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Original Road Safety Research

Characteristics of Fatal Road Traffic Crashes Associated with Alcohol and Illicit Substances in Queensland (2011-2015)

James E. Freeman[1], Alexander G. Parkes[1], Kerry A. Armstrong[1], Jeremy D. Davey[1]

[1] *Road Safety Research Collaboration, University of the Sunshine Coast, Australia*

Corresponding Author: James Freeman, 90 Sippy Downs Dr, Sippy Downs, QLD, 4556, jfreema1@usc.edu.au, +61 7 54301142

Key Findings

- Alcohol was overrepresented in fatal crashes
- Higher range BAC levels were common
- Combinations of high BAC and illegal drugs were frequent
- Alcohol and polydrug detections were overrepresented in single vehicle crashes

Abstract

Psychoactive substances affect driver behaviour in different ways, some of which can increase the risk of traffic crashes. This study investigated coroners findings for fatal road traffic crashes in Queensland for crash factors and driver behaviours associated with and without the presence of alcohol or illicit drugs. A total of 701 coroners reports for the period of 2011 to 2015 were analysed revealing 306 fatal incidents involving the detection of either alcohol or target illegal drugs (e.g., methamphetamine, THC [cannabis], cocaine or MDMA). Alcohol was most often detected (223 cases; 72.9% of the drug and alcohol sample and 31.8% of the entire sample), and a majority of fatalities involving alcohol (n = 114, 51% of alcohol cases) were at high range BAC levels (> .150g/100ml). Of these, 37 (32.5% of high range and 16.6% of alcohol cases) were detected with illicit drugs. Single vehicle and multi-vehicle crashes were evenly represented, although males were overrepresented in all crash types. Alcohol and poly-drug consumption were more likely to be associated with single vehicle crashes (81.7% and 64.6% respectively), while detections of methamphetamines and THC in isolation without other substances were slightly overrepresented by multi-vehicle crashes (58.6% and 59.4% respectively). Single vehicle crashes usually involved speeding, loss of control and failure to negotiate a curve while multi-vehicle crashes were disproportionately represented by reckless driving and misjudging traffic conditions. Overall, an important theme to emerge was the contribution of illicit drugs and alcohol to the majority of single vehicle crashes, highlighting the increased risk of this type of crash for drivers who are positive with these substances.

Keywords

Fatal crashes, alcohol, drugs, coroner, Queensland

Introduction

The increasing utilisation of authority-based road traffic crash (RTC) databases is providing greater insight into the origins of different types of fatal road crashes. Analysis of crash characteristics and toxicology findings within these databases, can provide new scientific knowledge regarding the personal/environmental/legislative factors contributing to (or associated with) fatal crashes, not least the increased risk of crash involvement for motorists who consume

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alcohol prior to driving (Martin, Gadegbeku, Wu, Viallon, & Laumon, 2017; Moskowitz & Fiorentino, 2000; Rao, et al., 2013; Stringer, 2018; Voas, Tippetts, & Fell, 2000). For example, a recent French study reported that drivers who exceeded the legal blood alcohol limit were 17.8 times more likely to be responsible for a fatal crash compared to those who did not drive above the legal limit (Martin, et al., 2017), and a recent study in Australia reported similar findings (16 times more likely to be responsible) for all alcohol concentrations combined (Drummer, et al., 2020).

Similar crash outcome results have been identified for motorists who consume illicit substances. In regards to the latter, a growing body of research has demonstrated the link between fatal crashes and cannabis (Drummer, et al., 2020; Martin, et al., 2017; Palamara, 2015; Romano, Torres-Saavedra, Voas, & Lacey, 2014; Romano, Voas, & Camp, 2017), amphetamine-based substances (Drummer, et al., 2020; Hels, Lyckegaard, Simonsen, Steentoft, & Bernhoft, 2013) and opioids (Drummer, et al., 2020; Martin, et al., 2017). However, it is also noted that considerable debate has been outlined in the literature regarding the exact impairing effects of different illicit substance types (Rogeberg, 2019), particularly in regards to cannabis use (Rogeberg & Elvik, 2016). Put simply, conclusive evidence regarding the exact causal relationship between fatal crash risk and illicit substance consumption (through meta-analytic studies) has yet to be obtained (Rogeberg, 2019; Rogeberg & Elvik, 2016). At the very least, there is some evidence to suggest that the risk of fatal crash involvement is less for illicit substances, compared to that of alcohol (Martin, et al., 2017). The first paper from the current program of research revealed that alcohol remained the most common substance associated with fatal crashes (Davey, Armstrong, Freeman, & Parkes, 2020), incidentally, these findings were similar to recent investigations of non-fatal crashes in Australia (DiRago, et al., 2019). However, questions remain regarding the associated crash risk of alcohol combined with illicit substance consumption (Chihuri, Li, & Chen, 2017; Sewell, Poling, & Sofuoglu, 2009), including the combination of various illicit substances when driving. While the research is in its infancy, there is growing evidence to suggest combining alcohol with low levels of cannabis may increases crash risk, due to the impairing effects of these substances (Li, Brady, & Chen, 2013; Li, Chihuri, & Brady, 2017; Romano, et al., 2017) with one study reporting a fivefold increase in fatal two-vehicle crashes compared to non-impaired drivers (Li, et al., 2017). However, a recent study by (Drummer, et al., 2020), indicated that while the crash risk for THC combined with alcohol was much higher than the risk for THC alone, it was still lower than the crash risk for all alcohol concentrations. This suggests the effects may be additive rather than compounding. Taken together, this combination of different substances warrants further research, not least, in regards to the development of effective policies and legislation to combat impaired driving. Furthermore, there is a need to consider how substances can influence specific driving performance (e.g., speeding) or exacerbate negative effects (e.g., fatigue), although numerous challenges exist in regards to disentangling effects that may be cumulative in nature.

