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Cannabis use in older drivers in Colorado: The LongROAD Study

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Abstract

This study examined cannabis use and driving outcomes among older drivers in Colorado, which has legalized medical and recreational use. The associations of self-reported past-year cannabis use with diverse driving outcomes were assessed in 598 drivers aged 65–79 (51% female, 70% with postsecondary education), using regression analysis to adjust for health and sociodemographic characteristics. Two hundred forty four (40.8%) drivers reported ever using cannabis. Fifty-four drivers (9.0%) reported past-year use, ranging from more than once a day (13.0%) to less than once a month (50.0%). Of past-year users, 9.3% reported cannabis use within 1 h of driving in the past year. Past-year users were younger, less highly educated, lower income, and reported significantly worse mental, emotional, social and cognitive health status than drivers without past-year use. Past-year users were four times as likely to report having driven when they may have been over the legal blood-alcohol limit (adjusted OR [aOR] = 4.18; 95% CI: 2.11, 8.25)

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but were not more likely to report having had a crash or citation (aOR = 1.36; 95% CI: 0.70, 2.66) in the past year. Users and non-users had similar scores on self-rated abilities for safe driving (adjusted beta = −0.04; 95% CI: −0.23, 0.15) and on driving-related lapses, errors and violations in the past year (adjusted beta = 0.04; 95% CI: −0.04, 0.12). Further study is needed to establish driving risks and behaviours related to cannabis use, independent of other associated risk factors, among older adults.

Keywords

Cannabis; Marijuana; Driving; Older driver; Geriatric; Traffic safety

1. Introduction

Cannabis use has been shown to impair cognition and other aspects of performance that influence driving safety (Bosker et al., 2012; Downey et al., 2013; Kelly et al., 2004; Lenné et al., 2011; Sewell et al., 2009). Several recent meta-analyses have demonstrated a significantly increased crash risk associated with cannabis use (Asbridge et al., 2012; Li et al., 2012; Rogeberg and Elvik, 2016). A pooled analysis from multiple European countries also showed a small increased risk of being seriously injured or killed in a crash while positive for cannabis, although this increase was not statistically significant (Hels et al., 2011). More recent epidemiologic research indicates that concurrent use of cannabis and alcohol has a positive interaction effect on fatal crash risk (Chihuri et al., 2017; Li et al., 2017a).

US population-based studies have demonstrated significant increases in the prevalence of cannabis use among adults aged 65 and older since 2001 (Han et al., 2016; Hasin et al., 2015; Salas-Wright et al., 2017), a period during which most US states passed medical cannabis laws, (National Conference of State Legislatures, 2018). However, there has been limited research on how the increasing prevalence of cannabis use in older adults may affect their driving behaviour. A 2013–2014 national US survey of adults aged 65 and older showed that past-year cannabis use was associated with greater self-reported driving under the influence of alcohol or illicit drugs or both in the past year, but data were not collected on driving under the influence of cannabis alone (Choi et al., 2016a, 2017). In a 2004 regional survey in Spain, where private consumption of cannabis was not prohibited by law (Pérez-Lanzac, 2008), none of the past-year cannabis users aged 50–70 years reported driving under its influence (Alvarez et al., 2007). We found no more recent estimates of driving while impaired by cannabis in older adults.

Most US states have passed medical cannabis laws, while ten states and the District of Columbia have legalized recreational cannabis use (National Conference of State Legislatures, 2018). However, the impact of state cannabis laws on crash fatality rates is unclear (Masten and Guenzburger, 2014; Santaella-Tenorio et al., 2017; Aydelotte et al., 2017). Medical cannabis laws have on average been associated with immediate reductions in traffic fatalities in young and middle-aged adults, but findings vary by state: seven states (all in the western US) saw a significant reduction in traffic fatality rates, whereas two states in the north-eastern US showed an increase (Santaella-Tenorio et al., 2017).

Colorado passed laws legalizing medical cannabis use in 2000 and recreational cannabis use in 2013. Since 2009, when legal medical cannabis became widely available commercially in Colorado, the proportion of Colorado drivers in fatal crashes found to be cannabis-positive has increased significantly, unlike drivers in 34 states without such laws (Salomonsen-Sautel et al., 2014). Further, Δ9-tetrahydrocannabinol (THC)-positive driving-under-the-influence (DUI) cases increased significantly between 2011 and early 2014 in Colorado (Urfer et al., 2014). Despite these increases in use while driving, changes in motor vehicle crash fatality rates for Colorado three years after recreational marijuana legalization did not differ significantly from changes in similar states without such legislation (Aydelotte et al., 2017). However, none of these studies focused specifically on older drivers. This study aims to describe the current epidemiology of cannabis use among drivers aged 65–79 years in Colorado and to examine its relationship to driving outcomes.

2. Materials and methods

2.1. Study design and sample

The LongROAD study is a prospective cohort study of 2990 active drivers aged 65 to 79 at baseline who reside in one of five sites across the US (Ann Arbor, MI; Baltimore, MD; Cooperstown, NY; Denver, CO, and San Diego, CA). LongROAD was designed to examine medical, behavioural, environmental, and vehicle technological factors associated with safe driving in older adults. The study design and population have been described in detail previously (Li et al., 2017b). In this paper, we analysed baseline data from the 600 Colorado LongROAD participants, because Colorado was the only site that collected baseline data on cannabis use. Data were collected from August 2015 through March 2017. The Colorado Multiple Institutional Review Board approved the study.

Eligibility and enrolment criteria were established to ensure that participants were relatively healthy, active drivers who would be available for at least 2–4 years of follow-up (depending on enrolment date). Eligibility criteria included: licensed driver aged 65–79 years at enrolment, driving on average at least once a week, driving one motor vehicle – model year 1996 or newer since older vehicles lacked the onboard diagnostic (OBD)-II port needed for planned data collection – at least 80% of the time, residing in the catchment area at least 10 months a year, fluent in English, and without significant cognitive impairment (e.g., Alzheimer’s disease) based on medical record review and a Six-Item Screener score ≥4 (sensitivity 67.5% and specificity 96.1% for clinically diagnosed dementia) (Callahan et al., 2002). In Colorado, 79% of all licensed drivers aged 65 and older are between ages 65 and 79 years (Federal Highway Administration, 2017)). Because the average age of Denver vehicles in 2016 was 11.2 years (Auto Alliance, 2018), the majority of vehicles would likely have met eligibility criteria.

