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# Driving Under the Influence of Cannabis: An Examination of Driving Beliefs and Practices of Medical and Recreational Cannabis Users across the United States

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## ABSTRACT

Trends toward the legalization of cannabis are raising concerns about driving under the influence of cannabis (DUIC). The goal of this study was to examine the percentage of cannabis users who believe DUIC is safe, who drive within one hour of using cannabis, and who have experienced a DUIC-related incident (i.e., ticket/accident). We further sought to compare these percentages in exclusively medical versus exclusively recreational versus mixed cannabis users and in participants surveyed before versus after legal sales of recreational cannabis. Finally, we examined predictors of DUIC beliefs, practices, and incidents. An anonymous online survey was administered to cannabis users across the 50 United States (N=1773; 54% Male) to assess DUIC beliefs, practices, and incidents. 52.4% reported believing DUIC is safe, 52.1% admitted to driving within one hour of using cannabis, but only 3.9% reported experiencing a DUIC-related incident. No significant differences were found in exclusively medical, exclusively recreational, and mixed cannabis users or in WA respondents surveyed before- and after-legal sales in WA state. Older age, less education, higher frequency and quantities of use, and driving within one hour of use predicted beliefs DUIC is safe. Younger age, more education, higher frequency and quantities of use, younger age of first use, and beliefs DUIC is safe predicted driving within one hour of using cannabis. Male gender, lower income, and higher frequency of use predicted DUIC-related incidents. Rates of DUIC are high among cannabis users but self-reported accidents/tickets are low. Recreational cannabis sales do not appear to be exacerbating these rates.

**Key words:** driving; driving under the influence; recreational cannabis; medical cannabis; recreational cannabis legalization

Cannabis use is presently at an all-time high in the United States (U.S.), with 44% of Americans admitting that they have tried cannabis and 11% reporting current cannabis use (Gallup, 2015). Trends toward the legalization of cannabis for recreational purposes are not only increasing the availability of cannabis but they are also decreasing stigma and perceptions of risks

(Okaneke, et al., 2015; Palamer, 2014). As such, fears are being expressed that increased rates of cannabis use combined with decreased perceptions of risks will exacerbate rates of driving under the influence of cannabis (DUIC), which may in turn pose a public health threat.

Results of experimental research on the acute effects of cannabis on psychomotor and cognitive

test performance justify fears that DUIC may represent a public health threat. As reviewed by Ramaekers, Berghaus, van Laar, and Drummer (2004), the results of numerous experimental studies have generally revealed dose dependent reductions in performance on tests of memory, divided attention, sustained attention, reaction time, tracking, and motor control. This review also describes a meta-analysis (Berghaus, Schultz, & Szegedi, 1998) that indicated that the percentage of psychomotor tests impaired by THC was highest during the first hour after smoking and sharply declined to zero 3-4 hours after use. Moreover, dose dependent effects were detected with higher doses of THC increasing the percentage of tests impaired and increasing the duration of impairments. Of course, one limitation of these experimental studies is that the degree to which impairments on these laboratory tests of psychomotor and cognitive abilities translates to actual driving ability is largely unknown. Indeed, many of these tests are far more simplistic than driving, which requires a much more complex integration of these skills.

Recent research (Hartman et al., 2016) utilizing a state-of-the-art full-motion driving simulator and vaporized cannabis found that higher levels of tetrahydrocannabinol (THC) were significantly associated with *decreased* speed and *increased* headway (i.e. distance) behind a lead vehicle. These results are consistent with the findings of other driving simulator studies, which showed significant decreases in speed (Anderson et al., 2010; Leené et al., 2010; Ronen et al., 2008; Ronen et al., 2010) increased headway (Leené et al., 2010), and refusal of more opportunities to pass (Ramaekers et al., 2004) under the influence of inhaled cannabis or THC, relative to placebo. Previous researchers have interpreted these findings to suggest that slower speed and increased headway allow drivers more time to react to changes (Hartman et al., 2016), which may be important in light of evidence that reaction time (e.g. Leené et al., 2010; Ronan et al., 2008) and lateral positive variability (Ramaekers et al., 2004) shows significant increases during cannabis intoxication. Moreover, findings of increased caution when DUIC are commonly interpreted to reflect awareness of impairment and attempts to compensate (Anderson et al., 2010; Hartman et al., 2016; Leené et al., 2010; Ronen et al., 2010).

