requires approval by the Victorian Department of Justice Research Ethics Committee, and an Access Agreement signed between the Researcher and the Victorian Institute of Forensic Medicine (VIFM). Approval was also obtained from the Monash University Human Research Ethics Committee.

Results

Overall Number of People Killed and Demographic Profile of Fatally Injured Drivers in Single-Vehicle Crashes

The Australian FRCD comprised 3557 single-vehicle crashes which resulted in the death of 2256 drivers and 1234 passengers in the period 2000 to 2006 inclusive. Approximately 54% of single-vehicle driver fatalities where the BAC was known recorded a BAC > 0.0 g/100ml, with 34% of fatally injured drivers exceeding a BAC of 0.15 g/100 ml. The BAC was considered accurate for 64% (n = 1439) of fatally injured drivers, unknown for 22% (n = 492), unavailable for 8% (n = 171) while for 5% the reading was delayed between 1-4 hours (n = 109) and 1% (n= 24) were not tested. Limiting the analysis to single-vehicle driver fatalities where BAC was known (n = 1439), 46% recorded a 0.000 BAC level; conversely, 54% of drivers tested positive for the presence of alcohol in their blood (i.e., BAC > 0.0). Of the males killed, 28% were aged 17 to 21 and 26% were aged 22 to 29 years. Of the females killed in single vehicle crashes, 39% were aged 17 to 29 years. (Figure 1).

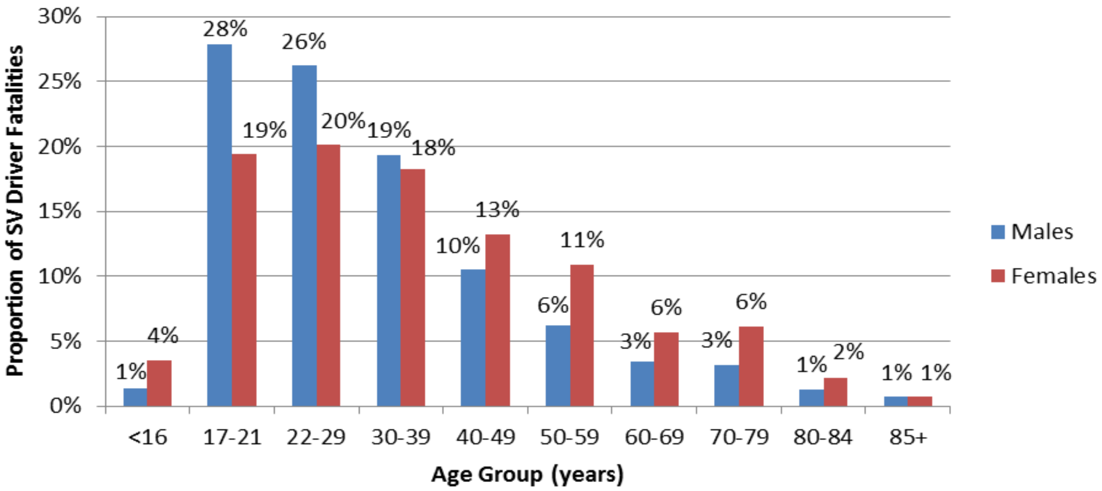

Figure 1: Proportion of Single-Vehicle Crash Driver Fatalities according to Age and Gender

Prevalence of Alcohol According to Gender and Age

Drivers aged 22-29 years comprised the largest proportion of drivers (32%) with alcohol at a detectible level in their blood (i.e., BAC > 0), with 65% of drivers in this age group having a BAC ≥ .05. Of the drivers with a BAC ≥ 0.05, 33% were aged 30-39 years.

Figure 2 presents the proportion of male and female single vehicle fatalities by BAC level. Two-thirds of females had a BAC of 0.000, compared to only 42% of killed males ($p \leq 0.05$). A higher proportion of males had a BAC level greater than 0.15 (34%) compared to females (20%). Similarly, a higher proportion of males than females tested positive for mid-range BAC levels (i.e., 0.07-0.149).