2.2. Recruitment, enrolment and data collection

We sent recruitment letters to potential participants identified through electronic medical records of affiliated primary care clinics in the Denver metropolitan area. Trained research assistants called individuals who did not opt out to screen for eligibility. We scheduled eligible, interested individuals for a study visit for enrolment and baseline assessment. All enrolled participants provided informed written consent and received $100 for participation in the three-hour baseline visit. All measures examined in the current analysis are from a questionnaire administered by research staff at the baseline visit. Sources for the items included in the questionnaire are detailed in Li et al (2017b).

2.3. Cannabis use

Colorado participants were asked if they had ever used cannabis, marijuana or hash (referred to hereafter as “cannabis”) and how many times, if any, they had used cannabis during the past 12 months. We also asked users if they had driven a motor vehicle within 1 h of using cannabis in the past year and, if so, how many times in the past 30 days they had driven within 1 h of using cannabis. Participants who reported using cannabis one or more times within the past 12 months were considered past-year “cannabis users.” Participants who reported no use of cannabis in the 12 months before the baseline visit were defined as “non-users.”

2.4. Driving-related measures—We examined four primary driving-related outcomes: self-rated abilities for safe driving; lapses, errors and violations; drinking and driving; and crashes and citations. These outcomes were based on self-reported driving-related measures described below.

Participants rated the following abilities “for their safe driving” on a scale from one (poor) to seven (excellent): their ability to see during the day, their ability to see at night, their ability to remember things, their ability to concentrate on more than one thing at a time, and their strength, flexibility or general mobility (Molnar et al., 2014). This measure demonstrates internal consistency (Cronbach’s $\alpha = 0.73$ for a four-item mean score) and predicts self-regulatory driving practices (Molnar et al., 2014). We averaged the separate scores to produce an overall score for “self-rated abilities for safe driving.”

The 26-item Driver Behaviour Questionnaire (DBQ) (Parker et al., 2000), which measures aberrant driving behaviour (e.g., how often the respondent forgets where he left his car, brakes too quickly on a slippery road, or disregards the speed limit), was administered to study participants. The DBQ has been shown to correlate with actual highway driving (Zhao et al., 2012) and to predict self-reported road traffic accidents, although its ability to predict state-reported crashes has not been established (af Wåhlberg et al., 2009). We considered the item on driving while impaired by alcohol separately because of the known association of alcohol use disorders with cannabis use (e.g., Choi et al., 2016b). Specifically, participants were asked how often they drove even though they realized that they may have been over the legal blood alcohol limit. Because only 14 respondents reported doing so more than occasionally, “drinking and driving” was categorized as ever versus never.

The remaining 25 items from the DBQ were categorized into driving lapses, errors, or violations, based on previous literature (Harrison, 2011, 2012; Parker et al., 1995; Reason et al., 1990). A three-factor structure for the DBQ has been shown to have acceptable fit (Martinussen et al., 2013) and stability over time (Koppel et al., 2018) among older drivers. Responses for each item ranged from never to nearly all the time. For each category, the means of multiple items were calculated, with higher means indicating more of the category of aberrant behaviour. To avoid potential problems resulting from repeated analyses of highly correlated variables, a single scale ("lapses, errors and violations"), was created based on findings from exploratory factor analysis (Cronbach's alpha = 0.659); a higher score indicates more of these aberrant behaviours (i.e., 'worse' driving).

Self-reported crashes and citations were collected using the "crashes and citations" domain from the Driving Habits Questionnaire (DHQ) (Owsley et al., 1999), which has been shown to have good test-retest reliability in community-dwelling older drivers (Song et al., 2015), although the validity of this measure has yet to be confirmed. Participants reported the number of accidents in which they were involved and the number of these for which police were called to the scene, the number of times in the past year they were pulled over by police and the number of times they were ticketed other than for a parking violation, while driving in the past year. Responses to these four questions were combined and categorized as any versus none.

We collected two secondary outcomes. First, we asked the participant whether, during the past year, he or she had reduced the amount of driving he/she did in any way and, if so, what the reason was. Responses were categorized as: reduced driving due to self-regulation (e.g., because of difficulty seeing during the night) or did not reduce driving due to self-regulation (i.e., no reduction at all or reduction for any other reason [e.g., retirement]). Second, we asked if they had decreased their driving in the past year due to a health problem (Yes/No).

2.5. Covariates

Potentially confounding variables were identified based on existing scientific literature (Black and Joseph, 2014; Choi et al., 2016b; Han et al., 2016; Hasin et al., 2015; Salas-Wright et al., 2017). Demographic characteristics considered included age, gender, race, ethnicity, education, income (collected as a categorical variable and dichotomized to approximate values above and below Colorado's median income at the time of data collection), employment, marital status and work for pay. Health-related characteristics included alcohol consumption (alcohol use in the past 3 months, having 4 or more alcoholic drinks on one occasion in the past 3 months), healthcare utilization (self-reported emergency department visits or hospitalizations in the past 12 months), physical or mental health conditions (ever had or been told they had specified conditions), and cognitive function (using the Telephone Interview for Cognitive Status (TICS) [Brandt et al., 1988], categorized as no impairment [score = 9] or any impairment [score < 9]). We also collected Patient-Reported Outcomes Measurement Information System (PROMIS) measures of mental, emotional, social and cognitive health, which were scored using PROMIS and American Psychiatric Association guidelines for the specific PROMIS survey items

(HealthMeasures, 2018; American Psychiatric Association, 2013), with higher scores indicating more of the symptoms or condition.

2.6. Data analysis

We reported the prevalence (ever, past year, and immediately before driving) and frequency of cannabis use and described driver characteristics among cannabis users and non-users. Prevalence ratios (PRs) and their 95% confidence intervals (CIs) for past-year cannabis use compared to non-use were calculated according to driver characteristics, using log-binomial regression.