Research quantifying levels of THC and its metabolites in drivers involved in traffic accidents has also been heavily relied upon to assess the extent of the DUIC problem and to infer risks associated with DUIC. Reviews of this literature have generally converged on the notion that accidents are roughly doubled in those with THC detected in their systems (Asbridge, et al., 2012; Hartman & Huestis, 2013; Li et al., 2011). However, there is substantial variability in these results, with a recent controlled meta-analysis suggesting that accident risk in those with THC in their system is substantially lower (odd ratio [OR] = 1.36; Rogeberg & Elvik, 2016). Of greater concern, this research is confounded by the fact that THC and its metabolites can be detected in the bodily fluids of regular cannabis users after a month or more of abstinence (Bergamaschi et al., 2013; Kapur, 1994; Karschner et al., 2015). As such, these estimates would include individuals who used cannabis regularly and/or recently but who were not acutely intoxicated at the time of the accident. Therefore, risks of DUIC may actually be higher than these studies would suggest (Gjerd & Mørland, 2016). Another problem with inferring risks of DUIC in this manner is that most drivers with THC detected in their system, test positive for alcohol or other drugs (Hoff, 2016; Rogeberg & Elvik, 2016). These problems are further muddled by the current lack of any standardized, valid, and reliable assay/instrument for detecting acute cannabis intoxication. These impediments hinder the ability to determine whether drivers who test positive for THC are intoxicated by cannabis at the time of the accident (ACMD, 2000) and obscure our understanding of the magnitude of the DUIC problem.

Given the barriers to detecting acute cannabis intoxication, it is important to explore complementary methods of examining the issue of DUIC. One avenue of research that is less developed is the examination of cannabis users' perceptions of the effects of cannabis on driving ability and their self-reports of DUIC, which may help shed light on the degree of the problem at hand. That is, if acute cannabis intoxication significantly increases the risk of accidents, but only a small proportion of cannabis users engage in this behavior, the public health risk would seem less concerning. In contrast, if a large proportion of cannabis users admit to DUIC then the

importance of understanding the risks of DUIC would be underscored.

Only a few studies have examined cannabis users' perceptions of the effects of cannabis on driving ability. Specifically, Aitken and colleagues (2000) found that a small group of Australian cannabis users unanimously perceived cannabis to be very safe for driving; while Lenné and colleagues (2001) found that 57% of Australian cannabis users reported that DUIC does not increase their accident risk. Similarly, a study conducted in England found that 58% of regular cannabis users believed cannabis only slightly impairs their driving ability (Terry & Wright, 2005). Collectively, these results indicate that the majority of cannabis users do not believe that cannabis significantly impairs their driving ability.

Consistent with these findings, previous research has revealed that 90% of Australian cannabis users (Reilly et al., 1998) and 82% of English cannabis users (Terry & Wright, 2005) reported DUIC at least once in their lives. Moreover, 28.5% of Australian users (Jones et al., 2003), 23% of Canadian cannabis users (Walsh & Mann, 1999), and 9.7% of cannabis users from Spain (Alvarez et al., 2007) reported DUIC in the past year. To our knowledge only two studies of self-reported DUIC have been conducted in the U.S. The first found that approximately 50% of a small sample of young adult (18-21 yrs.) cannabis users reported DUIC (Johnson & White, 1989). A more recent study found that 43.6% of a large sample of cannabis users from Colorado and Washington (WA) State reported DUIC in the past year, and 23.9% reported driving within one hour of using cannabis at least five times in the past month (Davis et al., 2016). These results suggest that DUIC is common among regular cannabis users; however, rates appear to vary somewhat across countries.