In regards to driving behaviours, there is a sizeable body of research that has examined a range of additional factors associated with crash outcomes, such as time of day (Huang & Lai, 2011; Kim, Ulfarsson, Kim, & Shankar, 2013; Regev, Rolison, & Moutari, 2018), driver demographics (Lam, 2002; Ma & Yan, 2014; Regev, et al., 2018; Skyving, Berg, & Laflamme, 2009), geographic region (Li, et al., 2013), freeway types (Gaweesh, Ahmed, & Piccorelli, 2019), weather conditions (Wang, Liang, & Evans, 2017; Wu, Zaitchik, & Gohlke, 2018), driving manoeuvres/driving tasks associated with crashes (Martensen & Dupont, 2013) etc. However, such research has primarily been undertaken to ascertain the utility of in-vehicle technology systems such as Advanced Driver Assistance Systems to avoid collisions (Aust, Fagerlind, & Sagberg, 2012) or explore the characteristics of single versus multiple vehicle crashes (Martensen & Dupont, 2013) (Martensen & Dupont, 2013), rather than links to licit or illicit substances. For example, (Aust, et al., 2012) examined factors associated with 28 fatalities in the Driving Reliability and Error Analysis Method (DREAM) and found that speed, drugs and/or alcohol as well as inadequate driver training contributed to almost half of all fatalities in the sample (although no clear links between substance type and driving were identified). Taken together, research has yet to extend to examine whether clear links can be found between different psychoactive substances (both legal and illegal) and the subsequent driving manoeuvres/tasks that led to fatal outcomes.

As a result, the current program of research focused on conducting an in-depth analysis of coroners findings for all fatally injured drivers (found to have consumed either alcohol or illicit drugs that are enforced in roadside drug testing in Australia) in the state of Queensland between the years 2011 to 2015. This paper is an extension of an earlier area of investigation that focused on: (a) the overall prevalence of alcohol and four illicit substances enforced for drivers in Australia (delta-9-tetrahydrocanabinol [THC], 3,4-Methylenedioxymethamphetamine [MDMA], methamphetamine [meth] and cocaine), (b) rate of crashes across the five-year time period and (c) the sociodemographic characteristics associated with such crashes. The specific research aims of the current paper were to:

1. Investigate the substance types (alcohol and illicit substances enforced for drivers in Queensland Australia) associated with single versus multi-vehicle crashes; and
2. Identify which fatal driver actions (e.g., speeding, losing control of the vehicle and dangerous driving) occurred more frequently with target substances and single or multi vehicle crashes.

Methods

Sample

All persons fatally injured in an RTC in Queensland (Australia) for the period 1 January 2011 to 31 December 2015 were initially included in the current study. A fatal crash is defined by any person who is killed on a public road (or individual who dies within 30 days from the injuries sustained in the crash). In total, records were received pertaining to 1355 cases (which may not reflect the total RTC fatality count for the period due to discretionary release of records by the Coroners Office). From this data repository 654 records (48.3 %) were excluded that were out of scope of this study. Specifically, exclusion criteria were, fatal crashes/collisions occurring off the road (e.g., residential driveways, private property, etc) or stemming from natural causes (e.g., sudden, fatal coronary event deemed to be resulting from a pre-existing condition) or deliberate self-harm (e.g., a suicide finding by the coroner), as well as cyclists, passengers and pedestrians.

Procedure

In Queensland, all details of a fatal traffic crash are filed with the state Coroners Court, this includes a toxicology analysis conducted from an ante-mortem or post-mortem sample in all cases, where possible (in some instances toxicology analysis may not be conducted due to a denatured sample, as in the case of incineration). Coroners summary reports for all fatal road traffic crashes (RTCs) that occurred in Queensland for the period of 2011 to 2015 were requested from the Office of the Sate Coroner Queensland. Coroners Findings and the Notice of Completion of Coronial Investigation (Form 20A) summary reports and associated toxicology certificates from the Queensland Health Forensic and Scientific Services, Forensic Toxicology Laboratory were reviewed for each case (where available). More specifically, the summary report often contains contextual information involving the circumstances relating to the death, including cause of death, location and time of death and sociodemographic information e.g., age, gender, etc. The toxicology certificate also provides contextual information regarding the sample (e.g., blood, urine, serum, other organ tissue, etc) and amount detected. In the majority of cases, the sample was taken from bloods however, in eight cases, liver samples were used and in six cases only urine was available. There were no illicit drugs or alcohol detections found in the urine or liver samples. Alcohol was measured as milligrams per 100 millilitres (reported in text as grams per 100 millilitres), while drugs were measured by milligrams per kilogram.

