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Police documentation of drug use in injured drivers: Implications for monitoring and preventing drug-impaired driving

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ABSTRACT

Introduction: Most countries have laws against driving while impaired by drugs. However, in many countries, including Canada and the United States, police must have individualized suspicion that the driver has recently used an impairing substance before they can gather the evidence required for laying a criminal charge. This report studies police documentation of drug involvement among drivers who had a motor-vehicle crash after using an impairing substance.

Methods: We obtained blood samples and police reports on injured drivers treated in participating British Columbia trauma centres following a crash. Blood was analyzed for alcohol, cannabinoids, other recreational drugs, and impairing medications. Corresponding police reports were examined to determine whether police recorded that the driver's ability was impaired by alcohol, drug or medication, or that one of these substances was a possible contributory factor in the crash.

Results: We obtained blood samples and corresponding police reports on 1816 injured drivers. Mean driver age was 44 years, 63.2% were male, and 25.8% were admitted to hospital. Alcohol was detected in 272 drivers (15.0%), THC (tetrahydrocannabinol - the principal psychoactive ingredient in cannabis) in 136 (7.5%), other recreational drugs in 166 (9.1%), and potentially impairing medications in 363 (20.0%). Police reported that the driver's ability was impaired by alcohol or that alcohol was a possible contributory factor in 64.1% of the crashes involving alcohol-positive drivers. Drug impairment or drugs as a possible contributory factor was reported in 5.9% of the crashes involving THC-positive drivers, and in 16.9% of the crashes involving drivers who tested positive for other recreational drugs. Medication impairment was reported in only 2.2% of the crashes involving medication-positive drivers.

Conclusion: Police seldom document drug involvement in drivers who were in a crash after using cannabis, other recreational drugs or potentially impairing medications. This finding raises serious concerns about the ability of the police to effectively enforce current drug-impaired driving laws and public health officials' continued reliance on police crash reports to monitor the prevalence of drug-impaired driving.

1. Introduction

Many drugs and medications impair driving ability and contribute to traffic crashes (Leufkens et al., 2007; Ramaekers et al., 2006; Wingen et al., 2006; Ramaekers et al., 2004; Ramaekers, 2003). Coroners' data (Beasley and Beirness, 2011; Brady and Li, 2013), hospital studies (Lowenstein and Koziol-McLain, 2001; Walsh et al., 2005; Brubacher et al., 2016), and roadside surveys (Beirness and Beasley, 2010; Beirness et al., 2015; Compton and Berning, 2015) show that impairing drugs or medications are detected approximately as often as alcohol among North American drivers. Similar to American probable cause, Canadian police must reasonably suspect that a driver has recently used an impairing substance in order to demand that he or she submit to alcohol or drug screening (Solomon and Chamberlain, 2014). In both countries, police who have the required individualized suspicion of recent drug use may require the driver to submit to a Standardized Field Sobriety Test (SFST) (Solomon and Chamberlain, 2014). Drivers who "fail" the SFST may be brought to a police station and examined by a

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Drug Recognition Expert (DRE), who performs a standardized examination looking for evidence of drug use and impairment. The DRE system is resource intensive, extremely technical and time consuming, and may only be conducted by a certified DRE. The certification program is lengthy and costly. Given their limited numbers, a DRE may not be readily available, especially in remote communities (Asbridge, 2006). Consequently, the great majority of drug-impaired drivers go undetected by the police and unsanctioned by the criminal justice system.

Cannabis has been legal for medical use in Canada since 2001, and twenty-five American states, starting with California in 1996, have either legalized or decriminalized medical cannabis. Alaska, Washington, Oregon, and Colorado have gone further and legalized cannabis for recreational use. Worldwide, several countries have decriminalized recreational cannabis use, but only Uruguay, Spain, Jamaica, and Columbia have legalized it.

In April 2017, the Canadian government introduced *Bill C-45*, the *Cannabis Act,* which would legalize the production, possession, distribution, and sale of cannabis and cannabis products for recreational use (Anon., 2017). At the same time, the government introduced *Bill C-46*, which would simplify, rationalize and strengthen all of the federal *Criminal Code* traffic offences. Among other things, the *Bill* would authorize the police to conduct mandatory roadside alcohol screening (MAS) of drivers without individualized suspicion, commonly referred to as "random breath testing" (RBT). Moreover, *Bill C-46* would create new drug-impaired driving offences by prohibiting driving with a stipulated amount of specified drugs in one's blood. The federal government has proposed three *per se* limits for THC. First, having 2 but less than 5 ng/mL of THC in whole blood would be a summary conviction offence punishable by a maximum fine of $1,000. Second, having 5 or more ng/mL of THC would be a hybrid offence (i.e. an offence that could be tried on summary conviction or by indictment). Third, having 2.5 or more ng/mL of THC and a blood-alcohol concentration equal $\geq$0.05% would also be a hybrid offence. The latter two *per se* offences would be subject to the same penalties as the alcohol-impaired driving offences.