In summary, a limited body of research indicates that a substantial proportion of cannabis users believe that DUIC is safe and engage in the practice. However, this research has largely been conducted outside of the U.S. or in small samples of young adults, and we are aware of only one study that has focused on a broader U.S. sample. Moreover, to our knowledge no research has been conducted to compare the driving beliefs and practices of exclusively recreational vs. exclusively medical vs. non-

exclusive medical/recreational cannabis users or to compare driving beliefs and practices before and after recreational marijuana stores opened their doors to the public. Exploring the impact of the legal sales of recreational cannabis on DUIC perceptions and practices may help address growing concerns about the influence of the new legal cannabis market on rates of DUIC. Further, information on the characteristics that predict DUIC beliefs and practices will help identify those at greatest risk, thereby aiding in targeting campaigns against DUIC.

Therefore, the aims of the present study were to: i) examine the percentage of cannabis users in the U.S. who believe that DUIC is safe, who report driving within one hour of using cannabis, and who report having been in an accident or receiving a ticket when DUIC, ii) compare these percentages in exclusively medical vs. exclusively recreational vs. non-exclusive medical/recreational cannabis users, iii) explore whether these beliefs and practices differ in residents of WA state surveyed before and after recreational cannabis became commercially available for legal purchase, and iv) determine which demographic characteristics, cannabis use patterns, and beliefs/practices predict DUIC beliefs, practices, and incidents.

## METHOD

### *Participants*

Participants were recruited via word-of-mouth and links on advertisements posted on various websites and in WA state cannabis dispensaries. A total of 1773 participants who had used cannabis in the past 90 days, were 16 years of age or older, and resided in the U.S. completed the survey. There were respondents from all 50 states but a disproportionate percentage of respondents (22.4%) resided in WA state (where the survey was housed). Table 1 displays the complete demographic characteristics of the sample.

### *Procedures*

Bastyr University's Institutional Review Board approved the study. As part of a larger anonymous online survey designed to assess cannabis use patterns, beliefs, and effects, participants answered the question described in

**Table 1. Sample Characteristics**

<b>Gender</b>	<i>n</i> = 1759	<b>Cannabis Use Purpose</b>	<i>n</i> = 1767
Male	54% ( <i>n</i> = 950)	Exclusively Recreational	37.6% ( <i>n</i> = 664)
Female	46% ( <i>n</i> = 809)	Exclusively Medical	30.6% ( <i>n</i> = 541)
<b>Age</b>	<i>n</i> = 1773	Recreational & Medical	31.5% ( <i>n</i> = 557)
	<i>M</i> = 34.23	Exclusively Religious	0.3% ( <i>n</i> = 5)
	( <i>SD</i> = 13.18)	<b>Cannabis Use Frequency</b>	<i>n</i> = 1770
<b>Race/Ethnicity</b>	<i>n</i> = 1758	< 2 times per year	1.2% ( <i>n</i> = 22)
Caucasian	87.7% ( <i>n</i> = 1541)	1 time every 4-6 months	1.1% ( <i>n</i> = 19)
African American	1.0% ( <i>n</i> = 18)	1 time every 2-3 months	1.9% ( <i>n</i> = 34)
Hispanic	3.4% ( <i>n</i> = 60)	1 time per month	2.0% ( <i>n</i> = 36)
Native American	1.5% ( <i>n</i> = 26)	2-3 times per month	4.8% ( <i>n</i> = 85)
Asian/Pacific Islander	1.6% ( <i>n</i> = 28)	1-3 times per week	10.6% ( <i>n</i> = 187)
Other	4.8% ( <i>n</i> = 85)	3-6 times per week	14.8% ( <i>n</i> = 262)
<b>Highest Level of Education</b>	<i>n</i> = 1769	1-4 times per day	42.4% ( <i>n</i> = 751)
< High School	2.3% ( <i>n</i> = 40)	5-10 times per day	12.5% ( <i>n</i> = 221)
High School/GED	29.5% ( <i>n</i> = 522)	All day, every day	8.6% ( <i>n</i> = 153)
Technical School	9.3% ( <i>n</i> = 164)	<b>Quantity Used Per Week</b>	<i>n</i> = 1760
Associate	16.1% ( <i>n</i> = 285)	<1 gram	20.7% ( <i>n</i> = 365)
Bachelors	29.3% ( <i>n</i> = 518)	1-2 grams	22.3% ( <i>n</i> = 393)
Masters	9.0% ( <i>n</i> = 159)	3-5 grams	30.3% ( <i>n</i> = 533)
Doctorate	4.6% ( <i>n</i> = 81)	6-7 grams	20.4% ( <i>n</i> = 359)
<b>Current Employment</b>	<i>n</i> = 1759	1 ounce	4.1% ( <i>n</i> = 73)
Full time	52.8% ( <i>n</i> = 928)	More than 1 ounce	2.1% ( <i>n</i> = 37)
Part time	21.7% ( <i>n</i> = 382)	<b>Age of First Use</b>	<i>n</i> = 1770
Unemployed	12.3% ( <i>n</i> = 216)	<10	1.5% ( <i>n</i> = 26)
Retired	3.9% ( <i>n</i> = 68)	11-13	13.3% ( <i>n</i> = 236)
Disabled	9.4% ( <i>n</i> = 165)	14-16	36.7% ( <i>n</i> = 649)
<b>Income: Last 12 Months</b>	<i>n</i> = 1756	17-18	23.3% ( <i>n</i> = 413)
<\$20,000	21.0% ( <i>n</i> = 364)	19-20	11.1% ( <i>n</i> = 197)
\$20-40,000	24.0% ( <i>n</i> = 416)	21-25	8.8% ( <i>n</i> = 155)
\$40-60,000	17.4% ( <i>n</i> = 301)	26-30	2.6% ( <i>n</i> = 46)
\$60-80,000	10.8% ( <i>n</i> = 188)	31-35	1.0% ( <i>n</i> = 17)
\$80-100,000	9.6% ( <i>n</i> = 166)	35-40	0.6% ( <i>n</i> = 10)
\$100-150,000	9.6% ( <i>n</i> = 166)	Over 40	1.2% ( <i>n</i> = 21)
>\$150,000	7.6% ( <i>n</i> = 132)		
<b>Relationship Status</b>	<i>n</i> = 1767		
Married	32.8% ( <i>n</i> = 579)		
Domestic Partnership	12.8% ( <i>n</i> = 230)		
Divorced	5.5% ( <i>n</i> = 98)		
Single	42.4% ( <i>n</i> = 749)		
Other	6.5% ( <i>n</i> = 114)		