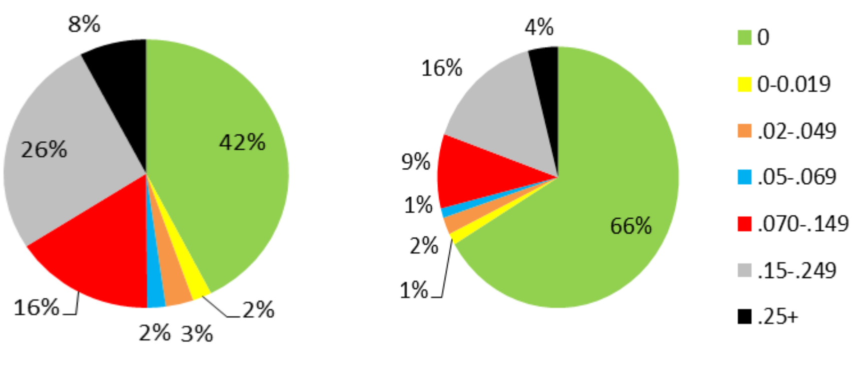

Figure 2: Proportion of Single-Vehicle Crash Driver Fatalities according to BAC and Gender

The BAC – driver age profile is presented in Figure 3. There are clear differences in BAC levels across the age categories, with high BAC values seemingly the preserve of drivers under 60 years of age; indeed, the data indicates that there were no driver fatalities aged over 80 years with an illegal BAC. In numeric terms, the highest number of deaths occurred in the 22 to 29 year old age group (n = 389), followed by drivers aged 17 to 21 inclusive (n = 368), where 30% had a BAC > 0.15. Of note is that 30% of fatally injured drivers aged 40-49 had a BAC > 0.25 and higher. Of the 368 novice drivers killed in single vehicle crashes, 55% had a BAC level of > 0.05, and 20% above 0.15.

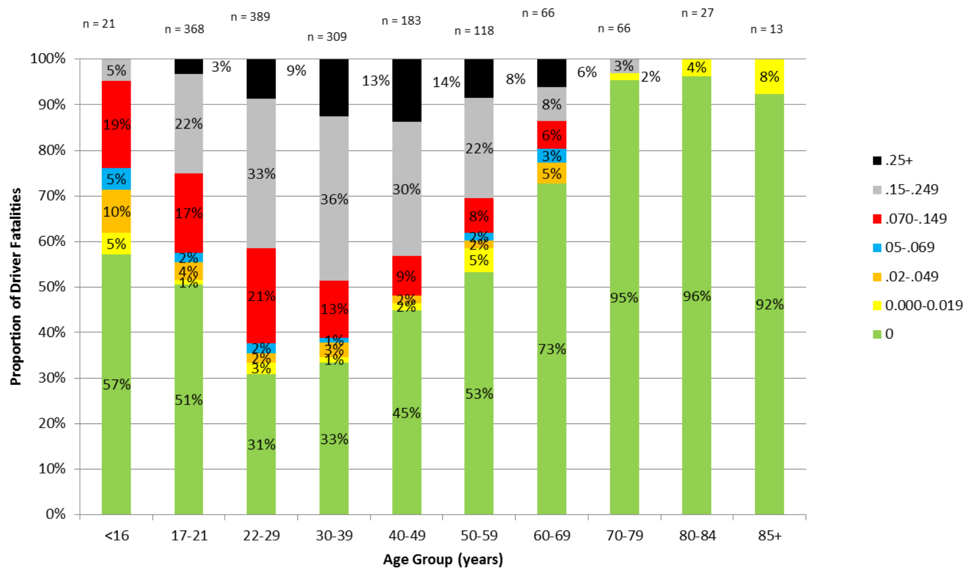

Figure 3: Proportion of Single-Vehicle Crash Driver Fatalities according to BAC and Age

Figure 4 and Figure 5 disaggregates Figure 3 into male and female driver fatalities, by BAC level. Of immediate interest is that only 48% of male novice drivers killed in single vehicle crashes had a BAC level of 0.0, in contrast to 74% of females. In each age group category, the proportion of males at each BAC level above 0.05 was greater than females of the same age. Males and females aged 22 to 29 inclusive and 30 to 39 years recorded the highest BAC levels.