Police powers to collect evidence of drug-impaired driving would also be expanded. First, the police would be authorized to demand a roadside oral fluid sample from drivers whom they reasonably suspect have any drugs in their body. Second, the police will be able to demand a blood sample from drivers whom they have reasonable grounds to believe have committed a drug-impaired driving offence within the last three hours. While *Bill C-46* would strengthen drug-impaired driving enforcement, police would still require individualized suspicion of recent drug use to demand that a driver submit to roadside oral fluid testing (Bill C-46, 2017).

2. Objective

To compare police reports of drug involvement in crashes with corresponding toxicology test results in a cohort of injured drivers treated in hospital after a crash. In particular we will answer the following questions:

1) How often do police document alcohol, drug and/or medication involvement in drivers who test positive for these substances?
2) What factors make it more likely that police will identify or suspect substance involvement in these drivers?
3) How often do police document alcohol, drug or medication involvement in drivers who test negative for these substances?

3. Methods

This study was approved by the University of British Columbia research ethics board (REB) and used data from an ongoing study of the association between traffic crashes and cannabis and other drugs. Because we used excess blood that remained after clinical use, and had implemented procedures to protect personal information, the REB did not require us to obtain consent from each driver. This minimized selection bias.

3.1. Sampling

Detailed sampling methods are reported elsewhere (Brubacher et al., 2016). In brief, we prospectively sampled injured drivers from seven participating British Columbia (BC) trauma centres between January 2010 and September 2015. All injured automobile drivers who had blood samples obtained as part of clinical care were eligible for inclusion. The decision to obtain blood was made by treating physicians based on their assessment of the driver's clinical condition, and not on any suspicion of drug use. Research assistants identified injured drivers through regular reviews of emergency department (ED) visit logs and then obtained excess blood that remained after clinical use. This blood was frozen for later toxicology analysis. Drivers with minor injuries who did not require bloodwork were excluded. Drivers were also excluded if blood samples were obtained more than six hours after the crash, no excess blood remained after clinical use, or there were no police reports for the crash. Motorcyclists and commercial vehicle drivers were excluded because these categories of drivers were not included in the parent study.

Health records of injured drivers were reviewed and basic demographic and medical information was recorded. We recorded all medications given as part of the driver's clinical care prior to phlebotomy. Any 'post-crash' medications were accounted for when reporting the medications detected in a driver's blood samples.

3.2. Police crash reports

We obtained police crash records *via* probabilistic linkage based on driver's name, age, gender, and date of crash. Police reports include crash details and list factors that police believed contributed to the crash, including human condition factors which are attributed to individual drivers and not to the crash in general. Police can list up to four contributory factors for each person involved in the crash. We considered police to have suspected drug involvement if the police report indicated "ability impaired by drugs" or "drugs suspected" as possible contributory factors. Similarly, we considered police to have suspected alcohol involvement if the report indicated "ability impaired by alcohol" or "alcohol suspected", and medication involvement if the report indicated "ability impaired by medications" ("medications suspected" is not an option in BC police reports). The reports also allow police to cite other "human condition" factors (inattention, internal/external distraction, extreme fatigue, fell asleep, illness, and sudden loss of consciousness).

3.3. Toxicology analysis

Broad spectrum toxicology testing on whole blood samples was conducted at the BC Provincial Toxicology Centre (Brubacher et al., 2016). Toxicology testing detected alcohol, cannabinoids, other recreational drugs (cocaine, amphetamines including designer drugs, and opiates), as well as psychotropic pharmaceuticals (including antihistamines, benzodiazepines, other hypnotics, and sedating antidepressants). We categorized THC and alcohol according to concentration range. Other recreational drugs (e.g. amphetamines, cocaine) were recorded as not detectable, detectable, or above the Norwegian legal limit for driving. Norway was the first country to set evidence-based *per se* limits for driving after using drugs. The detection limit at the BC Provincial Toxicology Centre was 0.2 ng/mL for THC and 1 ng/mL for other drugs. The Norwegian *per se* limits for recreational drugs are 41 ng/mL for amphetamine, 45 ng/mL for methamphetamine, 48 ng/mL for MDMA, and 24 ng/mL for cocaine (Vindenes

et al., 2012). Impairing medications, such as benzodiazepines or antidepressants, were recorded as detectable or non-detectable. The detection limit for most medications was 1 ng/mL.

3.4. Explanatory variables

Driver age was stratified into two age groups: < 30, and 31–65 years. We also studied the association with gender. Medical and psychiatric conditions (from the medical record) were classified as either present or absent. Crash severity was categorized as treated and released from the ED, or admitted to hospital. Crash characteristics included: single *versus* multi-vehicle crash; and nighttime (between 9 p.m. and 6 a.m.) *versus* daytime crash.