We examined the association of past-year cannabis use with each of the four primary driving-related outcomes. "Self-rated abilities for safe driving" and "lapses, errors and violations" were analysed as continuous variables using linear regression. The two dichotomous outcomes, "drinking and driving" and "crashes and citations," were analysed using logistic regression. We constructed unadjusted and adjusted analyses for each outcome. We first adjusted for sociodemographic factors or health conditions that may confound the association of cannabis use with driving outcomes. We considered a variable as a potential confounder if it was significantly associated with both cannabis use and the selected driving outcome at $p < 0.20$ and if its addition to the model substantially changed the effect estimate (i.e., the regression coefficient corresponding to cannabis use) by > 10% for dichotomous outcomes or > 30% for continuous outcomes. We examined any additional influence of emotional distress (specifically depression, anxiety, and anger measures) on the relationships between cannabis use and the driving outcomes separately, because the directionality of their relationship with cannabis has not been established. We used the same criteria for testing and retention as for other covariates. Sensitivity analyses were conducted for continuous outcomes to examine models that used a > 10% change level; results were similar in magnitude and statistical significance (data not shown). In linear regression models, assumptions and fit were assessed graphically using a normal probability plot, studentised residuals, and Cook's distance. Multicollinearity was assessed using tolerances and variance inflation factors. Logistic regression model assumptions and fit were assessed using Pearson and deviance residuals, and the Akaike Information Criterion. Linearity of continuous covariates was assessed using the Box-Tidwell method. Model diagnostics and fit were found to be acceptable and convergence was satisfied in all analytic models. We reported the beta estimates from linear regression analyses, and the odds ratios (ORs) from logistic regression analyses, with their corresponding 95% CIs. A conventional alpha level of 0.05 was employed to assess statistical significance. All data analysis was conducted using SAS 9.3 (SAS Institute, Inc., Cary, North Carolina).

3. Results

The Colorado site enrolled 600 participants for the LongROAD study. Five hundred ninety-eight enrolled participants (99.7%) provided data on cannabis use, of whom 244 (40.8%) reported having ever used cannabis. Fifty-four participants (9.0%) reported cannabis use in the past year. Of 54 past-year users, 27 (50.0%) used cannabis less than once a month, nine (16.7%) 1–3 times per month, eleven (20.4%) 1–5 times per week, and seven (13.0%) more than once per day. Only five participants (0.8%) reported having used cannabis within 1 h of driving in the past year, while three (0.5%) had used it within 1 h of driving in the past 30 days. This represents 9.3% and 5.6%, respectively, of the past-year users.

Table 1 shows cannabis use in the past 12 months according to participant characteristics. Drivers in the oldest age group were significantly less likely to use cannabis compared to the youngest age group. Drivers were more likely to use cannabis if they were less highly educated, had a lower household income, used alcohol in the past 3 months or had ever been diagnosed with a mental health condition (e.g., depression or anxiety disorder). None of the cannabis users reported a diagnosed substance abuse/alcohol dependency. Cannabis use did not vary significantly with other socio-demographic characteristics, health care utilization or other health conditions. Those reporting moderate to severe symptoms of depression, anxiety and social isolation, at least mild symptoms of anger and none to slight emotional support were more likely to report past-year cannabis use (Table 1). Greater prevalence of cannabis use in the past year was also associated with at least some cognitive impairment (i.e., score < 9 on the TICS) and with more concerns about cognition.

Compared to non-users, cannabis users rated their abilities for safe driving as significantly worse in unadjusted analysis (Table 2). This association was not influenced by differences in sociodemographic characteristics or health conditions. Differences in anxiety and anger symptoms between users and non-users appeared to mediate this relationship, which was weaker and no longer statistically significant after these variables were included in the model.

Past-year cannabis use was positively associated with the lapses, errors and violations scale in unadjusted analysis; no sociodemographic characteristics or health conditions confounded this estimate. However, after accounting for greater anger symptoms in cannabis users, the association was smaller and no longer statistically significant (Table 2).

Compared to older drivers who had not used cannabis in the past year, past-year users were nearly four times as likely to report drinking and driving after accounting for sociodemographic differences between groups (Table 2). After taking into account poorer cognitive function in cannabis users, the association was strengthened.

Past-year cannabis use was not associated with self-reported involvement in a crash or receipt of a citation in the past year. Adjustment for other differences between groups did not change these results substantively (Table 2).

Cannabis users were significantly more likely than non-users to have reduced their driving in the past year due to self-regulation (11.1% versus 4.2%, p = 0.038). They were also more likely to have reduced their driving due to a health condition (24.1% versus 6.8%, p < 0.001).

4. Discussion

The prevalence of past-year cannabis use among older drivers in the LongROAD Colorado cohort was 9%. This is substantially higher than the prevalence reported in recent nationally representative surveys of US adults aged 65 and older, which ranged from 1.4 to 2.1% between 2012 and 2014 (Han et al., 2016; Choi et al., 2016b; Salas-Wright et al., 2017). Several factors could explain the higher rate of use in our sample. Our sample was highly educated (82% had at least a college degree) and higher education has been associated with a greater likelihood of past-year cannabis use (Salas-Wright et al., 2017). We also excluded adults aged 80 and older, who may have lower rates of cannabis use compared to those aged 65 to 79 years. In addition, our data were collected more recently than in these national surveys, and there has been a substantial and continuing upward trend in cannabis use among adults aged 65 and older since 2001 (Han et al., 2016; Hasin et al., 2015; Salas-Wright et al., 2017). Further, Colorado is one of a few US states to have legalized recreational cannabis (National Conference of State Legislatures, 2018), which may have resulted in participants being more willing to report their use. Legalization is also likely to have increased the number of older Coloradans using cannabis compared to residents of other states where it remains illegal. While state-level data on the prevalence of cannabis use among US adults aged 65 and older is not available, the prevalence among Colorado adults aged 26 and older is nearly double that of the total US population (21.9% versus 11.6%) (Substance Abuse and Mental Health Services Administration (SAMHSA, 2017).

Past-year cannabis use was associated with a constellation of symptoms and concerns affecting every aspect of mental, social and emotional health assessed. Further, the prevalence of past-year cannabis use was nearly three times higher among those with diagnosed psychiatric conditions such as depression and anxiety disorder compared to non-users. These results are similar to findings from studies of nationally representative samples of older adults in the US, which have reported higher rates of mental health conditions including anxiety and depression, more life stressors (e.g., financial or legal problems), lower perceived social support and a greater likelihood of binge drinking alcohol, among past-year cannabis users compared to non-users (Choi et al., 2016b; Salas-Wright et al., 2017).