Drug testing was performed by the Forensic Toxicology Laboratory and involved full drug screening utilising gas chromatography involving mass spectral detection (CG/MS) as well as high performance liquid chromatography that included diode array detection (HPLC/DAD), and was accompanied by high-performance liquid chromatography with mass spectral detection (LC/MS/MS). For episodes involving the person initially surviving the crash that required medical assistance (e.g., 33 cases), ante mortem blood samples were analysed in the laboratory to achieve toxicology screening. The time period for antemortem analysis post-crash ranged from 45 minutes to 3 and a half hours, although the specimen was obtained from one case after approximately 5 hours post-crash. However, it was not possible to identify the length of time for post-mortem samples (from the toxicology certificate) of the delay between death and when the sample was obtained. All this time period was usually less than 3 days. A full drug analysis was completed for 95.6% of the sample, with 31 cases being excluded due to limited availability of a fluid sample. Toxicology analysis involved a variety of drugs/substances including alcohol, illicit drugs (e.g., cannabis) as well as prescription medication. However, this study focused only on substances that can be detected on the roadside through oral fluids (e.g., 3.4-methylenedioxymethamphetamine [MDMA], Δ9-tetrahydrocannabinol [THC], methamphetamine, and cocaine).

Results

Sample Characteristics

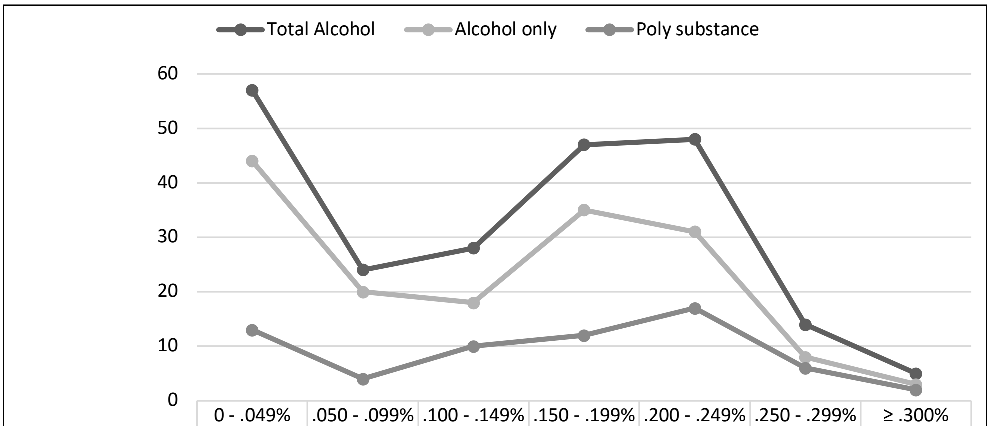
The final sample consisted of 701 cases pertaining to the deaths of controllers of motor vehicles. The mean age of the sample was 42.8 (*SD* = 18.8) and contained 578 males (82.5%) and 123 females (17.5%). The vehicles involved were classified as passenger vehicles (including utility vehicles and vans; *n* = 463, 66.2%), motorcycles (including mopeds and quad bikes; *n* = 197, 28.1%), and heavy vehicles (trucks, tractors, cranes; *n* = 41, 5.8%). In total, 306 drivers (43.7%) tested positive for alcohol and or target drugs (e.g., THC, methamphetamine, MDMA or cocaine). Table 1. outlines the frequencies of drug and alcohol detection (including a more extensive list of combinations initially outlined in (Davey, et al., 2020). This analysis further indicates alcohol was the most commonly detected substance both in isolation as well as combined with other substances.

As described in Table 1., alcohol was detected in 223 (31.8%) of all fatalities and was found to be present exclusively without the target drugs in 159 (71.3%) of these cases. Alcohol was detected at blood alcohol concentration (BAC) levels ranging from .001 to .393g/100ml with a median of 137.5. Figure 1 provides a depiction of cases grouped by BAC level in .05 g/100ml increments, including cases where alcohol was detected exclusively or with target drugs. The most frequently occurring alcohol concentration was a BAC between 0 and 0.05 g/100ml (*n* = 57, 8.1% of the total sample) followed by .200 to .249 g/100ml (*n* = 48; 6.8% of the entire sample) and .150 - .199 g/100ml (*n* = 47; 6.7% of the entire sample). THC was the