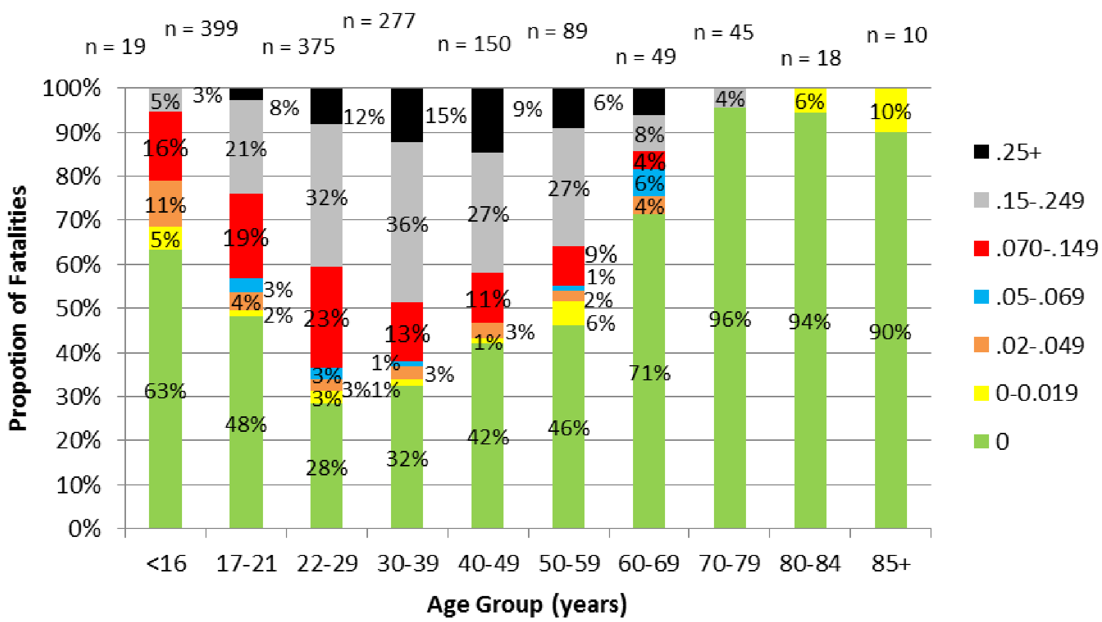

Figure 4: Male Single-Vehicle Crash Driver Fatalities by BAC and Age

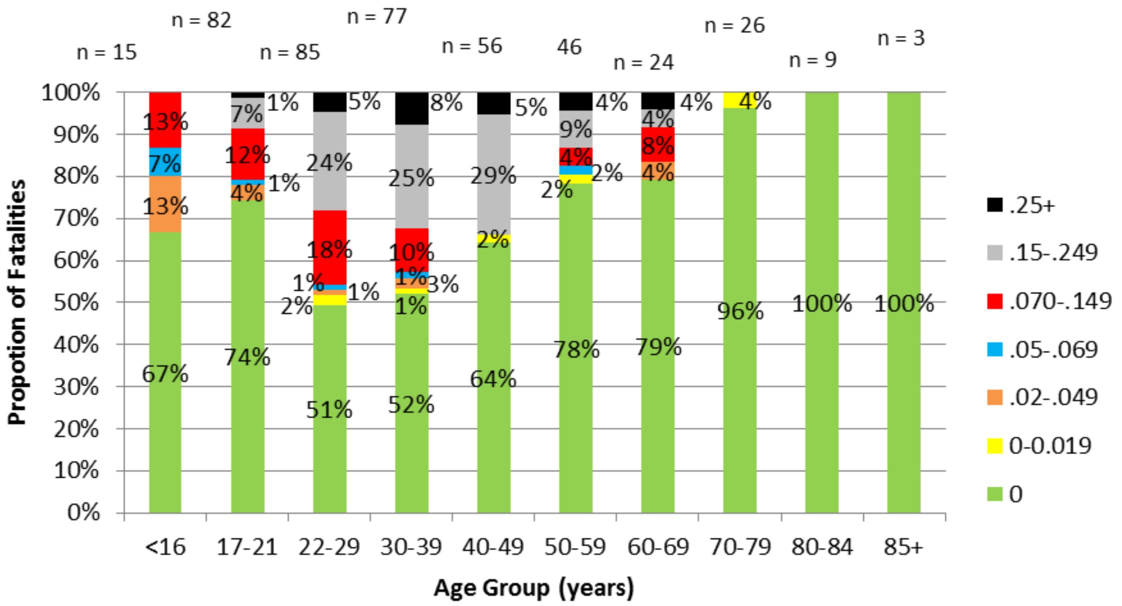

Figure 5: Female Single-Vehicle Crash Driver Fatalities by BAC and Age

Combined use of Alcohol and Other Drugs

Overall, there were 1141 drivers with complete toxicology reports undertaken with alcohol or other drug present (Males: n = 1140; Females: n = 145). Of these, 592 (33%) were found to be positive for drugs other than alcohol. A higher proportion of females (26.2%) than males (16.8%) had 'other drugs present' (including prescription drugs), however a higher proportion of males (28%) than females (21%) had alcohol plus other drugs detected. There are clear age and sex differences with respect to the presence of alcohol and / or other drugs at the time of the crash.

Overall, cannabinoids were more prevalent than anti-anxiety and anti-depressant medication, particularly for males aged 22-39 years. There were higher proportions of drug-alcohol combinations for drivers who recorded a BAC > 0.15. Other drug affected refers to the presence of any drug comprising the majority of prescription, illegal and non-drug chemicals such as poison.

Table 2: Presence of Alcohol and Other Drugs according to Gender for Single-Vehicle Crash Driver Fatalities (% by age-group)