the Measures section. Participants were not compensated.

### Measures

*Demographics.* Participants were asked to input their age, country, and state/province of residence. Only respondents residing in the U.S. were considered. Participants were also asked to indicate their gender, ethnicity, employment, relationship, education, and family income.

*Cannabis Use Patterns.* Participants were asked to indicate whether or not they used cannabis for recreational, medicinal, and/or religious purposes. They were also asked to indicate the frequency they use cannabis, the quantity of cannabis used per week, and their age when they first tried cannabis.

*DUIC Beliefs, Practices, and Incidents.* To assess DUIC beliefs, participants were asked whether or not they believe cannabis impairs their ability to drive safely. To assess DUIC practices, participants were asked whether they drive within one hour of using cannabis. Finally, to assess DUIC-related incidents, participants were asked whether they had ever been in an accident, or received a ticket, while DUIC. All responses were dichotomized into yes/no [1/0] responses.

### Data Analysis

The percentages of participants who reported believing DUIC is safe, who reported driving within one hour of using cannabis, and who reported having a DUIC-related incident were computed. Chi-square tests were used to compare these percentages among exclusively medical cannabis users, exclusively recreation cannabis users, and non-exclusive medical/recreational cannabis users. Additional chi-square tests were used to compare WA State respondents' DUIC beliefs, practices, and incidents pre- and post-legal sales. WA state residents were selected because only one respondent resided in Alaska, only six Colorado residents completed the survey prior to legal sales, and no Oregon residents completed the survey after recreational cannabis became available for purchase. A series of logistic regression analyses were used to determine which demographic characteristics, cannabis use patterns, and DUIC beliefs, practices and

incidents, predicted DUIC-related beliefs, practices, and incidents.