Table 1. Frequencies of target drug and alcohol detection among fatally injured motor vehicle controllers

	n	% D&A	% N	Level range	Mean (SD)
Total N	701	-	100%	-	-
Drug and alcohol negative	395	-	56.3%	-	-
Total drug & or alcohol (D&A)	306	100%	43.7%	-	-
Total alcohol positive (g/100ml)	223	72.9%	31.8%	.010 - .393	.128 (.92)
*Total alcohol only	159	52%	22.7%	.010 - 2.20	.527(.592)
*Alcohol > .05% only	115	37.6%	16.4%	-	-
*Alcohol < .05% only	58	19%	8.3%	-	-
Total drug positive drivers	147	48%	21.0%	-	-
Total THC positive (mg/kg)	109	35.6%	15.5%	.001- .110	.016 (.018)
Total Meth positive (mg/kg)	63	20.6%	9.0%	.010 - 3.10	.483 (.664)
*THC only	37	12.1%	5.3%	.001 - .082	.018 (.019)
*Methamphetamine only	30	9.8%	4.3%	.010 - 2.20	.527 (.593)
Total poly substance	80	26.1%	11.4%	-	-
†Alcohol + THC	37	12.1%	5.3%	-	-
†Alcohol + Meth	5	1.6%	0.7%	-	-
†Alcohol + THC + Meth	6	2.0%	0.9%	-	-
†Alcohol + THC + Cocaine	2	0.7%	0.3%	-	-
†Alcohol + Ecstasy + THC	1	0.3%	0.1%	-	-
THC + Meth	16	5.2%	2.3%	-	-
THC + Alcohol <.05	6	2%	0.9%	-	-
Meth + Alcohol <.05	2	0.7%	0.3%	-	-
THC + Meth + Alcohol <.05	4	1.3%	0.6%	-	-
Ecstasy + Alcohol <.05	1	0.3%	0.1%	-	-

Note: Alcohol level = g/100ml; * = detected exclusively without other substances; †= alcohol ≥ .05; Poly substance = any combinations of target drugs and or alcohol, THC = tetrahydrocannabinol, Meth = methamphetamine; motor vehicle includes, light and heavy vehicles and motorcycles.



	0 - .049%	.050 - .099%	.100 - .149%	.150 - .199%	.200 - .249%	.250 - .299%	≥ .300%
Total Alcohol	57	24	28	47	48	14	5
Alcohol only	44	20	18	35	31	8	3
Poly substance	13	4	10	12	17	6	2

Fig 1. Blood alcohol levels with and without illicit drug positive detection. % = Blood Alcohol Concentration (g/100ml); Alcohol only = detected exclusively without the presence of target drugs (n = 223); Poly substance = THC, meth, MDMA or cocaine detected with alcohol.

most frequently detected substance in conjunction with alcohol and was most often detected at higher BACs (e.g., .150 – .249 g/100ml; *n* = 28; 4.0% of the entire sample and 25.7% of the THC positive sample). In total 114 drivers were detected with a high range BAC (≥ .150 g/100ml) representing 16.3% of the entire sample. Furthermore, 37 (32.5%) of these drivers also had target drugs detected, which is suggestive of high levels of intoxication at the time of the fatal accident.

Crash Characteristics: Single Versus Multiple Vehicle

Single vehicle (SV) and multiple (MV) crashes were analysed independently with consideration for achieving greater predictive utility from independent models due to the unique features of the two crash types (Geedipally & Lord, 2010). Table 2 presents frequencies and results of chi square tests of independence for substance type by crash type. SV crashes constituted only a slightly larger proportion of crash incidences (*n* = 353, 50.4%) compared to MV (*n* = 332, 47.4%) and 16 crashes involved hitting a pedestrian or were classified as other (e.g., hit animal). A statistically significant association was found for alcohol, poly substance and male drivers overrepresentation among SV in comparison to MV crashes. In contrast, higher representations of single target drugs were found among MV crashes, however only the distribution of THC was statistically significant. Finally, independent samples *t*-tests revealed that drivers who were killed in SV crashes were statistically significantly younger (*M* = 40.6, SD = 18.6) than driver fatalities of MV incidents (*M* = 45.1, *SD* = 19; *t*(679) = -2.99, *p* = .003) and, drivers who were detected with illegal concentrations of alcohol or target drugs were also statistically significantly younger (*M* = 34.6, *SD* = 11.8) compared to drivers who tested negative for target drugs or alcohol concentration (*M* = 47.7, *SD* = 20.5; *t*(694) = 9.44, *p* < 001). However, it should be noted that the mean ages of both groups suggest the fatally injured drivers were experienced drivers e.g., mean age greater than 40.

Further analyses were conducted to determine the prevalence of single and multi-vehicle crashes at each of seven levels of alcohol concentration. A trend was observed whereby higher rates of MV crashes tended to occur within the legal range of alcohol concentration (< .05g/100ml) and above this level of concentration SV crashes were substantially more prevalent. The higher ranges of alcohol concentration (e.g., 150 – 249g/100ml) showed the greatest differences in higher SV crash rates (See Figure 2.).