Age group (years)	Males						Females					
	Alcohol		Other drug present		Alcohol + other drugs		Alcohol		Other drug present		Alcohol + other drug	
	n	%	n	%	n	%	n	%	n	%	n	%
< 16	3	75.0	0	0.0	1	25.0	1	14.3	3	42.9	3	42.9
17-21	123	60.9	24	11.9	55	27.2	11	47.8	5	21.7	7	30.4
22-29	169	54.5	38	12.3	103	33.2	27	55.1	12	24.5	10	20.4
30-39	124	52.1	40	16.8	74	31.1	24	55.8	9	20.9	10	23.3
40-49	84	64.6	19	14.6	27	20.8	9	39.1	6	26.1	8	34.8
50-59	46	78.0	5	8.5	8	13.6	5	55.6	1	11.1	3	33.3
60-69	16	84.2	0	Nil	3	15.8	4	100	0	Nil	0	Nil
70-79	2	40.0	3	60	0	Nil	7	53.8	4	30.8	2	15.4
80-84	0	Nil	0	Nil	1	100	0	0.0	0	Nil	0	Nil
85+	1	100	0	Nil	0	Nil	1	100	0	Nil	0	Nil
Total	624	54.7	192	16.8	324	28.4	76	52.4	38	26.2	31	21.4

**Note that none of the drivers tested positive for heroin.*

Crash Characteristics

Figure 6 presents the distribution of blood alcohol concentration according to posted speed limit for fatally injured drivers. Of the 1558 driver fatalities where the speed limit was reported, most occurred on 100 km/h (33%) roads, and 23% and 7% had a BAC > 0.15 and 0.25 respectively. There were a larger proportion of fatally injured drivers with a BAC > .05 compared to those with a zero BAC at 60km/h, 50km/h and 80km/h roads. For the roads with unlimited speed limits, the majority of driver fatalities comprised drivers with an illegal BAC.