4. Statistical analyses

4.1. Police identification of drug-positive drivers

This analysis included only drivers who tested positive for drugs or medications or alcohol. For each category of toxicology results, we determined the proportion of injured drug, alcohol, or medication positive drivers for whom police indicated drug, alcohol or medication involvement (the outcome variable). We also calculated the proportion of crashes involving drivers who were positive for alcohol, drugs or impairing medications in which the police cited human condition (other than substance use) as a possible contributory factor.

4.2. Factors affecting police identification of drug-positive drivers

This analysis included only drivers who tested positive for drugs or medications. To determine predictors of police correctly identifying drug-positive drivers, we separated injured drivers by impairing substance and used logistic regression to measure the strength of association between outcome (suspected drug or medication involvement) and the explanatory variables (age, gender, medical history, crash severity, and crash characteristics). Since the number of cases with suspected drug involvement was small in most cases, we used Firth's bias-reduced penalized-likelihood method (Firth, 1993). We fit separate models for each independent variable, and one adjusted model that included all variables simultaneously. We computed odds ratios and 95% confidence intervals using model coefficient estimates and standard errors. Less than 1% of drivers (17/1816) had unknown crash characteristics and were excluded from this analysis.

4.3. Police suspicion of drug involvement in drug-negative drivers

We performed similar analyses on the subset of drivers who tested negative for all substances to determine the prevalence and predictors of incorrect documentation of drug-involvement.

All analyses were performed in R version 3.3.1 (R Core Team, 2017).

5. Results

Over the course of this study, 1816 injured drivers had excess blood available and could be linked to police crash reports (Fig. 1). The mean age was 44, and 63% were male. Over one-quarter (25.8%) required admission to hospital, and almost one-third (31.7%) were involved in single-vehicle crashes (Table 1).

We found that 272 drivers (15%) tested positive for alcohol and 136 (7.5%) tested positive for THC, including 75 (4.1%) with THC > 2 ng/mL. Other recreational drugs were detected in 166 drivers (9.1%), including 49 (2.7%) who tested above the Norwegian legal limits. Impairing medications were detected in 363 drivers (20.0%). Many drivers had used multiple impairing substances. Half of the THC-positive drivers (67/136) and 42.6% of alcohol-positive drivers (116/272) also tested positive for another impairing substance (Table 2).

Consistent with prior research (Brubacher et al., 2013), police correctly documented alcohol involvement in 66.5% of the alcohol-positive cases, with higher detection rates among drivers with higher BAC levels. In contrast, police documented drug involvement in only 8 of 136 THC-positive drivers (5.9%), and only 6 of 75 drivers (8.0%) with THC > 2 ng/mL. Interestingly, police did not suspect drug use in any

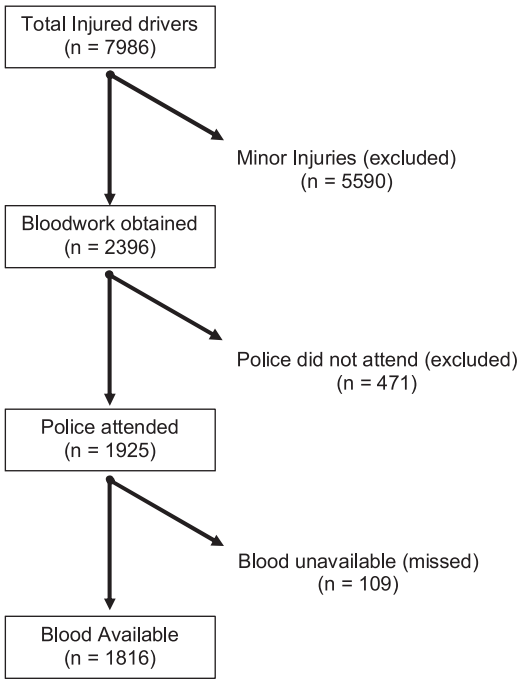

Fig. 1. Flow diagram. During the study period, 7986 injured drivers attended a participating hospital and were assessed for eligibility. Of these, 6061 drivers were excluded (5590 drivers had minor injuries that did not require bloodwork, and the police did not attend 471 crashes). Of the 1925 eligible drivers, 109 drivers (6%) were excluded because excess blood was unavailable. The remaining 1816 drivers were included in the study.

Table 1
Characteristics of the 1816 injured drivers included in this study.

Variables	Number of Drivers (%)
Age:	
< 20	82 (4.5%)
20–30	428 (23.6%)
31–65	1070 (58.9%)
> 65	236 (13.0%)
Gender:	
Male	1147 (63.2%)
Female	669 (36.8%)
Heath:	
Medical condition	869 (47.9%)
Psychiatric condition	136 (7.5%)
No health condition	811 (44.7%)
Crash type:	
Multi-vehicle	1241 (68.3%)
Single-vehicle	575 (31.7%)
Nighttime	674 (37.1%)
Single-vehicle nighttime crash	273 (15.0%)
Crash severity:	
Admitted to hospital	469 (25.8%)
Treated and released	1347 (74.2%)
Time from crash to blood draw (minutes)	Mean = 98.3 (SD = 61.8) Q1 = 60 Median = 82 Q3 = 115

Table 2
Police Reports. This Table lists how often police list suspected substance use and/or human factors as contributory factors in the crash. Note that Canada has proposed *per se* limits for THC of 2 ng/mL, with higher penalties for drivers with THC > 5 ng/mL.