The data was further examined for noticeable interactions between crash type (e.g., SV and MV crashes) and crash factors (e.g., driver behaviour or environmental features) and factors that contribute to fatal injury (e.g., not wearing a seatbelt) as well as the detection of target drugs or alcohol (see Table 3 for reported statistics). Interestingly, when comparing groups of drug and alcohol positive with drug and alcohol negative drivers across the most prevalent driver error (e.g., failure to negotiate a curve, *n* = 176),

Table 2. Analyses of Single versus Multiple Crash Types

		Total		Single Vehicle		Multiple vehicle		Chi Square	
		N	***%***	***n***	***% N***	***n***	***% N***	***χ2***	***p***
Alcohol ≥ .05	**Yes**	115	16.4%	94	36.3%	21	6.3%	50.49	< .001***
	No	586	83.6%	259	73.4%	311	93.7%		
THC	**Yes**	37	5.3%	13	3.7%	22	6.6%	3.06	0.08*
	No	664	94.7%	340	96.3%	310	93.4%		
Meth	**Yes**	30	4.3%	12	3.4%	17	5.1%	1.24	0.264
	No	671	95.7%	341	96.6%	315	94.9%		
Poly Substance	**Yes**	80	11.4%	53	15.0%	26	7.8%	8.65	0.003**
	No	621	88.6%	300	85.0%	306	92.2%		
D&A or A	**Yes**	258	36.8%	172	48.7%	86	33.3%	37.95	< .001***
	No	427	60.9%	181	51.3%	246	57.6%		
Sex	**Male**	562	80.2%	310	79.1%	252	85.4%	5.08	0.024*
	Female	125	17.8%	82	20.9%	43	14.6%		

Note: Alcohol level = g/100ml; D&A = drugs and (alcohol ≥ .05g/100ml); **p* = < .05; ***p* = < .01; ****p* = < .001; *χ2* = Pearson Chi-Square; 16 cases had missing data for the SV/MV variable; THC = tetrahydrocannabinol, Meth = methamphetamine.

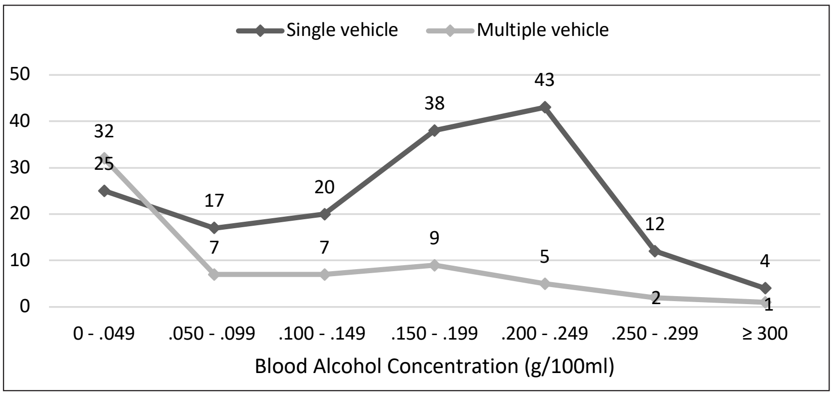


Fig 2. Single and multiple vehicle crash distribution across levels of blood alcohol concentration.

Table 3. Crash Type by Driver Actions and Drug or Alcohol Toxicology

	Total		SV		MV		Chi Square	
Crash Factor [drugs/alcohol]	**N**	**% N**	***n***	**%**	***n***	**%**	**$\chi 2$**	***p***
Failure to negotiate a curve	176		121	68.8%	55	31.3%		
[Negative]	101	57.4%	57	32.4%	44	25.0%	16.729	<.001***
[Positive]	75	42.6%	64	36.4%	11	6.3%		
Speeding	159		103	64.8%	56	35.2%		
[Negative]	62	39.0%	32	20.1%	30	18.9%	7.722	.005**
[Positive]	97	61.0%	71	44.7%	26	16.4%		
Lost control	75		60	80.0%	15	20.0%		
[Negative]	34	45.3%	24	32.0%	10	13.3%	3.443	0.064
[Positive]	41	54.7%	36	48.0%	*5*	6.7%		
Fatigue	52		27	51.9%	25	48.1%		
[Negative]	31	59.6%	15	28.9%	16	30.8%	0.384	0.535
[Positive]	21	40.4%	12	23.1%	9	17.3%		
Reckless driving	37		16	43.2%	21	56.8%		
[Negative]	15	40.5%	6	16.2%	9	24.3%	0.108	0.742
[Positive]	22	59.5%	10	27.0%	12	32.4%		
Failure to secure a seatbelt	88		74	84.1%	14	15.9%		
[Negative]	31	35.2%	27	30.7%	4	5.4%	0.323	0.57
[Positive]	57	64.8%	47	53.4%	10	13.5%		
Failure to spot/misjudge traffic	49		0	0.0%	49	100.0%		
[Negative]	40	81.6%	0	0.0%	40	81.6%	7.14	.
[Positive]	9	18.4%	0	0.0%	9	18.4%		
Distraction	26		13	50.0%	13	50.0%		
[Negative]	16	61.5%	6	23.1%	10	38.5%	2.6	0.107
[Positive]	10	38.5%	7	26.9%	3	11.5%		
Road conditions - weather	31		18	58.1%	13	41.9%		
[Negative]	22	71.0%	10	32.3%	12	38.7%	4.949	.026*
[Positive]	9	29.0%	8	25.8%	1	3.2%		