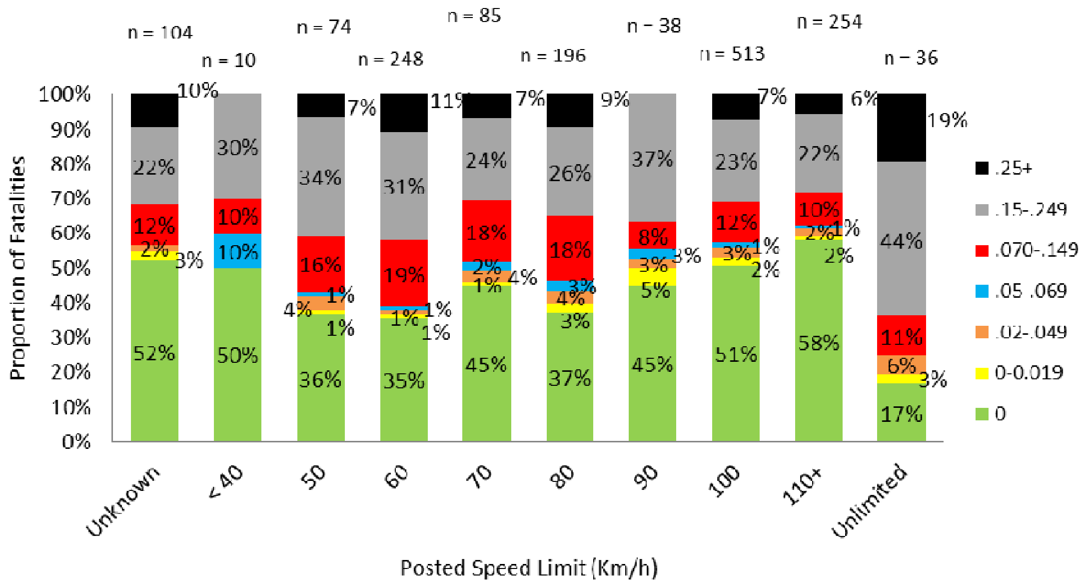

Figure 6: Proportion of Single-Vehicle Crash Driver Fatalities by BAC according to Posted Speed Limit

Jurisdictional Analysis

Of the single-vehicle driver fatalities in Victoria where a BAC recording was made, 52% had a zero-BAC, whereas only 23% of drivers killed in the NT in single-vehicle crashes had a zero-BAC. Fatally injured drivers with a BAC of .15-.249 comprised the largest group of illegal BAC drivers for all states and territories as displayed in Figure 7 below.

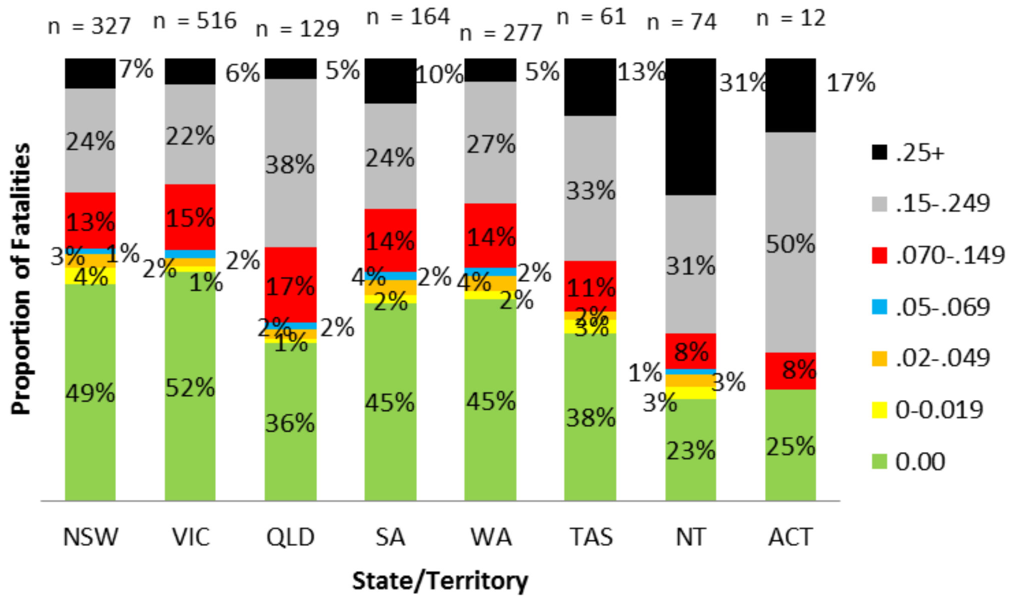

Figure 7: Single-Vehicle Crash Driver Fatalities by BAC and State

Road Characteristics

Analysis of the road contributory factors to single-vehicle driver fatalities from 2000-2006 revealed that 82% of fatalities occurred on two-way divided roads. This held true across the entire BAC distribution. The largest proportion of driver fatalities occurred on sealed and paved roads (91%), and in comparison, very few fatalities occurred on unsealed roads (8%).

Discussion

The analysis of fatal single-vehicle crashes in Australia provides an insight into the BAC distribution of drivers in regard to demographic and crash characteristics. Of the single-vehicle crashes were BAC was known, overall, 51% had a BAC < 0.05 although there was marked variation across States and Territories. For instance, 71% of drivers killed in the Northern Territory had a BAC > 0.05, compared to 45% in Victoria.