## RESULTS

### Overall Results

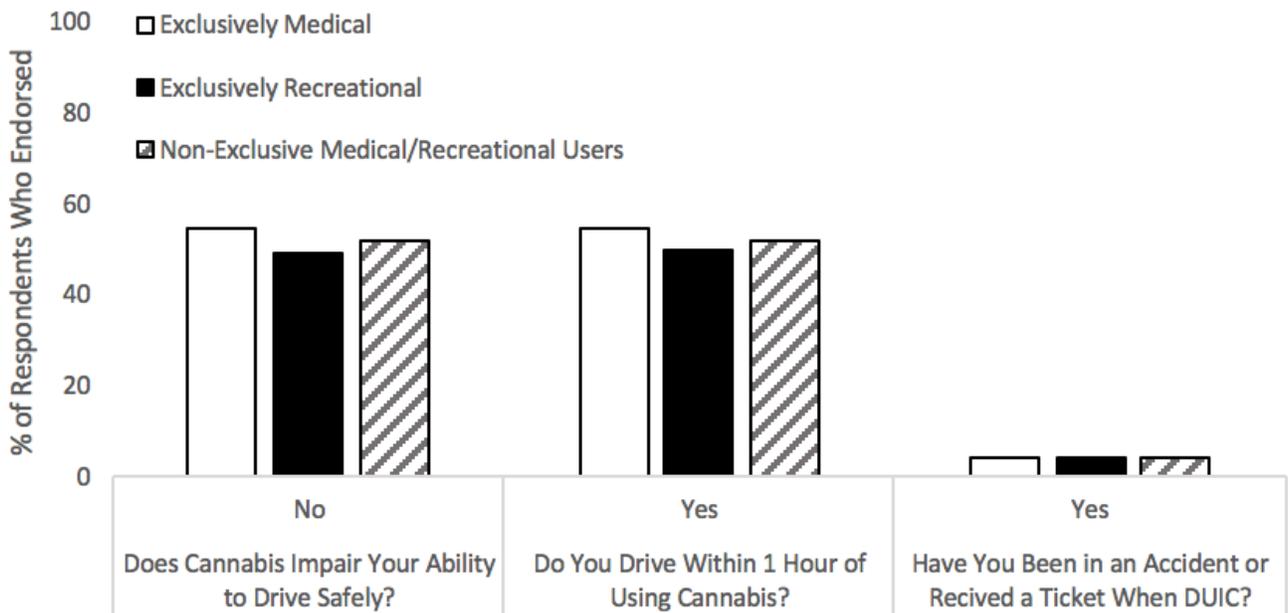
A total of 52.4% of the sample indicated that cannabis does not impair their ability to drive safely. Consistent with this perception, 52.1% of participants indicated that they drive within one hour of using cannabis. However, only 3.9% of participants reported that they had received a ticket or been in an accident while DUIC. Interestingly, 29.6% of the participants who reported believing that cannabis impairs their ability to drive safely, also reported that they drive within one hour of using cannabis.

### Medical vs. Recreational vs. Non-Exclusive Medical/Recreational Users

To compare medical cannabis users, recreational cannabis users, and mixed recreational/medical cannabis users' DUIC beliefs, practices, and incidents, participants who reported using cannabis for exclusively recreational purposes ( $n = 664$ ; 37.6%), for exclusively medical purposes ( $n = 541$ ; 30.6%), or for both medical and recreational purposes ( $n = 557$ ; 31.5%), were selected. Respondents ( $n = 5$ ; 0.3%) who reported use for religious purposes were excluded from these analyses. As depicted in Figure 1, there were no significant differences in the percentages of exclusively medical, exclusively recreational, and non-exclusive medical/recreational cannabis users' beliefs about the safety of DUIC,  $\chi^2(2) = 5.12$ ,  $p = .08$ , practices of driving within one hour of using cannabis,  $\chi^2(2) = 2.66$ ,  $p = .26$ , or in their self-reported accidents/tickets when DUIC,  $\chi^2(2) = 1.04$ ,  $p = .59$ .

### Pre- and Post-Legal Sales of Recreational Cannabis

To explore potential impacts of the legal sales of recreational cannabis on DUIC beliefs, practices, and incidents, participants who indicated residing in WA were selected ( $n = 398$ ). Those who completed the survey before the first recreational cannabis store opened in WA State



**Figure 1.** Comparisons of exclusively medical, exclusively recreational, and non-exclusive medical/recreational cannabis users’ DUIC-related beliefs, practices, and incidents. No significant differences were found across groups.