Note: Alcohol level = ≥ .05g/100ml; in some cases, MV and SV data was not included in the coroners report and therefore total *N* may not reflect the total *N* reported elsewhere the majority of crashes did not involve target drugs or alcohol (*n* = 101, 57.4%) and, for target drug and alcohol negative drivers, the distribution between single and multi-vehicle crashes was more evenly distributed than in cases of the same error where target drugs or alcohol were detected (e.g., 65.2% of drivers detected with target drugs or alcohol that failed to negotiate a curve were SV crashes). The factors that were also overrepresented by drivers unaffected by target drugs or alcohol were fatigue (*n* = 31; 57.0%), failing to spot/misjudge traffic (*n* = 40; 81.6%), distraction (*n* = 16; 61.5%) and road conditions affected by the weather (*n* = 22; 71.0%). Whereas drivers who were detected with alcohol or target illegal drugs were more commonly involved in crashes involving speeding (*n* = 97; 61.0%), failing to secure a seatbelt (*n* = 57; 64.8%), losing control of the vehicle (n = 41; 54.7%) and reckless driving (*n* = 22; 59.5%). Single vehicle crashes were more likely to occur in cases of failing to negotiate a curve (*n* = 121; 68.8%), speeding (*n* = 103; 64.8%), failing to secure a seatbelt (*n* = 74; 84.1%), losing control of the vehicle (*n* = 60; 80.0%) and road conditions affected by weather (*n* = 18; 58.1%). In contrast, multivehicle crashes involved a greater proportion of cases of reckless driving (*n* = 21; 56.8%) and, failing to spot or misjudging traffic (*n* = 49; 100%). Distracted drivers were equally involved in SV and MV crashes. A series of chi square analyses between all three variables (crash type, crash factor and substance detection) revealed statistically significant interactions for crash type and toxicology associated with the following crash features: failure to negotiate a curve ($p < .001$), speeding ($p = .005$) and road conditions affected by weather ($p = .026$).

A more detailed analysis of substance type across the most common pre collision driver actions, did not indicate a clear pattern of association (refer to Table 4.). Within the D&A related sample, alcohol was the most common substance detected in conjunction with the majority of driver behaviours and errors. However, poly substance was most common in cases of speeding (*n* = 41, 47.7% of D&A cases), fatigue (n = 7, 35% of D&A cases), overtaking (*n* = 5, 50% of D&A cases), failure to wear a helmet (*n* = 4, 50% of D&A cases) and driving through a red light (*n* = 2, 100% of D&A cases). For the following driver errors, THC was the most common within the D&A sample: failing to spot or misjudged traffic (*n* = 6; 66.7% of D&A cases), failing to spot a stationary or slow vehicle (*n* = 3, 30.0% of D&A cases) and hitting an object on the road (*n* = 4; 57.1% of D&A cases). Methamphetamine was the most detected substance in cases of veering into oncoming traffic (*n* = 8; 33.3% of D&A cases).

Regional Analysis

A final analysis was conducted to review regional differences in SV and MV crash types and substance related crashes. Crash locations were divided into five groups using the Accessibility and Remoteness Index of Australia (ARIA+; Australian Bureau of Statistics [ABS], 2020). Of the 692 reports that contained crash locations (98.7% of all cases), slightly more occurred within major cities (*n* = 236, 34.1%) than inner regional areas (*n* = 234, 33.8%) followed by outer regional areas (*n* = 171, 24.7%), while remote and very remote crashes accounted for 27 (3.9%) and 24 (3.5%) of ARIA grouped fatalities respectively. In regard to crash type, SV crashes were found to have a higher representation in major cities (*n* = 125, 53%), outer regional (*n* = 90, 52.6%), remote (*n* = 22, 81.5%) and very remote areas (*n* = 20, 83.3%), whereas inner regional crashes had a greater percentage of MV crashes (*n* = 137, 58.5%). In a comparison of drug and alcohol negative with drug or alcohol positive crashes, the representation of fatalities across the ARIA classifications was generally comparable, with the exception of the non-drug/alcohol group being substantially over represented (*n* = 150, 63.8%) in inner regional ARIAs than fatalities with drug or alcohol detection (*n* = 85, 36.2%).

Discussion

The current study undertook a deeper examination into coroners findings between 2011 and 2015 in order to: (a) investigate the personal and environmental factors associated with single versus multi-vehicle substance related crashes and (b) explore what links exist between driving tasks and substance types that were associated with different types of fatal crashes. As outlined in (Davey, et al., 2020) alcohol was the most commonly detected substance (e.g., 72.9% of the drug and alcohol sample and 31.8% of the entire sample), which is consistent with previous research (Chen & Jou, 2018; National Highway Traffic Safety Administration, 2017; Romano, et al., 2017). However, the current study involved a deeper exploration that revealed: (a) as expected, low levels of alcohol were also associated with 57 fatal crashes (and combined with illicit substances for 18.1% of that sample), (b) alcohol was most commonly associated with THC consumption (11.6% of the substance sample), (c) alcohol was the most common drug type associated with other substances (e.g., common denominator) and (d) the proportion of THC and methamphetamine fatalities increased with excessive alcohol consumption (as outlined in Figure 1.). Due to the current zero tolerance enforcement approach for the targeted illicit substances, a detailed analysis of substance levels was not conducted. However, it was noted that high levels of target drugs were detected with alcohol and similarly, high levels of alcohol detected with target drugs (depicted in Table 1). A future area of enquiry might provide a comprehensive analysis of drug levels with associated crash features. On the one hand, the findings further reinforce the on-going problem of inappropriate alcohol consumption creates for road safety. On the other hand, the results suggest further research is warranted into the possible synergistic effects of low level alcohol consumption with other psychoactive substances, which has recently been found to be demonstrated (Romano, et al., 2014; Romano, et al., 2017; Sewell, et al., 2009).