Among all older drivers in the sample, only 0.8% reported using cannabis within 1 h of driving. Of the past-year users, 9.3% had driven within one hour of cannabis use in the past year and 5.6% had done so in the past 30 days. We found only one other study reporting on driving after cannabis use among older adults, a 2004 survey in two regions of Spain in which none of the past-year cannabis users aged 50–70 years reported driving under the influence of cannabis in the past year, although about 7% reported having been a passenger in a vehicle driven by someone under the influence (Alvarez et al., 2007). This study is not directly comparable to ours, however, both due to the difference in the time period under study as well as the specific question asked.

Past-year cannabis users in our sample were significantly more likely to report having driven at least once in the past year when they may have been over the legal blood-alcohol limit compared to non-users, similar to the findings of Salas-Wright et al. (2017). Among Colorado DUI cases, nearly one-third of blood samples that tested positive for THC, the main psychoactive constituent of cannabis, also had elevated blood alcohol concentrations (Urfer et al., 2014). In metropolitan France, Martin et al. (2017) found that half of drivers in fatal crashes considered to be under the influence of cannabis were also under the influence of alcohol. Past-year cannabis use may be a marker for older adults who are at greater risk of driving while impaired by alcohol, and thus for alcohol-related crashes and crash fatalities. There may be a potentiating effect of cannabis on alcohol-related crashes. Laboratory testing suggests that simultaneous use of alcohol and cannabis produces significantly higher blood concentrations of THC than cannabis use alone (Hartman et al., 2015), while studies using a driving simulator or driving course showed that the combination of low-dose alcohol and cannabis caused more impairment than either drug used alone (Sewell et al., 2009). Recent epidemiologic research also indicates that concurrent use of cannabis and alcohol confers a positive interaction effect on fatal crash risk and culpability (Chihuri et al., 2017; Li et al., 2017a).

We found a small but significant positive association between cannabis use and self-reported lapses, errors and violations. Differences in risky driving behaviours between drivers who do and do not use cannabis could help explain the previously reported increase in crash risk associated with cannabis use (Asbridge et al., 2012; Li et al., 2012; Rogeberg and Elvik, 2016). Greater self-reported anger symptoms in cannabis users may explain the observed association of cannabis use with lapses, errors and violations in our sample, since the estimate was smaller and no longer statistically significant after adjusting for anger symptoms. Frequent cannabis use has been linked to high levels of anger and aggression in some studies, but the directionality of the relationship has not been established and other studies show contradictory results (Walfish et al., 1990; Ostrowsky, 2011). The data reported here cannot establish whether cannabis use is simply correlated with or in fact causes lapses, errors and violations. Further study of the interrelationship among cannabis use, anger and aggression symptoms and aberrant driving behaviour is needed.

Although the epidemiologic literature has demonstrated an increased crash risk associated with cannabis use, with pooled odds ratios of 1.22–2.66 (Asbridge et al., 2012; Li et al., 2012; Rogeberg and Elvik, 2016), our study did not find a significant association between past-year cannabis use and the odds of having a crash or being pulled over or ticketed by police. This may reflect that few older drivers in our cohort actually drove immediately after use. It is also possible that older drivers may under-report crashes and citations. The DHQ, which we used to assess self-reported crashes and citations, has not been validated against independent sources of crash data or arrest records. Alternatively, this result may have been due to chance given the small numbers of both cannabis users and reported crashes and citations. We analysed the “crashes and citations” domain of the Driving Habits Questionnaire (Owsley et al., 1999) as a single outcome. Results may have differed had we examined crashes and citations separately, although there were few instances of either crashes or citations in our sample.

In their comprehensive review, Sewell et al. (2009) reported that cannabis users perceive their driving under the influence of cannabis as impaired, which has behavioural consequences including decreased driving speed, fewer attempts to overtake, and increased “following” distance (the distance between themselves and the car in front of them). Given these findings, we conjectured that past-year cannabis users might rate their abilities to drive safely differently from non-users. We did find evidence to support this: self-reported abilities for safe driving differed significantly between past-year users and non-users. However, the association was largely mediated by differences in anger and anxiety symptoms, similar to our findings related to aberrant driving behaviour. Several more recent studies have reported that some cannabis users may perceive their driving under the influence of cannabis to be at least as safe as their driving when drug-free (Cavazos-Rehg et al., 2018; Green, 2018; Swift et al., 2010). Such findings may reflect changing perceptions about risk associated with driving while under the influence of cannabis in response to increasing legalization of both medical and recreational cannabis.

Our study has several potential limitations. The findings reported here were based on a sample of affluent, highly educated older drivers living in metropolitan Denver who were recruited through primary care clinics. Further, many potential participants could not be reached or were contacted but declined participation. Selection bias may therefore have influenced the observed relationship between cannabis and driving behaviours. In addition, these results may not be generalizable to other populations or locales. Older drivers of low socioeconomic status (SES) may have been less likely to participate because we excluded drivers with cars older than the 1996 model year; vehicle age is inversely correlated with household income (Richter, 2018). Because cannabis use was inversely associated with household income in our study, the true prevalence of past-year use may be higher than we estimated. Outcomes were based solely on self-report, using the DBQ and the DHQ. While the DBQ has been shown to correlate with actual highway driving (Zhao et al., 2012) as well as self-reported crashes (af Wåhlberg et al., 2009), the ability of either instrument to predict objectively measured crash risk has not been established. The number of past-year cannabis users was relatively small, limiting the study's power to identify small differences between past-year users and non-users. Future studies from LongROAD that include a larger number of study sites may address this limitation. Finally, results were based on cross-sectional data collected at baseline and reflect associations between simultaneously reported past-year cannabis use and current driving behaviours. Hence, as noted above, we cannot determine whether the observed associations reflect causal relationships.