**Figure 2.** Comparisons of DUIC-related beliefs, practices, and incidents before and after legal sales of recreational cannabis in WA State. No significant differences were detected between groups.

(11/4/2013 – 07/08/2014) were identified as pre-legal sales respondents ( $n = 279$ ), while those who completed the survey after this date (07/09/2014 – 12/15/2014) were identified as post-legal sales respondents ( $n = 119$ ). As depicted in Figure 2, there were no significant differences in the two groups' beliefs about the safety of DUIC,  $\chi^2(1) = 2.76$ ,  $p = .10$ , practices of driving within one hour of using cannabis,  $\chi^2(1) = 3.68$ ,  $p = .055$ , or in their self-reported DUIC-related incidents,  $\chi^2(1) = 1.39$ ,  $p = .24$ . However, there was a trend for a higher percentage of pre-legal sales respondents than post-legal sales respondents (44.4% vs. 35.3%;  $p = .055$ ) to report driving within one hour of using cannabis.

### *Predictors of Driving Perceptions and Practices*

As shown in Table 2, logistic regression analysis revealed that older age, less education, higher frequency of cannabis use, higher quantity of cannabis use, and driving within one hour of use were significant predictors of beliefs that DUIC is safe. A second logistic regression analysis revealed that younger age, higher education, higher frequency of cannabis use, higher quantity of cannabis use, lower age of first use, and beliefs that DUIC is safe were significant predictors of driving within one hour of using cannabis (Table 2). A final logistic regression analysis revealed that male gender, lower income, and higher frequency of use were significant predictors of DUIC-related incidents (Table 2).

## DISCUSSION

The results of this large-scale anonymous survey of cannabis users across the 50 United States indicate that over 50% of cannabis users report believing that DUIC is safe and over 50% admit to driving within one hour of using cannabis. These findings suggest that some ambiguity remains about the perceived safety of DUIC among cannabis users and underscores the need for additional research on the risks of DUIC and of disseminating the results of this research to the general population. It was somewhat surprising that 29.6% of the cannabis users who reported

believing that cannabis impairs their ability to drive safely, also admitted that they drive within one hour of using cannabis. This indicates that a substantial proportion of cannabis users are DUIC despite their personal belief that this is not a safe practice. This suggests that there are other motivating factors at play (e.g., proneness to risk-taking behaviors) in the decision to DUIC. Future research should further explore the reasons for why individuals report DUIC in order to assist in better targeting anti-DUIC campaigns and other interventions.

Results of the current study also suggest that self-reported accidents and tickets when DUIC are rather low (3.9%). This finding is remarkably consistent with Johnson and White's (1989) finding that 4% of young adults in the U.S. reported smoking cannabis before an accident. It is highly likely that these self-reported rates are lower than actual rates due to self-report bias (including a potential desire to try to decrease perceptions of harm associated with cannabis use and instances of memory failures) as well as by the fact that those who have been killed when DUIC would not be represented in our survey. Also without knowledge of the percentage of time respondents drive sober versus under the influence of cannabis and their rates of accidents while sober versus intoxicated, it is not possible to interpret this statistic with respect to elevated risks associated with DUIC. Therefore, future research should attempt to gather this information to better understand the potential risks of DUIC. Nevertheless, the results suggest that a substantial proportion of cannabis users are DUIC without incident.

The results of comparisons of exclusively medical, exclusively recreational, and non-exclusive medical/recreational cannabis users indicated no significant differences in DUIC beliefs, practices, and incidents. Similarly, there were no significant differences in the beliefs, practices, and incidents of WA state residents surveyed before and after

**Table 2.** Logistic regression analyses using demographic variables, cannabis use patterns, and DUIIC beliefs, practices, and incidents to predict DUIIC predict beliefs, practices and incidents