Table 4. Substance Type and Pre-Collision Driver Action

	Total		D & A Negative		D & A Positive		*Alcohol		*Meth		*THC		Poly-substance	
	N	%	n	% N	n	% N	n	% N	n	% N	n	% N	n	% N
Failure to negotiate a curve	178	25.4%	103	57.9%	75	42.1%	35	19.7%	5	2.8%	8	4.5%	27	15.2%
Speeding	162	23.0%	64	39.5%	98	60.5%	39	24.1%	12	7.4%	8	4.9%	39	24.1%
Veered off road	115	16.4%	65	57.0%	50	43.0%	28	24.6%	4	3.5%	5	4.4%	13	11.4%
Veered into oncoming traffic	90	12.8%	66	73.3%	24	26.7%	5	5.6%	8	8.9%	7	7.8%	4	4.4%
Failure to secure seatbelt	89	12.7%	32	36.0%	57	64.0%	34	38.2%	5	5.6%	5	5.6%	13	14.6%
Lost control	75	10.7%	34	45.3%	41	54.7%	25	33.3%	4	5.3%	0	0.0%	12	16.0%
Fatigue	52	7.4%	31	59.6%	21	40.4%	6	11.5%	6	11.5%	2	3.9%	7	13.5%
Failure to spot/misjudged traffic	49	7.0%	40	81.6%	7	14.3%	1	2.0%	2	4.1%	4	8.2%	2	4.1%
Reckless driving	37	5.3%	15	40.5%	22	59.5%	10	27.0%	4	10.8%	1	2.7%	7	18.9%
Road conditions (weather)	31	4.4%	22	71.0%	9	29.0%	2	6.5%	1	3.2%	3	9.7%	3	9.7%
Failure to spot stationary vehicle	30	4.3%	22	73.3%	8	26.7%	2	6.7%	1	3.3%	4	13.3%	1	3.3%
Overtaking	29	4.1%	20	69.0%	10	34.5%	2	6.9%	2	6.9%	1	3.5%	5	17.2%
Failure to give way to vehicle	26	3.7%	24	92.3%	2	7.7%	0	0.0%	1	3.9%	0	0.0%	1	3.9%
Distraction	26	3.7%	16	61.5%	10	38.5%	3	11.5%	2	7.7%	3	11.5%	2	7.7%
Mechanical issue	25	3.6%	13	52.0%	12	48.0%	7	28.0%	1	4.0%	2	8.0%	2	8.0%
Object on road	19	2.7%	12	63.2%	7	36.8%	1	5.3%	1	5.3%	4	21.1%	1	5.3%
Road configuration (structural)	17	2.4%	11	64.7%	6	35.3%	5	29.4%	1	5.9%	0	0.0%	0	0.0%
Failure to wear a helmet	14	1.7%	6	42.9%	8	57.1%	4	28.6%	0	0.0%	0	0.0%	4	28.6%
Drove through red light	7	1.0%	5	71.4%	2	28.6%	0	0.0%	0	0.0%	1	14.3%	1	14.3%
Total *n*	701	100.0%	507	72.3%	234	33.4%	115	16.4%	30	4.3%	34	4.9%	83	11.8%

Note: Alcohol level = ≥ .05g/100ml; D&A = Drugs and (alcohol ≥ 50); *Detected exclusively without the presence of other substances; THC = tetrahydrocannabinol, Meth = methamphetamine.

A comparative analysis of single and multiple vehicle crashes revealed that alcohol was more commonly associated with single rather than multiple vehicle crashes e.g., 81.7% vs 18.23%. This was one of the clearer themes to emerge from the research. This finding supports a growing body of evidence that indicates alcohol is disproportionately represented in single vehicle crashes (Öström & Eriksson, 1993; Rao, et al., 2013). Taken together, and similar to recommendations made by Mørland, et al. (2011), the majority of single vehicle crashes (in the current sample) appear to be clearly preventable.

In contrast, few clear trends appear to emerge regarding multi-vehicle crashes (apart from multi-vehicle crashes likely to be associated with failing to spot or judge traffic which was attributed to driver error without the presence of drugs or alcohol in 81.6% of cases). While the current study indicated a slightly higher proportion of fatally injured drivers in multi-vehicle accidents had consumed either cannabis or methamphetamines, further research is required to explore the reliability of this result (as the cell sizes are quite small). A clearer trend (similar to that of alcohol), was that poly substance use was also over-represented in single vehicle crashes e.g., 64.6% versus 35.4%. While the current methodology limits exploration into synergistic effects, the result is consistent with previous research that has indicated a possible deleterious impact of poly substance consumption on the driving task (Chihuri, et al., 2017; Li, et al., 2017).