5. Conclusions

We found that nearly 10% of Colorado drivers aged 65–79 years reported using cannabis in the past year, but less than 1% reported driving immediately after using cannabis. Therefore, driving under the influence of cannabis does not appear likely to have an important impact on crash rates among older drivers currently. Other risk factors, such as falls (Scott et al., 2017) or other age-related health conditions (Choi et al., 2012; Classen, 2014; Pomidor, 2016), may be more appropriate targets for prevention programs at present. However, ongoing examination of this issue is warranted since, if the prevalence of cannabis use in older adults in the US continues to rise as it did between 2001 and 2014 (Han et al., 2016; Hasin et al., 2015; Salas-Wright et al., 2017), driving after cannabis use and driving under the influence of cannabis are also likely to increase in this population. Further, past-year cannabis users were four times as likely to report having driven when they may have been over the legal blood alcohol limit compared with those who had not used cannabis in the past year. Thus, even though overall cannabis use is low among older drivers, many of those who do use cannabis may be at significantly higher risk of crashes due to concurrent use of alcohol. Despite potential risks from both cannabis use and increased driving after drinking, we found no increase in the likelihood of a self-reported crash or police citation in the past year with past-year cannabis. However, power for this outcome was limited; re-examination in a larger sample is warranted. We found modest associations between cannabis use and both self-reported abilities to drive safely and self-reported lapses, errors and violations, which may have been mediated by greater anger and/or anxiety symptoms reported by cannabis users. This study adds important new information to the very limited data available on cannabis use among older drivers and its relationship to driving behaviour. In future reports using longitudinally collected data, the LongROAD study will be better able to examine the temporal relationship of cannabis use and driving behaviours, tease out the effects of mediating variables on this relationship, and investigate changes over time in driving behaviours that occur with continuing cannabis use.

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References

af Wåhlberg A, Dorn L, Kline T, 2009 The Manchester Driver Behaviour Questionnaire as a predictor of road traffic accidents. Theor. Issues Ergon. Sci. 12 (1), 66–86. 10.1080/14639220903023376.

Alvarez FJ, Fierro I, Del Rio MC, 2007 Cannabis and driving: results from a general population survey. Forensic Sci. Int. 170, 111–116. 10.1016/j.forsciint.2007.03.024. [PubMed: 17628369]

American Psychiatric Association, 2013 Online Assessment Measures: Level 2 Cross-cutting Symptom Measures.Retrieved February 28, 2018, from:. www.psychiatry.org/psychiatrists/practice/dsm/educational-resources/assessment-measures.

Asbridge M, Hayden JA, Cartwright JL, 2012 Acute cannabis consumption and motor vehicle collision risk: systematic review of observational studies and meta-analysis. BMJ 344, e536 10.1136/bmj.e536. [PubMed: 22323502]

Auto Alliance, 2018 State Facts: Congressional District 1. Retrieved February 8, 2019, from:. https://autoalliance.org/in-your-state/CO/1/.

Aydelotte JD, Brown LH, Luftman KM, Mardock AL, Teixeira PG, Coopwood B, Brown CV, 2017 Crash fatality rates after recreational marijuana legalization in Washington and Colorado. Am. J. Public Health 107 (8), 1329–1331. 10.2105/ajph.2017.303848. [PubMed: 28640679]

Black P, Joseph LJ, 2014 Still dazed and confused: midlife marijuana use by the baby boom generation. Deviant Behav. 35 (10), 822–841. 10.1080/01639625.2014.889994.

Bosker WM, Kuypers KP, Theunissen EL, Surinx A, Blankespoor RJ, Skopp G, Jeffery WK, Walls HC, van Leeuwen CJ, Ramaekers JG, 2012 Medicinal Δ(9)-tetrahydrocannabinol (dronabinol) impairs on-the-road driving performance of occasional and heavy cannabis users but is not detected in Standard Field Sobriety Tests. Addiction 107 (10), 1837–1844. 10.1111/j.1360-0443.2012.03928.x. [PubMed: 22553980]

Brandt J, Spencer M, Folstein M, 1988 The telephone interview for cognitive status. Neuropsychiatry Neuropsychol. Behav. Neurol. 1 (2), 111–117.

Callahan CM, Unverzagt FW, Hui SL, Perkins AJ, Hendrie HC, 2002 Six-item screener to identify cognitive impairment among potential subjects for clinical research. Med. Care 40 (9), 771–781. 10.1097/00005650-200209000-00007. [PubMed: 12218768]

Cavazos-Rehg PA, Krauss MJ, Sowles SJ, Zewdie K, Bierut L, 2018 Operating a motor vehicle after marijuana use: perspectives from people who use high-potency marijuana. Subst. Abuse 39 (1), 21–26. 10.1080/08897077.2017.1365802.

Chihuri S, Li G, Chen Q, 2017 Interaction of marijuana and alcohol on fatal motor vehicle crash risk: a case-control study. Inj. Epidemiol. 4 (8). 10.1186/s40621-017-0105-z.

Choi NG, Dinitto DM, Marti CN, 2016a Risk factors for self-reported driving under the influence of alcohol and/or illicit drugs among older adults. Gerontologist 56 (2), 282–291. 10.1093/geront/gnu070. [PubMed: 25063352]

Choi NG, Dinitto DM, Marti CN, 2016b. Older marijuana users: life stressors and perceived social support. Drug Alcohol Depend. 169, 56–63. 10.1016/j.drugalcdep.2016.10.012. [PubMed: 27776245]

Choi NG, Dinitto DM, Marti CN, 2017 Older adults driving under the influence: associations with marijuana use, marijuana use disorder, and risk perceptions. J. Appl. Gerontol 1–21. 10.1177/0733464817745379.

Choi M, Mezuk B, Rebok GW, 2012 Voluntary and involuntary driving cessation in later life. J. Gerontol. Soc. Work 55 (4), 367–376. 10.1080/01634372.2011.642473. [PubMed: 22574868]

Classen S, 2014 Summary of an evidence based review on interventions for medically at risk older drivers. Occup. Ther. Health Care 28 (2), 223–228. 10.3109/07380577.2014.896490. [PubMed: 24754773]

Downey LA, King R, Papafotiou K, Swann P, Ogden E, Boorman M, Stough C, 2013 The effects of cannabis and alcohol on simulated driving: influences of dose and experience. Accid. Anal. Prev. 50, 879–886. 10.1016/j.aap.2012.07.016. [PubMed: 22871272]

Federal Highway Administration, 2017 Office of Highway Policy Information. Highway Statistics 2016. Retrieved November 30, 2018, from: https://www.fhwa.dot.gov/policyinformation/statistics/2016/.