Substance	Subgroup	n	Prevalence	Police suspect:			
				Alcohol	Drugs	Medications	Human Condition[b]
Alcohol	BAC = 0	1544	85.0%	13 (0.8%)	38 (2.5%)	4 (0.3%)	487 (31.5%)
	0 < BAC < 0.05	30	1.7%	8 (26.7%)	1 (3.3%)	0	9 (30.0%)
	0.05 ≤ BAC < 0.08	20	1.1%	6 (30.0%)	2 (10.0%)	0	11 (55.0%)
	0.08 ≤ BAC < 0.16	50	2.8%	29 (58.0%)	4 (8.0%)	3 (6.0%)	19 (38.0%)
	BAC ≥ 0.16	172	9.5%	138 (80.2%)	7 (4.1%)	2 (1.2%)	51 (29.7%)
	BAC > 0	272	15.0%	181 (66.5%)	14 (5.1%)	5 (1.8%)	90 (33.1%)
Alcohol alone	BAC > 0	156	8.6%	100 (64.1%)	5 (3.2%)	0	47 (30.1%)
THC	THC = 0	1680	92.5%	167 (9.9%)	44 (2.6%)	7 (0.4%)	522 (31.1%)
	THC > 0	136	7.5%	27 (19.9%)	8 (5.9%)	2 (1.5%)	55 (40.4%)
	0 < THC < 2 ng/mL	61	3.4%	11 (18.0%)	2 (3.3%)	1 (1.6%)	21 (34.4%)
	2 ≤ THC < 5 ng/mL	59	3.2%	14 (23.7%)	5 (8.5%)	1 (1.7%)	26 (44.1%)
	THC ≥ 5 ng/mL	16	0.9%	2 (12.5%)	1 (6.2%)	0	8 (50.0%)
THC alone	THC > 0	69	3.8%	1 (1.4%)	0	0	27 (39.1%)
Other recreational	Negative	1650	90.9%	158 (9.6%)	24 (1.5%)	7 (0.4%)	500 (30.3%)
drugs	Positive	166	9.1%	36 (21.7%)	28 (16.9%)	2 (1.2%)	77 (46.4%)
	Above Limit[a]	49	2.7%	8 (16.3%)	9 (18.4%)	1 (2.0%)	22 (44.9%)
Other drugs alone		42	2.3%	0	8 (19.0%)	0	15 (35.7%)
Medications	Negative	1453	80.0%	150 (10.3%)	22 (1.5%)	1 (0.1%)	416 (28.6%)
	Positive	363	20.0%	44 (12.1%)	30 (8.3%)	8 (2.2%)	161 (44.4%)
Medications alone		220	12.1%	2 (0.9%)	9 (4.1%)	2 (0.9%)	93 (42.3%)
Any substance	Negative	1120	61.7%	8 (0.7%)	3 (0.3%)	1 (0.1%)	299 (26.7%)
	Positive	696	38.5%	186 (26.7%)	49 (7.0%)	8 (1.1%)	278 (39.9%)
Other than alcohol		424	23.3%	5 (1.2%)	35 (8.3%)	3 (0.7%)	188 (44.3%)

[a] For other recreational drugs, "above limit" indicates cases with blood levels above the Norwegian legal limits (n = 49). The Canadian government has not yet proposed criminal *per se* driving limits for these drugs.
[b] Human condition factors include: "driver inattentive", "driver internal/external distraction", "extreme fatigue", "fell asleep", "illness", and "sudden loss of consciousness".

of the 69 drivers who tested positive for THC alone.

Police were better at recognizing drivers who had used other recreational drugs. They documented drug involvement in 28 of 166 drivers (16.9%) who tested positive for other recreational drugs, including 9 of 49 drivers (18.4%) who tested above the Norwegian legal limits. Police indicated involvement of medications in only 8 of 363 drivers (2.2%) who tested positive for an impairing medication.

Police suspected a human condition (other than drug use) as a contributory factor in 278 of 696 drivers (39.9%) who tested positive for an impairing substance. In comparison, a human condition was identified in 299 of 1120 drivers (26.7%) who tested negative for drugs (chi-squared = 34.1, p < 0.001). Police were less likely to attribute a human condition to drivers who used alcohol alone (47 of 156 drivers, 30.1%) than in drivers who used other impairing substances (188 of 424 drivers, 44.3%) (chi-squared = 9.6, p-value = 0.002). A human condition was most likely to be attributed to drivers who tested positive for recreational drugs other than cannabis (77 of 166 drivers, 46.4%) (Table 2).