	Beliefs DUIIC is Safe			Drive Within One Hour			DUIIC-Related Incidents		
	<i>Model Statistics</i>			<i>Model Statistics</i>			<i>Model Statistics</i>		
	$\chi^2$	$R^2$	$p$	$\chi^2$	$R^2$	$p$	$\chi^2$	$R^2$	$p$
	407.47	.29	< .001	499.69	.35	< .001	39.43	.08	< .001
Predictors	<i>Predictor Statistics</i>			<i>Predictor Statistics</i>			<i>Predictor Statistics</i>		
	Wald $\chi^2$	OR	$P$	Wald $\chi^2$	OR	$p$	Wald $\chi^2$	OR	$p$
Age	16.77	1.02	< .001	20.92	0.98	< .001	0.65	1.01	.42
Gender (F=0; M=1)	1.41	1.15	.23	1.26	1.14	.26	8.53	2.31	<b>.004</b>
Education	9.14	0.89	<b>.002</b>	16.91	1.18	<b>.001</b>	0.25	1.05	.62
Income	0.18	0.99	.67	0.01	1.00	.93	4.13	0.86	<b>.04</b>
Frequency of Cannabis Use	4.39	1.10	<b>.04</b>	21.10	1.26	< .001	4.20	1.31	<b>.04</b>
Quantity of Cannabis Use	11.73	1.25	< .001	23.87	1.39	< .001	0.00	1.00	.99
Age Cannabis First Used	2.02	0.95	.16	22.08	0.83	< .001	3.34	0.83	.07
Beliefs DUIIC Safe	-----	-----	-----	185.26	2.24	< .001	0.62	0.89	.43
Drive Within One Hour	186.40	5.04	< .001	-----	-----	-----	3.35	1.76	.07
DUIIC-Related Incident	0.44	0.82	.51	3.06	1.73	.08	-----	-----	-----

Note.  $R^2$  = Nagelkerke  $R^2$ , OR = odds ratio, bolded values indicate  $p < .05$

recreational cannabis sales. The latter results are consistent with a recent study which utilized the U.S. Fatality Analysis Reporting System and found that the changes in motor vehicle crash fatality rates since legalization for Washington and Colorado are comparable to those from similar states that have not legalized recreational marijuana (Aydelotte et al., 2017). However, it is important to note that the survey data utilized for the present study do not extend beyond December, 2014 (5 months after legal sales commenced in WA). Given that beliefs, practices, and incidents may take more time to change, it is important that future research continue to monitor the potential impacts of legal sales of recreational cannabis on attitudes, practices, and incidents related to DUIIC.

Although not statistically significant in the reduced sample, there was a 9.1% decline in the percentage of people reporting that they believe DUIIC is safe and a 10.6% decrease in the percentage of people reporting driving within one hour of using cannabis after recreational cannabis became legally available for purchase. It is possible that changes in legislation may be increasing awareness of cannabis policies in the general public, increasing concerns about enforcement of drugged driving, and/or that labeling of recreational cannabis may be having its intended effects. For instance, all recreational cannabis sold in WA State must contain a label with the following message, "Marijuana can impair concentration, coordination, and judgment. Do not operate a vehicle or machinery under the influence of this drug" (Washington State Legislature, Title 314, Chapter 55-105). Such messages may be helping to deter people from DUIIC. Regardless, preliminary results of the present study are encouraging and indicate that the legalization of recreational cannabis may not be intensifying rates of DUIIC. Nevertheless, it will be important for future more controlled research to verify these findings, extend them to other states preparing to legalize

recreational cannabis, and continue to examine changes across longer periods of time.

The logistic regression analysis used to examine predictors of beliefs that DUIIC is safe revealed that participants' age, education, frequency of cannabis use, quantity of use, and driving within one hour of using cannabis are significant predictors, with admitting to driving within one hour of using cannabis emerging as the strongest predictor of these beliefs. The odds ratio associated with participants' age, frequency, and quantity of use indicate that as these variables increase so do the chances that the individual will report believing that DUIIC is safe. These findings appear to indicate that older, more experienced cannabis users are more likely to believe that DUIIC is safe. It is possible that those who frequently use high quantities of cannabis are motivated to endorse such beliefs in order to justify the potential necessity of combining the routine behaviors of using cannabis and driving. While research examining motivations for DUIIC - and how these vary as a function of age and cannabis use history - is needed to fully understand these results, it is also possible that older more experienced users perceive cannabis to be more benign as they have grown more accustomed to its effects. However, it is important to note that recent research suggests that there are no tolerance effects to the acute administration of THC and even regular users are adversely affected by the psychomotor effects of THC (Ramaekers et al., 2016). As such, it will be important to identify, and if necessary correct, cannabis users' beliefs about tolerance effects and the safety of DUIIC.