Green KM, 2018 Perceptions of driving after marijuana use compared to alcohol use among rural American young adults. Drug Alcohol Rev. 37, 637–644. [PubMed: 29464852]

Han BH, Sherman S, Mauro PM, Martins SS, Rotenberg J, Palamar J, 2016 Demographic trends among older cannabis users in the United States, 2006–13. Addiction 112, 516–525. 10.1111/add.13670. [PubMed: 27767235]

Harrison WA, 2011 Psychometric and Rasch Analysis of the Driver Behaviour Questionnaire (DBQ). [PDF]. Eastern Professional Services Pty Ltd., Melbourne.

Harrison WA, 2012 Preliminary Analysis of Proposed New Rasch-based DBQ Items. [PDF]. Eastern Professional Services Pty Ltd., Melbourne.

Hartman RL, Brown TL, Milavetz G, Spurgin A, Gorelick DA, Gaffney G, Huestis MA, 2015 Controlled cannabis vaporizer administration: blood and plasma cannabinoids with and without alcohol. Clin. Chem. 61 (6), 850–869. 10.1373/clinchem.2015.238287. [PubMed: 26019183]

Hasin DS, Saha TD, Kerridge BT, Goldstein RB, Chou SP, Zhang H, … Jung J, 2015 Prevalence of marijuana use disorders in the United States between 2001–2002 and 2012–2013. JAMA Psychiatry 72 (12), 1235–1242. 10.1001/jamapsychiatry.2015.1858. [PubMed: 26502112]

HealthMeasures, 2018 PROMIS®. Retrieved February 28, 2018, from. http://www.healthmeasures.net/score-and-interpret/interpret-scores/promis.

Hels T, Bernhoft IM, Lyckegaard A, Houwing S, Hagenzieker M, Legrand S-A, … Verstraete A, 2011 Risk of Injury by Driving With Alcohol and Other Drugs. Project No. TREN-05-FP6TR-S07.61320–518404-DRUID. .

Kelly E, Darke S, Ross J, 2004 A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. Drug Alcohol Rev. 23 (3), 319–344. 10.1080/09595230412331289482. [PubMed: 15370012]

Koppel S, Stephens AN, Charlton JL, Di Stefano M, Darzins P, Odell M, Marshall S, 2018 The Driver Behaviour Questionnaire for older drivers: Do errors, violations and lapses change over time? Accid. Anal. Prev 113, 171–178. [PubMed: 29407664]

Lenné MG, Dietze PM, Triggs TJ, Walmsley S, Murphy B, Redman JR, 2011 The effects of cannabis and alcohol on simulated arterial driving: influences of driving experience and task demand. Accid. Anal. Prev. 42 (3), 859–866. 10.1016/j.aap.2009.04.021.

Li M-C, Brady JE, DiMaggio CJ, Lusardi AR, Tzong KY, Li G, 2012 Marijuana use and motor vehicle crashes. Epidemiol. Rev. 34 (1), 65–72. 10.1093/epirev/mxr017. [PubMed: 21976636]

Li G, Chihuri S, Brady JE, 2017a Role of alcohol and marijuana use in the initiation of fatal two-vehicle crashes. Ann. Epidemiol. 27 (5), 342–347. 10.1016/j.annepidem.2017.05.003. [PubMed: 28595738]

Li G, Eby DW, Santos R, Mielenz TJ, Molnar LJ, Strogatz D, Betz ME, DiGuiseppi C, Ryan LH, Jones V, Pitts SI, Hill LL, DiMaggio CJ, LeBlanc D, Andrews HF, the LongROAD Research Team, 2017b Longitudinal Research on Aging Drivers (LongROAD): study design and methods. Inj. Epidemiol 4 (22). 10.1186/s40621-017-0121-z.

Martin J-L, Gadegbeku B, Wu D, Viallon V, Laumon B, 2017 Cannabis, alcohol and fatal road accidents. PLoS One 12 (11), e0187320 10.1371/journal.pone.0187320. [PubMed: 29117206]

Martinussen LM, Hakamies-Blomqvist L, Møller M, Özkan T, Lajunen T, 2013 Age, gender, mileage and the DBQ: the validity of the Driver Behavior Questionnaire in different driver groups. Accid. Anal. Prev. 52, 228–236. [PubMed: 23396202]

Masten SV, Guenzburger GV, 2014 Changes in driver cannabinoid prevalence in 12 U.S. states after implementing medical marijuana laws. J. Safety Res. 50, 35–52. 10.1016/j.jsr.2014.03.009. [PubMed: 25142359]

Molnar LJ, Charlton JL, Eby DW, Langford J, Koppel S, Kolenic GE, Marshall S, 2014 Factors affecting self-regulatory driving practices among older adults. Traffic Inj. Prev. 15 (3), 262–272. 10.1080/15389588.2013.808742. [PubMed: 24372498]

National Conference of State Legislatures, 2018 State Medical Marijuana Laws, 6/27/2018. Retrieved October 10, 2018, from:. http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx.

Ostrowsky MK, 2011 Does marijuana use lead to aggression and violent behavior? J. Drug Educ. 41 (4), 369–389. 10.2190/de.41.4.c. [PubMed: 22455101]

Owsley C, Stalvey B, Wells J, Sloane ME, 1999 Older drivers and cataract: driving habits and crash risk. J. Gerontol. A Biol. Sci. Med. Sci. 54 (4), M203–11. [PubMed: 10219012]

Parker D, McDonald L, Rabbitt P, Sutcliffe P, 2000 Elderly drivers and their accidents: the aging driver questionnaire. Accid. Anal. Prev. 32, 751–759. 10.1016/S0001-4575(99)00125-6. [PubMed: 10994602]

Parker D, Reason JT, Manstead AS, Stradling SG, 1995 Driving errors, driving violations and accident involvement. Ergonomics 38 (5), 1036–1038. 10.1080/00140139508925170. [PubMed: 29105607]

Pérez-Lanzac C, 2008 El cannabis pelea por un espacio legal. El Pais. Retrieved January 29, 2019, from: elpais.com/diario/2008/12/09/sociedad/1228777201_850215.html.