Police were more likely to document alcohol involvement in single vehicle crashes (OR = 2.32; 95%CI: 1.34, 4.03, p = 0.003). Police were also more likely to document drug involvement in THC-positive drivers who were admitted to hospital (OR = 6.22; 95%CI: 1.35–43.21, p = 0.018), or who had a medical condition (OR = 10.35; 95%CI: 1.97–85.66, p = 0.005). None of the explanatory factors were associated with increased likelihood of police suspecting drugs in drivers who tested positive for recreational drugs other than cannabis or of police suspecting medications in drivers who tested positive for medications (Table 3).

Police suspected involvement of drugs, medications or alcohol in 11 of the 1120 drivers (1.0%) who tested negative for all substances. In drivers who tested negative for all substances, police were more likely to document substance involvement in those involved in nighttime crashes (OR = 8.29, 95%CI: 2.28–44.07, p = 0.001) and in those involved in single vehicle crashes (OR = 3.53, 95%CI: 1.07–12.03, p = 0.039).

6. Discussion

We found that police crash reports seldom document drug involvement in crashes involving drug-positive drivers, even in cases with high drug levels or where a human condition was identified as a possible contributory factor in the crash. This strongly suggests that police seldom recognize the presence of drugs or drug impairment among crash-involved drivers. This conclusion has important public health implications. Impaired driving laws are designed to improve public safety by deterring driving after drug or alcohol use (Berger et al., 1990; Shults et al., 2001). For such laws to be effective, drivers must believe that they are likely to be apprehended and punished (Wright et al., 2010). Conversely, the deterrent effects of the impaired-driving laws will be limited if drug-impaired drivers who are involved in crashes and come to police attention are not even charged, let alone convicted (Watling et al., 2010).

Current Canadian and American drug-impaired driving laws, as well as the proposed amendments in Canada's *Bill C-46*, require the police to have individualized suspicion of recent drug use in order to gather the evidence needed for laying criminal charges. However, if police identify only a small minority of drug-positive drivers, they will have a very limited ability to enforce drug-impaired driving laws that require individualized suspicion. Thus, our findings suggest a need for laws that authorize police to screen drivers for drugs without individualized suspicion or, more specifically, laws that authorize mandatory drug screening, commonly referred to as "random drug testing" (RDT).

Table 3
Police suspicion of drugs or medications. This Table shows the association between driver and/or crash factors and police suspicion of drug use among cannabis-positive drivers and among drivers positive for other recreational drugs. Overall, police suspected drugs among 8 of the 135 cannabis-positive drivers and among 28 of the 165 drivers who were positive for other recreational drugs. Police suspected medications among 8 of the 362 medication-positive drivers. These numbers differ slightly from Table 2 because they exclude drivers with missing crash characteristics for the purpose of regression analysis.

Subset (Positive for:)	Coefficient	Multiple Logistic Regression		Univariate Logistic Regression	
		OR (95%CI)	P-value	OR (95%CI)	P-value
Outcome = Police suspect drugs					
Cannabis	(Intercept)	0.01 (0.00, 0.10)	< 0.001		
	Age < 30 *versus* 30 +	2.46 (0.46, 17.17)	0.300	1.57 (0.40, 7.02)	0.517
	Male *vs* female	0.36 (0.07, 1.70)	0.195	0.35 (0.09, 1.43)	0.139
	Nighttime *vs* daytime	1.02 (0.19, 5.40)	0.977	1.19 (0.27, 4.70)	0.804
	Single *vs* multi-vehicle	2.41 (0.49, 13.96)	0.282	2.19 (0.56, 9.79)	0.261
	Admitted	**6.22 (1.35, 43.21)**	**0.018**	**6.11 (1.48, 34.45)**	**0.012**
	Medical condition	**10.35 (1.97, 85.66)**	**0.005**	**5.48 (1.33, 30.86)**	**0.018**
	Psychiatric condition	0.10 (0.00, 1.55)	0.111	0.66 (0.01, 6.03)	0.771
Recreational drugs	(Intercept)	0.19 (0.06, 0.61)	0.005		
	Age < 30 *versus* 30 +	1.60 (0.68, 3.74)	0.283	1.41 (0.62, 3.18)	0.407
	Male *vs* female	0.65 (0.26, 1.68)	0.357	0.65 (0.27, 1.66)	0.355
	Nighttime *vs* daytime	0.81 (0.36, 1.84)	0.621	0.93 (0.41, 2.08)	0.859
	Single *vs* multi-vehicle	2.24 (0.97, 5.49)	0.058	2.05 (0.90, 4.96)	0.088
	Admitted	0.76 (0.31, 1.78)	0.533	0.85 (0.35, 1.96)	0.714
	Medical condition	1.18 (0.47, 2.91)	0.723	1.07 (0.47, 2.38)	0.876
	Psychiatric condition	0.83 (0.19, 2.91)	0.783	1.02 (0.25, 3.17)	0.976
Outcome = Police suspect medications					
Medications	(Intercept)	0.00 (0.00, 0.04)	< 0.001		
	Age < 30 *versus* 30 +	1.85 (0.26, 10.69)	0.518	1.78 (0.32, 7.57)	0.472
	Male *vs* female	2.34 (0.48, 22.70)	0.316	2.98 (0.62, 28.83)	0.187
	Nighttime *vs* daytime	1.17 (0.24, 5.07)	0.838	1.55 (0.34, 6.45)	0.551
	Single *vs* multi-vehicle	2.47 (0.56, 14.30)	0.234	2.73 (0.65, 15.37)	0.173
	Admitted	1.62 (0.38, 7.35)	0.505	1.94 (0.46, 8.77)	0.357
	Medical condition	2.08 (0.40, 14.66)	0.403	1.10 (0.26, 6.21)	0.899
	Psychiatric condition	0.20 (0.00, 1.85)	0.187	0.25 (0.00, 2.11)	0.251
Outcome = Police suspect any substance					
Negative for all substances	(Intercept)	0.00 (0.00, 0.01)	< 0.001		
	Age < 30 *versus* 30 +	1.25 (0.31, 4.56)	0.741	2.15 (0.61, 6.82)	0.220
	Male *vs* female	0.47 (0.14, 1.62)	0.223	0.82 (0.26, 2.68)	0.728
	Nighttime *vs* daytime	**8.29 (2.28, 44.07)**	**0.001**	**8.55 (2.41, 44.90)**	**0.001**
	Single *vs* multi-vehicle	**3.53 (1.07, 12.03)**	**0.039**	**4.38 (1.38, 14.44)**	**0.013**
	Admitted	3.02 (0.86, 10.12)	0.082	**3.41 (1.03, 10.83)**	**0.045**
	Medical condition	0.67 (0.17, 2.44)	0.547	0.72 (0.20, 2.27)	0.577
	Psychiatric condition	2.26 (0.22, 12.32)	0.434	3.78 (0.40, 16.72)	0.199