Additionally, single vehicle crashes were also more likely to be associated with male drivers, speeding, losing control of the vehicle, failure to negotiate a curve and alcohol consumption. As noted above, while examination of the extent and factors associated with suicides was beyond the scope of the current study, future research could benefit from identifying the characteristics of crashes stemming from deliberate self-harm (not least to ensure that such events do not spuriously affect road toll calculations). As outlined in Milner and De Leo (2012's) seminal study, there are a multitude of challenges associated with identifying and separating numerous personal and environmental factors that interact to create a road crash. This is in addition to the personal/familial consequences of identifying an episode of deliberate self-harm that involves a multi-vehicle crash e.g., collision with a truck. In regards to gender, a central theme to emerge from this program of research is that males are over represented in substance related crashes, which is consistent with research that has demonstrated males have historically been overrepresented in crash databases (Mayhew, Ferguson, Desmond, & Simpson, 2003; Palamara, Broughton, & Chambers, 2013). In regards to speeding and losing control of the vehicle, both factors are well documented to increase crash risk (Viallon & Laumon, 2013) which are likely further compounded by the impairing effects of substance use. Regardless, non-rule compliance in regards to speeding remains a major road safety concern, which can be manifested in a range of different crash types (Abegaz, Berhane, Worku, Assrat, & Assefa, 2014).

Similar to single versus multi-vehicle crashes, analysis of combined substances versus no substances revealed that while there were few differences in the "no drugs" category, motorists who tested positive to either alcohol or drugs were more likely to be in single vehicle crashes with circumstances relating to increased likelihood of: (a) failure to negotiate curve, b) speeding, (c) not wearing a seat belt, (d) reckless driving and (e) losing control of the vehicle. The results again suggest that the ingestion of substances can create a range of impairing effects in regards to recognising (and responding appropriately) to risk. A corresponding examination of drug type by crash type (single versus multiple) revealed: drinking alcohol was more associated with single vehicle crashes whereas THC and methamphetamine related crashes had a higher propensity to involve multiple vehicles. While research has indicated that alcohol creates driving impairments (Ogden & Moskowitz, 2004), cannabis creates driving skill impairments (Hartman & Huestis, 2013) and body of research indicates that methamphetamine consumption increases risk taking (Brecht & Herbeck, 2014), the current study's methodology does not permit for such effects to be clearly identified or disentangled (including specific drug levels). Additionally, it should be noted that identifying the presence of a drug does not equate to clear existence of impairment, particularly in regards to levels of tolerance (e.g., frequency/pattern of past consumption) and the problem of quantifying a level of impairment based on blood concentrations of a substance (Reisfield, Goldberger, Gold, & DuPont, 2012). That is (and in contrast to breath alcohol concentration levels), a linear relationship between identified levels of a drug and corresponding levels of impairment does not currently exist within the scientific literature (which has clear implications for roadside drug driving detection and prosecution). This matter is further complicated via post-mortem re-distribution that involves the changes that occur in drug concentrations after death. At the very least, the relationship between drug levels and impairment deserves further research, particularly within the area of novel psychoactive substances (e.g, 6AM morphine for heroin users etc.) wherein published data may be less substantiated. Another limitation of the study is that time of crash was not included in the analyses (as 25% of the coroners' summary reports omitted such information), which precluded analyses regarding the interaction between day/night and substance type as well as crash type.

In the final analysis of crash types and substance related crashes by regional ARIA classification, the findings for the distributions of fatal crashes across each region were comparable to data published by Steinhardt, Sheehan, and Siskind (2009) for an earlier period, suggesting a somewhat stable distribution across time. Not surprisingly, SV crashes were overrepresented in remote and very remote areas, which is indicative of the lower volume of traffic on these roads. A noteworthy finding regarding substance related crash distributions across regions, was that a lower representation of drug and or alcohol related crashes occurred in inner regional areas. A plausible explanation for this result may be the lower frequency of alcohol vendors in these areas as a percentage of the population (Morrison, Ponicki, Gruenewald, Wiebe, & Smith, 2016). However, this particular area of research warrants further investigation.

Conclusion

The current study represents an extension of the first published in-depth analysis of coroners findings in the state of Queensland (Davey, et al., 2020), with a focus on the circumstances surrounding substance impaired crashes. Consistent with the impairing effects of substances, examination into the origins of crashes remains complex and likely includes a range of personal and environmental factors. Nevertheless, clear trends emerged regarding links between: (a) excessive alcohol consumption and crash involvement, (b) excessive alcohol consumption combined with illicit substances (which indicates motorists' failure to acknowledge escalating risk) and (c) illicit substance consumption and multi-vehicle crashes e.g., head on collisions. While only preliminary, the results suggest further scientific effort is needed to understand and prevent impaired driving (both for alcohol and illicit substance use), not least because of the possible decriminalisation of some substances in the future and the multiple challenges this will present in regards to understanding and negotiating risk of impairment.

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