Pomidor A, 2016 Clinician's Guide to Assessing and Counseling Older Drivers. National Highway Traffic Safety Administration Washington, DC.

Reason J, Manstead A, Stradling S, Baxter J, Campbell K, 1990 Errors and violations on the roads: a real distinction. Ergonomics 33 (10–11), 1315–1332. 10.1080/00140139008925335. [PubMed: 20073122]

Richter W, 2018 Average Age of Cars & Trucks by Household Income and Vehicle Type Over Time. Retrieved January 11, 2019 from:. https://wolfstreet.com/2018/08/21/average-age-of-cars-trucks-vehicles-by-household-income-vehicle-type/.

Rogeberg O, Elvik R, 2016 The effects of cannabis intoxication on motor vehicle collision revisited and revised. Addiction 111, 1348–1359. 10.1111/add.13347. [PubMed: 26878835]

Salas-Wright CP, Vaughn MG, Cummings-Vaughn LA, Holzer KJ, Nelson EJ, AbiNader M, Oh S, 2017 Trends and correlates of marijuana use among late middle-aged and older adults in the United States, 2002–2014. Drug Alcohol Depend. 171, 97–106. 10.1016/j.drugalcdep.2016.11.031. [PubMed: 28063338]

Salomonsen-Sautel S, Min S-J, Sakai JT, Thurstone C, Hopfer C, 2014 Trends in fatal motor vehicle crashes before and after marijuana commercialization in Colorado. Drug Alcohol Depend. 140, 137–144. 10.1016/j.drugalcdep.2014.04.008. [PubMed: 24831752]

Santaella-Tenorio J, Mauro C, Wall MM, Kim JH, Cerda M, Keyes KJ, Hasin DS, Galea S, Martins SS, 2017 US traffic fatalities, 1985–2014, and their relationship to medical marijuana laws. Am. J. Public Health 107, 336–342. 10.2105/AJPH.2016.303577. [PubMed: 27997245]

Scott KA, Rogers E, Betz ME, Hoffecker L, Li G, DiGuiseppi C, 2017 Associations between falls and driving outcomes in older adults: systematic review and meta-analysis. J. Am. Geriatr. Soc. 65 (12), 2596–2602 PubMed PMID: PMCID: PMC5729077. [PubMed: 28873218]

Sewell RA, Poling J, Sofuoglu M, 2009 The effect of cannabis compared with alcohol on driving. Am. J. Addict. 18 (3), 185–193. 10.1080/10550490902786934. [PubMed: 19340636]

Abuse Substance and Mental Health Services Administration (SAMHSA), 2017 Center for Behavioral Health Statistics and Quality. 2016–2017 National Survey on Drug Use and Health: Model-Based Prevalence Estimates (50 States and the District of Columbia). Retrieved January 11, 2019, from: https://www.samhsa.gov/data/report/2016-2017-nsduh-national-maps-prevalence-estimates-state.

Swift W, Jones C, Donnelly N, 2010 Cannabis use while driving: a descriptive study of Australian cannabis users. Drugs 17 (5), 573–586. 10.3109/09687630903264286.

Urfer S, Morton J, Beall V, Feldman J, Gunesch J, 2014 Analysis of Δ9-tetrahydrocannabinol driving under the influence of drugs cases in Colorado from January 2011 to February 2014. J. Anal. Toxicol. 38, 575–581. 10.1093/jat/bku089. [PubMed: 25217549]

Walfish S, Massey R, Krone A, 1990 Anxiety and anger among abusers of different substances. Drug Alcohol Depend. 25, 253–256. 10.1016/0376-8716(90)90150-D. [PubMed: 2347289]

Zhao N, Mehler B, Reimer B, D'Ambrosio LA, Mehler A, Coughlin JF, 2012 An investigation of the relationship between the driving behavior questionnaire and objective measures of highway driving behavior. Transp. Res. Part F Traffic Psychol. Behav. 15, 676–685. 10.1016/j.trf.2012.08.001.

Table 1

Cannabis use versus no cannabis use in the past 12 months according to characteristics of older drivers.

Variable		Cannabis Use Past Year Yes (n = 54)	Cannabis Use Past Year No (n = 544)	PR	95% CI
Age Group n (%)	65–69 Years	32 (59.26)	230 (42.28)	1	REF
	70–74 Years	17 (31.48)	201 (36.95)	0.64	0.36, 1.12
	75–79 Years	5 (9.26)	113 (20.77)	0.35	0.14, 0.87
Gender n (%)	Male	27 (50.0)	263 (48.3)	1	REF
	Female	27 (50.0)	281 (51.7)	0.94	0.57, 1.57
Race n (%)	White/Caucasian	50 (94.3)	481 (89.2)	1	REF
	Non-White	3 (5.7)	58 (10.8)	0.52	0.17, 1.62
Ethnicity n (%)	Not Hispanic or Latino	50 (96.1)	505 (94.9)	1	REF
	Hispanic/Latino	2 (3.9)	27 (5.1)	0.77	0.20, 2.99
Highest Level of Education n (%)	Master’s or Higher Degree	18 (33.3)	256 (47.6)	1	REF
	Bachelor’s Degree	20 (37.0)	125 (23.2)	2.10	1.15, 3.84
	Less than Bachelor’s Degree	16 (29.7)	157 (29.2)	1.41	0.74, 2.69
Total Household Income Past Year n (%)	$50,000 or More	34 (66.7)	420 (79.6)	1	REF
	Less than $50,000	17 (33.3)	108 (20.4)	1.82	1.05, 3.14
Marital Status n (%)	Married/Living with Partner	36 (67.9)	367 (69.1)	1	REF
	Never Married, Separated, Divorced, or Widowed	17 (32.1)	164 (30.9)	1.05	0.61, 1.82
Work for Pay Past Month n (%)	No	33 (61.1)	374 (68.9)	1	REF
	Yes	21 (38.9)	169 (31.1)	1.36	0.81, 2.29
Past-Year Emergency Department Visits n (%)	None	38 (70.4)	406 (75.3)	1	REF
	At Least One	16 (29.6)	133 (24.7)	1.25	0.72, 2.18
Past-Year Hospital Stays n (%)	None	44 (81.5)	463 (85.1)	1	REF
	At Least One	10 (18.5)	81 (14.9)	1.27	0.66, 2.42
Alcohol Use Past 3 Months n (%)	None	7 (12.9)	167 (30.7)	1	REF
	Any	47 (87.0)	377 (69.3)	2.76	1.27, 5.98
Had 4+ Drinks on One Occasion Past 3 Months n (%)	No	45 (83.3)	492 (90.4)	1	REF
	Yes	9 (16.7)	52 (9.6)	1.76	0.91, 3.42
Ever Diagnosed with Health Condition (Categories)[a] n (%)	Cancer	19 (35.2)	173 (31.8)	1.15	0.67, 1.95