Providing police with authority to undertake RDT will present significant legal challenges. Both the American *Bill of Rights* and the *Canadian Charter of Rights and Freedoms* provide protection against unreasonable search or seizure. In both countries, whether a search or seizure is reasonable is largely based on balancing the state's interest in protecting the public with the need to limit intrusions on personal freedoms. Unlike in the United States, an infringement of an individual's right to protection against unreasonable search or seizure in Canada may be justified if the violation is a reasonable limit *"prescribed by law as can be demonstrably justified in a free and democratic society."* In any event, Canadian or American laws authorizing RDT would need to balance individual rights with the societal benefits of preventing drug-impaired traffic crashes.

The situation is somewhat similar to RBT. It has been strongly argued that the RBT provisions in Canada's *Bill C-46* comply with the *Canadian Charter of Rights and Freedoms*. These proponents base their conclusions on, among other things, RBT's proven effectiveness in reducing impaired-driving crashes (Shults et al., 2001; Peek-Asa, 1999; Room et al., 2005; Anderson et al., 2009; Ferris et al., 2015; Solomon et al., 2017), its minimally intrusive nature and the fact that it entails a total delay of about two minutes (Solomon et al., 2017). However, RBT has not been enacted in the United States because of concerns with violating the *Bill of Rights*' search and seizure provisions. Nevertheless, some American researchers have argued that RBT would not violate the *Bill of Rights* because RBT's public safety benefits outweigh the limited intrusion on the rights of drivers (Voas and Fell, 2013).

It will be considerably harder to establish that RDT meets the requirements of the *Charter* or *Bill of Rights*, as it takes longer and would be considered more intrusive than RBT. Moreover, drug-impaired driving has not caused as many deaths and injuries as alcohol-impaired driving (Wettlaufer et al., 2017). Finally, unlike the situation with RBT, there is currently no substantial body of research establishing the effectiveness of RDT in reducing drug-related crashes.

Police inability to recognize drug-positive drivers also has implications for monitoring drug-impaired driving. In many countries, road trauma surveillance is based primarily on police crash reports (United Nations Road Safety Collaboration, 2010). In our study, police crash reports failed to identify more than 90% of drug-positive drivers, and thus markedly underestimated drug-impaired driving prevalence. This observation is confirmed by other evidence. For example, while recent research indicates that the incidence of driving after drug use is not more common in Canada than driving after drinking, drug-impaired driving charges constituted only 3.9% of total impaired driving charges in 2016 (Solomon et al., 2017). Similarly, a 2013 Canadian study estimated that almost 14,000 trips were made by cannabis-positive drivers for each drug-impaired driving charge (Solomon and Chamberlain, 2014). The fact that police reports dramatically underestimate the true prevalence of drug-impaired driving must be considered when making resource allocation decisions targeting drug-impaired driving or when evaluating policies that may impact drug-impaired driving rates, such as legalizing recreational cannabis use.