The odds ratios generated from the logistic regression analysis used to predict driving within one hour of using cannabis, indicate that younger age, higher education, higher frequency of use, higher quantity of use, lower age of first use, and beliefs that DUIIC is safe predict driving within one hour of using

cannabis. Given that beliefs that DUIC is safe was the strongest predictor of driving within one hour of using cannabis, it is somewhat unclear why younger age and higher education predicted driving within one hour of using cannabis despite the finding that older age and lower education predicted beliefs that DUIC is safe. One possible explanation is that younger individuals may be more likely to engage in known risks. In other words, while it appears that older individuals are more likely to believe that DUIC is safe, they may be more cautious in their actual behavior.

The results of the regression analysis used to predict self-reported tickets/accidents when DUIC revealed that gender, income, and frequency of cannabis use, were significant predictors. The odds ratio for frequency of use indicates that those who use cannabis more frequently are more likely to report receiving a ticket or being in an accident when DUIC. The odds ratio for income indicate that lower income is associated with reporting a DUIC-related incident. Finally, gender showed the strongest relationship, with the odds ratio indicating that men are 2.31 times more likely to report a DUIC-related incident.

There are numerous hurdles to examining the issue of DUIC. As previously described, these include the lack of any valid and reliable index of acute cannabis intoxication, the confounding effects of polysubstance use, and individual differences in drug metabolism and tolerance that can vary as a function of the frequency, quantity, and duration of cannabis use. The present study is also limited by several factors, including potential self-report bias, which may include underreporting of DUIC-related incidents, desire to decrease perceptions of harm associated with cannabis use, failure to disclose driving within one hour of using cannabis, and instances of memory failure. However, the anonymous nature of the survey should have diminished these biases.

Other limitations include self-selection bias associated with the use of a convenience sample, lack of ethnic diversity in the sample, and the sample's heavy use of cannabis (over 50% were daily users and used more than 3 grams per week). Given that frequency and quantity of use predicted DUIC beliefs and practices, these sample characteristics may have inflated the reported percentages. Nevertheless, while data from the present study may not reflect the general population, they do capture the beliefs and practices of the population most relevant to the discussion about DUIC and public health (i.e., frequent cannabis users). Moreover, the large sized sample increases confidence in the generalizability of the results to similar populations of cannabis users across the U.S. and helps to increase confidence in the veracity of the findings.

Finally, it is important to note that the cross-sectional nature of the survey prohibits the ability to arrive at causal conclusions. As such the predictors identified in the logistic regression analyses should not be considered causal agents in DUIC-related beliefs, practices, and incidents. Nevertheless, identification of these predictors may help to guide future campaigns against DUIC. Similarly, while the results from the present study failed to garner any evidence for concerns that the legal sales of recreational cannabis would exacerbate the DUIC problem, the causal role of this new legal market cannot be definitively determined using the present cross-sectional design. Rather, results from the present study merely provide encouraging preliminary evidence that the legal sales of recreational cannabis do not appear to be associated with immediate changes in DUIC-related beliefs, practices, and incidents. Once again, these results should be used to encourage future, more controlled, longitudinal investigations into the impact of changing cannabis laws on the DUIC problem.

### Conclusion

The results of this large-scale anonymous survey revealed that over 50% of cannabis users believe that cannabis does not impair their driving ability and over 50% report driving within one hour of using cannabis. This underscores the need to develop valid and reliable roadside indicators of acute cannabis intoxication. The present study also uncovered a number of demographic variables and cannabis use patterns that predict DUIC beliefs and practices that could be used to target future road safety educational initiatives, anti-DUIC campaigns, and other interventions to reduce DUIC. Finally, results from the present study provide encouraging preliminary evidence that legal sales of recreational cannabis do not appear to be exacerbating rates of DUIC.

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