Variable		Cannabis Use Past Year Yes (n = 54)	No (n = 544)	PR	95% CI
	Cardiovascular	30 (55.6)	321 (59.0)	0.88	0.53, 1.47
	Mental Health[b]	28 (51.9)	136 (25.0)	2.85	1.72, 4.71
	Metabolic	17 (31.5)	163 (30.0)	1.07	0.62, 1.84
	Musculoskeletal	44 (81.5)	413 (75.9)	1.36	0.70, 2.63
	Neurologic	22 (40.7)	237 (43.6)	0.90	0.54, 1.51
	Respiratory	9 (16.7)	91 (16.7)	1.00	0.50, 1.97
	Vision	28 (51.9)	279 (51.3)	1.02	0.61, 1.70
Depression[c] (T-score levels) n (%)	None to Slight (T-Score < 55)	48 (88.8)	516 (94.9)	1	REF
	Mild (T-Score 55.0–59.9)	3 (5.6)	25 (4.6)	1.26	0.42, 3.79
	Moderate to Severe (T-Score 60.0 +)	3 (5.6)	3 (0.5)	5.88	2.52, 13.67
Anxiety[c] (T-Score levels) n (%)	None to Slight (T-Score < 55)	47 (87.0)	513 (94.3)	1	REF
	Mild (T-Score 55.0–59.9)	3 (5.6)	27 (5.0)	1.19	0.39, 3.61
	Mod to Severe (T-Score 60.0 +)	4 (7.4)	4 (0.7)	5.96	2.83, 12.55
Anger[c] (T-Score levels) n (%)	None to Slight (T-Score < 55)	48 (88.9)	525 (96.5)	1	REF
	Mild (T-Score 55.0–59.9)	4 (7.4)	12 (2.2)	2.98	1.22, 7.27
	Moderate to Severe (T-Score 60.0 +)	2 (3.7)	7 (1.3)	2.65	0.76, 9.28
Social Isolationc (T-Score Levels) n (%)	None to Slight (T-Score < 55)	50 (92.6)	529 (97.2)	1	REF
	Mild (T-Score 55.0–59.9)	2 (3.7)	12 (2.2)	1.65	0.45, 6.13
	Moderate to Severe (T-Score 60.0 +)	2 (3.7)	3 (0.6)	4.63	1.53, 14.00
Emotional Support (T-Score Levels) n (%)	Moderate to High (T-Score 60.0 +)	18 (33.3)	247 (45.4)	1	REF
	Mild (T-Score 55.0–59.9)	3 (5.6)	58 (10.7)	0.72	0.22, 2.38
	None to Slight (T-Score < 55)	33 (61.1)	239 (43.9)	1.79	1.03, 3.09
Telephone Interview for Cognitive Status n (%)	No impairment (score = 9)	44 (81.5)	489 (89.9)	1	REF
	Any impairment (score < 9)	10 (18.5)	55 (10.1)	1.86	0.99, 3.52
				RR	95% CI
Applied Cognition: General Concerns[c] (T -Score) mean (SD)		32.4 (5.3)	30.9 (4.8)	1.05	1.01, 1.11

PR = Prevalence Ratio, RR = Rate Ratio for past-year cannabis use versus non-use for each demographic characteristic, health condition or symptom.

[*]“Cannabis” includes marijuana, cannabis or hash.

[a]Only health problems reported by at least 5% of the total sample are shown.

[b] Excludes substance abuse/alcohol dependency.

[c] PROMIS measures.

Table 2

Associations between cannabis use in the past 12 months and driving outcomes.

	Cannabis Use n = 54	No Use n = 544			
	Mean (SD)	**Mean (SD)**	**Unadjusted Beta Estimate (95% CI)**	**Beta Estimate Adjusted for Confounders* (95% CI)**	**Beta Estimate Adjusted for Confounders / Mediators (95% CI)**
Self-Rated Abilities for Safe Driving	5.74 (0.64)	5.94 (0.67)	**−0.20 (−0.39, 0.15)**	**−0.20 (−0.39, 0.15)**[a]	−0.04 (−0.23, 0.15)[b]
Lapses, Errors and Violations	1.69 (0.33)	1.59 (0.30)	**0.10 (0.01, 0.18)**	**0.10 (0.01, 0.18)**[a]	0.04 (−0.04, 0.12)[c]
	n (%)	n (%)	Unadjusted Odds Ratio (OR) (95% CI)	OR Adjusted for Confounders (95% CI)	OR Adjusted for Confounders / Mediators (95% CI)
Any Drinking and Driving in Past Year†	15 (30.0)	63 (11.9)	**3.16 (1.64, 6.12)**	**3.63 (1.84, 7.15)**[d]	**4.18 (2.11, 8.25)**[e]
Any Crash or Citation in Past Year	14 (25.9)	136 (25.0)	1.10 (0.58, 2.09)	1.23 (0.64, 2.37)[f]	1.36 (0.70, 2.66)[g]

Note: “Cannabis” includes marijuana, cannabis or hash. Two cannabis users and two non-users were missing data for “Any Crash or Citation in Past Year.”.

*Models “adjusted for confounders” include socio-demographic factors and health conditions that met criteria for inclusion. Models “adjusted for confounders / mediators” include socio-demographic factors, health conditions and mental, social, emotional and cognitive symptoms that met criteria for inclusion.

†Excludes individuals with missing information on household income (n = 19).

[a]No sociodemographic factors or health conditions confounded this estimate.

[b]Adjusted for anxiety and anger symptoms.

[c]Adjusted for anger symptoms.

[d]Adjusted for household income.

[e]Adjusted for household income and cognitive function (TICS).

[f]Adjusted for education level.

[g]Adjusted for education level and anger symptoms.