Our findings also provide insight into the potential role of drugs in

causing crashes. Police were more likely to attribute a human condition as a suspected contributory factor to drug-positive drivers than to drivers who were positive for alcohol alone. Similarly, human condition was less likely to be attributed to drivers who had not used any impairing substance. These findings suggest that, although the police identified only a small percentage of the drug-positive drivers, they appeared to recognize that a significant number of these drivers were impaired in some fashion and suspected that this impairment had contributed to the crash. More research is needed on the characteristics of collisions that involve drug-impaired drivers.

7. Limitations

The major limitation in this study is that we only had data on the presence of drugs and not drug-related impairment. Some drug-positive drivers were likely not impaired. However, given that police were more likely to attribute human conditions to drug-positive drivers, it is probable that many of these drivers were indeed impaired. Furthermore, since we obtained actual drug levels in blood, we could demonstrate that the police seldom suspected drug involvement even among drivers with THC levels above 2 ng/mL (Canada's proposed criminal *per se* driving limit). Another limitation is that we did not interview the police. Consequently, we do not know if the police suspected drug use in some cases, but felt that they lacked sufficient evidence to document it as a suspected possible contributory factor. This does not change the significance of our findings. If police do not have enough evidence to list "drugs suspected" in the police report, then they are very unlikely to pursue drug-impaired driving charges.

Our study involved drivers of passenger vehicles (including light trucks) who sustained moderate to severe injuries in crashes that were investigated by the police. Severe injuries may make it more difficult for police to detect evidence of drug impairment and the results may differ in crashes involving uninjured or minimally injured drivers. However, in this study, we found that police ability to recognize drug involvement was not significantly better in drivers with moderate injuries who were treated and released from the ED as compared to drivers with more severe injuries who were admitted to hospital (Table 3). Furthermore, since police in BC seldom investigate property damage only crashes, it is unlikely that they will identify drug involvement in these cases.

Another consideration is the effect of delays from crash till time of blood draw. A strength of our study is that we were able to obtain blood relatively soon after the crash (within 2 h in over 75% of cases). Nevertheless, due to ongoing metabolism, it is likely that drug concentrations at time of crash were typically higher than those obtained in hospital. As a result, our findings would under-estimate the number of drivers with positive drug levels at time of crash and would over-estimate police ability to identify drug-involvement in these cases. This effect would not change our conclusion that police seldom document drug involvement in drug-positive drivers. This may also explain some cases where police indicated drug involvement in drivers who tested negative.

British Columbia was the first province in Canada to train DREs (in 1995) and awareness of drug-impaired driving by BC police is high. However not all front-line traffic police in BC have been trained to identify signs of drug impairment and our findings may not apply to jurisdictions which provide different "drug-recognition" training for traffic police.

8. Conclusions

Police crash reports do not document drug involvement in the vast majority of crashes involving drug-positive drivers. This finding raises serious concerns about the ability of police to effectively enforce the current or even proposed expanded drug-impaired driving laws. Unless police are given additional enforcement powers, such as authority to conduct RDT, the drug-impaired driving laws will continue to have a very limited deterrent impact. Our findings also suggest that police crash reports should not be relied on to estimate the prevalence of drug-impaired driving. Drug driving policy decisions and program evaluations should be based on more accurate measures of driving after drug use, such as roadside surveys and the systematic drug testing of crash-involved drivers.

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Conflict of interest

None of the authors have any conflict of interest.