The majority of fatally injured drivers who tested positive for alcohol were aged 20 to 29 years, and a large proportion (48%) of fatally injured drivers where BAC was known recorded a BAC of 0.15-0.249. The results indicated that 63% of driver fatalities in the 30-39 year age group had an illegal BACs (i.e., > .05) compared to 23% of drivers in the 60-69 year age group. . Furthermore, these crashes typically occurred on two-way divided roads, and on roads with a posted speed limit of 100 km/h. It was interesting to note that the combined use of cannabinoids with alcohol was also higher at the BAC dose of 0.15-0.249, once again predominantly in the 30-39 year age group.

More than half (66%) of the fatally injured drivers who tested positive for alcohol in our analysis had also consumed other drugs. The most common other drug was cannabinoids, followed by anti-anxiety medication. The combination of cannabinoids and alcohol most likely contributed to the increased crash risk for these drivers. Evidence from prior investigations of the characteristics of drink-drivers who test positive for illicit drugs has suggested that these drivers are typically male, have had a prior drink-driving conviction, and are more likely to be unemployed and to be problem drinkers (Bernhoft et al., 2005; Brady & Li, 2013; Fell, Tippetts, & Voas, 2010).

In a recent systematic review, Asbridge and colleagues (2012) concluded that the consumption of cannabis results in an increased crash risk for fatally injured drivers. This crash risk is substantially higher when cannabis is combined with alcohol, particularly for those drivers with a BAC > .05 (Drummer et al., 2004). In general, studies have indicated that cannabis impairs driving by slowing reaction time, increasing driver lane deviation and impairing driver concentration (See Hartman & Huestis, 2012 for a review). When these effects are combined with alcohol, it is not surprising that increased cannabis blood concentrations have also been associated with increased rates of driver culpability (Hartman & Huestis, 2012).

The current analysis also acknowledges speed as a contributing factor to single-vehicle crashes of fatally injured drivers. Approximately half of the driver fatalities that occurred on 100km/h roads involved alcohol-related crashes, and 65% of alcohol-related driver fatalities on 60km/h roads involved alcohol. The larger proportion of alcohol involved fatalities found on 60km/h roads could reflect the location of the driver to the drinking areas. Overall, very few driver fatalities occurred on roads that had no speed limits. All the fatalities that occurred on roads with unlimited speed limits occurred in the Northern Territory. Approximately 74% of driver fatalities that occurred on roads with unlimited speed limits had a BAC > .05. It is important note that since 2007 a speed restriction has been introduced on roads in the Northern Territory that previously had unlimited speed limits on particular roads.

Some limitations should be taken into account when interpreting study findings. First, national licence data by age and gender were not available. Second, the paper is about the distribution of alcohol involvement rather than incidence and it is important to acknowledge that the authors decided to include BAC levels beyond 0.15 which may be suggestive of binge drinking or a clinical substance-abuse problem. Furthermore, 0.15 is also a ‘legal’ cut-off whereby in some states an alcohol interlock is automatically fitted at 0.15.

The information provided here has the potential to inform policy makers and government bodies about the individuals who would benefit most from interventions. Drink-driving interventions and countermeasures may include those that aim to prevent drink-driving for first time offenders, or may include those that aim to reduce recidivism. For example, reduction of recidivism can occur via legal enforcement, legal reforms, licence withdrawal, vehicle impoundment, or participation in a drink-driving rehabilitation program. There is mixed evidence to support the use of rehabilitation programs to reduce repeat drink-driving offenders (SWOV, 2010). Following this further research on the efficacy of rehabilitation programs in combination with law enforcement for particular target groups is warranted. Finally, there is strong evidence of the effectiveness of alcohol interlock devices in preventing drink-driving episodes (Roth, Voas & Marques, 2007; Marques & Voas, 2010), and the data presented here supports the focus on the expansion of alcohol interlock programs throughout Australia as per the National Road Safety Strategy 2011–2020 (Australian Transport Council, 2011).

Conclusions

In summary, the prevalence of drink-drug driving that was found for fatally injured drivers from 2000-2006 is significant and a cause for considerable concern. In particular, the data highlighted the need to address the drink-driving behaviour of male and female drivers aged 20-39 years. Of particular concern is the significant number of drivers that have recorded BAC content levels exceeding 0.05. These findings highlight the need to develop tailored educational and enforcement programs to tackle the significant drink-driving problem in single-vehicle crashes.

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