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References

Anderson, P., Chisholm, D., Fuhr, D.C., 2009. Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. Lancet 373 (9682), 2234–2246.
Introduction of the Cannabis Act: Questions and Answers. Government of Canada.
Asbridge, M., 2006. Drugs and driving: when science and policy don't mix. Can. J. Public Health 97 (4), 283–285.
Beasley, E., Beirness, D., 2011. Drug Use by Fatally Injured Drivers in Canada (2000–2008). Canadian Centre on Substance Abuse, Ottawa, ON.
Beirness, D.J., Beasley, E.E., 2010. A roadside survey of alcohol and drug use among drivers in British Columbia. Traffic Inj. Prev. 11 (3), 215–221.
Beirness, D., Beasley, E., McClafferty, K., 2015. Alcohol and Drug Use Among Drivers in Ontario: Findings from the 2014 Roadside Survey. Ontario Ministry of Transportation, Toronto, Ontario.
Berger, D.E., Snortum, J.R., Homel, R.J., Hauge, R., Loxley, W., 1990. Deterrence and prevention of alcohol-impaired driving in Australia, the United States, and Norway. Justice Q. 7 (3), 453–465.
Bill C-46, 2017. Legislative Background: Reforms to the Transportation Provisions of the *Criminal Code* (Bill C-46).
Brady, J.E., Li, G., 2013. Prevalence of alcohol and other drugs in fatally injured drivers. Addiction 108 (1), 104–114.
Brubacher, J.R., Chan, H., Fang, M., Brown, D., Purssell, R., 2013. Police documentation of alcohol involvement in hospitalized injured drivers. Traffic Inj. Prev. 14 (5), 453–460.
Brubacher, J.R., Chan, H., Martz, W., Schreiber, W., Asbridge, M., Eppler, J., et al., 2016. Prevalence of alcohol and drug use in injured British Columbia drivers. BMJ Open 6 (3).
Compton, R.P., Berning, A., 2015. Drug and Alcohol Crash Risk. National Highway Traffic Safety Administration, Washington, D.C Report No.: DOT HS 812 117.
Ferris, J., Devaney, M., Sparkes-Davis, M., Davis, G., 2015. A National Examination of Random Breath Testing and Alcohol-Related Traffic Crash Rates (2000–2012). Foundation for alcohol research and education, Deakin West, Australia.
Firth, D., 1993. Bias reduction of maximum likelihood estimates. Biometrika 80 (1), 27–38.
Leufkens, T.R., Vermeeren, A., Smink, B.E., van Ruitenbeek, P., Ramaekers, J.G., Leufkens, T.R.M., et al., 2007. Cognitive, psychomotor and actual driving performance in healthy volunteers after immediate and extended release formulations of alprazolam 1 mg. Psychopharmacology (Berl.) 191 (4), 951–959.
Lowenstein, S.R., Koziol-McLain, J., 2001. Drugs and traffic crash responsibility: a study of injured motorists in Colorado. J. Trauma-Inj. Infect. Crit. Care 50 (2), 313–320.
Peek-Asa, C., 1999. The effect of random alcohol screening in reducing motor vehicle crash injuries. Am. J. Prev. Med. 16 (1 Suppl), 57–67.
R Core Team, 2017. R: A Language and Environment for Statistical Computing Vienna, Austria. R Foundation for Statistical Computing.
Ramaekers, J.G., 2003. Antidepressants and driver impairment: empirical evidence from a standard on-the-road test. J. Clin. Psychiatry 64 (1), 20–29.
Ramaekers, J.G., Berghaus, G., van Laar, M., Drummer, O.H., 2004. Dose related risk of motor vehicle crashes after cannabis use. Drug Alcohol Depend. 73 (2), 109–119.
Ramaekers, J.G., Kauert, G., van Ruitenbeek, P., Theunissen, E.L., Schneider, E., Moeller, M.R., et al., 2006. High-potency marijuana impairs executive function and inhibitory motor control. Neuropsychopharmacology 31 (10), 2296–2303.
Room, R., Babor, T., Rehm, J., 2005. Alcohol and public health. Lancet 365 (9458), 519–530.
Shults, R.A., Elder, R.W., Sleet, D.A., Nichols, J.L., Alao, M.O., Carande-Kulis, V.G., et al.,

2001. Reviews of evidence regarding interventions to reduce alcohol-impaired driving. Am. J. Prev. Med. 21 (4 Suppl), 66–88.
Solomon, R., Chamberlain, E., 2014. Canada's new drug-impaired driving law: the need to consider other approaches. Traffic Inj. Prev. 15 (7), 685–693.
Solomon, R., Ellis, C., Zheng, C., 2017. Persons Charged With Drug-Impaired Driving by Offence and Jurisdiction: Canada. Mothers Against Drunk Driving, Oakville, Ontario, pp. 2008–2016.
United Nations Road Safety Collaboration, 2010. Data Systems: A Road Safety Manual for Decision-Makers and Practitioners. WHO press, Geneva.
Vindenes, V., Jordbru, D., Knapskog, A.-B., Kvan, E., Mathisrud, G., Slordal, L., et al., 2012. Impairment based legislative limits for driving under the influence of non-alcohol drugs in Norway. Forensic Sci. Int. 219 (1-3), 1–11.
Voas, R.B., Fell, J.C., 2013. Strengthening impaired-driving enforcement in the United States. Traffic Inj. Prev. 14 (7). http://dx.doi.org/10.1080/15389588.2012.754095.
Walsh, J.M., Flegel, R., Atkins, R., Cangianelli, L.A., Cooper, C., Welsh, C., et al., 2005. Drug and alcohol use among drivers admitted to a Level-1 trauma center. Accid. Anal. Prev. 37 (5), 894–901.
Watling, C.N., Palk, G.R., Freeman, J.E., Davey, J.D., 2010. Applying Stafford and Warr's reconceptualization of deterrence theory to drug driving: can it predict those likely to offend? Accid. Anal. Prev. 42 (2), 452–458.
Wettlaufer, A., Florica, R.O., Asbridge, M., Beirness, D., Brubacher, J., Callaghan, R., et al., 2017. Estimating the harms and costs of cannabis-attributable collisions in the Canadian provinces. Drug Alcohol Depend. 173, 185–190.
Wingen, M., Ramaekers, J.G., Schmitt, J.A., Wingen, M., Ramaekers, J.G., Schmitt, J.A.J., 2006. Driving impairment in depressed patients receiving long-term antidepressant treatment. Psychopharmacology (Berl.) 188 (1), 84–91.
Wright, V., Deterrence in, Criminal, Justice, 2010. Washington, D.C.: The Sentencing Project: Research and Advocacy for Reform; 2010 November. Evaluating Certaintly vs Severity of Punishment.