Changes in traffic crash rates after legalization of marijuana: results by crash severity

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ABSTRACT

Objective: The objective of this study was to estimate the effects of marijuana legalization on injury and fatal traffic crash rates in the United States during the period 2009–2019.

Method: State-by-state quarterly crash rates per mile of travel were modeled as a function of time, unemployment rate, maximum posted speed limit, seat belt use rate, alcohol use rate, and indicators of legalized recreational marijuana sales and use.

Results: Legalization of the recreational use of marijuana was associated with a statistically significant 6.6% increase in injury crash rates and a nonsignificant 2.3% increase in fatal crash rates. In contrast, the subsequent onset of retail marijuana sales—3 to 18 months later depending on the state—did not elicit additional substantial increases to injury or fatal crash rates. Thus, the combined effect of legalization and retail sales was a statistically significant 5.9% increase in injury crash rates and a nonsignificant 3.8% increase in fatal crash rates. However, these estimates varied by state. The effects of legal marijuana use and sales on injury crash rates ranged from a 7% decrease to an 18% increase. The effects on fatal crash rates ranged from an 8% decrease to a 4% increase.

Conclusions: The estimated increases in injury and fatal crash rates after marijuana legalization are consistent with earlier studies, but they were not always statistically significant, and the effects varied across states. However, this is an early look at the time trends, and researchers and policymakers need to continue monitoring the data. National, state, and local governments considering changes to their marijuana policies should be cautious, proceed slowly, and take note of the lessons learned from these initial experiences.

Keywords: impaired driving; safety; cannabis

INTRODUCTION

Safe operation of an automobile requires a degree of perception, judgment, coordination, and alertness. Impairment of any of these faculties can lead drivers to collide with other vehicles or with people and objects along the road. Although alcohol has long been the most common impairing substance found among crash-involved drivers, marijuana impairment is becoming more common, especially in places where restrictions against marijuana use have been relaxed. But questions remain as to how marijuana use before driving affects crash risk. And how does increased public access to marijuana affect the number of traffic crashes?

Driving simulator studies have demonstrated that marijuana use slows reaction time, hampers road tracking and lane keeping, and impairs one's ability to maintain attention, but some drivers under the influence of marijuana compensate by slowing down or increasing their following distances (Brooks-Russell et al., 2019; Hartman et al., 2016). It remains unclear whether this compensation by drivers aware of their impairment entirely makes up for that impairment. Indeed, research regarding the net effects of marijuana use on driver crash risk has been inconclusive. Some studies have reported a higher crash risk for drivers testing positive for marijuana (Li et al., 2013). Other studies have reported no difference in crash risk, especially after accounting for other factors (e.g., driver age, sex) that are known to affect crash risk (Compton, 2017). A meta-analysis of 26 published studies concluded that marijuana use increases the odds of driver crash involvement between 18% and 32% (Rogeberg et al., 2018). However, the odds ratios for the 26 pooled studies varied widely—ranging from 0.29 to 28.88.

As with the research on marijuana use and crash risk, research relating marijuana decriminalization and legalization to crash risk has reached various conclusions. Decriminalization, defined as significantly reducing the penalties for marijuana possession, can

be thought of as a middle ground between prohibition and legalization. Cook et al. (2020) tracked the rate of fatal crashes in 24 U.S. cities that decriminalized marijuana possession. They found that decriminalization was not associated with a significant change in overall fatal crash rates (incident rate ratio = 1.02), but that there was a significant 13% increase in fatal crashes involving 15- to 24-year-old male drivers. On the other hand, laws allowing the distribution of marijuana for medical purposes have been associated with an 8% to 11% reduction in traffic fatality rates—possibly because drivers are substituting marijuana for other more impairing substances (Anderson et al., 2013; Cook et al., 2020; Santaella-Tenorio et al., 2017).

Some recent studies have examined the effects on crash risk of laws legalizing recreational use and sales of marijuana. Vogler (2017) estimated an 8% increase in quarterly fatalities per capita in Colorado, Washington, Oregon, and Alaska after recreational marijuana use was legalized. Delling et al. (2019) reported a 9% increase in motor vehicle crash-related hospitalizations in Colorado after marijuana legalization. Aydelotte et al. (2019) concluded that fatal crash rates in Colorado and Washington increased by approximately 1.8 fatal crashes per billion vehicle miles of travel (VMT) after retail marijuana sales began. Hansen et al. (2020) concluded that deaths per billion VMT in Colorado and Washington increased slightly after retail sales began, but the estimates were not statistically significant. Santaella-Tenorio et al. (2020) concluded that deaths per billion VMT increased significantly in Colorado after retail sales began, but there was no statistically significant change in Washington. Lane and Hall (2019) concluded that death rates in Colorado, Washington, and Oregon increased by approximately 0.90 deaths per million population in the month after retail sales began, but then declined slightly in subsequent months. Windle et al. (2021) estimated a 15% increase in fatal crashes per capita after recreational marijuana was legalized in 10 states and the District of Columbia. Finally, laws

legalizing retail sales of recreational marijuana in Colorado, Washington, and Oregon have been associated with 4% to 6% increases in crashes of all severities (Highway Loss Data Institute, 2018, 2020; Monfort, 2018).

In sum, the research to-date has reported increases in crashes after the legalization of recreational marijuana, but the estimated effects vary depending on the states and years examined and the methodology employed. One reason for the varying effects could be the relative paucity of data for the periods after marijuana legalization. Including additional years of data as well as additional states should provide a better picture of the trends in crash rates.

The objective of the current study was to see how the legalization of recreational marijuana use has affected highway safety, both in the three states that have been the focus of earlier studies and in the states that legalized marijuana several years later. Specifically, the objective was to determine the effects of the state-by-state changes in marijuana laws on trends in their traffic crashes during the years 2009 through 2019 for Colorado, Washington, Oregon, California, and Nevada.

METHOD

Data on quarterly traffic crashes in 11 U.S. states during 2009–2019 were extracted from the databases maintained by each state (either directly or by special request). Data on quarterly VMT by state were obtained from the *Traffic Volume Trends* series of the Federal Highway Administration (2020). Quarterly estimates of the civilian population employed and unemployed for each state were obtained from the U.S. Bureau of Labor Statistics (2020). The estimated annual percentages of front-seat vehicle occupants using seat belts in each state were obtained from the National Center for Statistics and Analysis (2020). Estimates of annual per capita

alcohol consumption by state were obtained from the National Institute on Alcohol Abuse and Alcoholism (Slater & Alpert, 2021).

Colorado and Washington both legalized recreational use of marijuana among adults ages 21 and older in December of 2012. However, retail sales of marijuana were not permitted until 2014. Three additional western states—Oregon, California, and Nevada—followed suit during the years 2015–2018 (Table 1). These five states comprised the five study groups. The comparison group was comprised of the six remaining western states (as defined by the U.S. Census Bureau): Arizona, Idaho, Montana, New Mexico, Utah, and Wyoming. The Census Bureau also classifies Alaska and Hawaii in the western region, and Alaska legalized recreational use of marijuana in 2015. However, the limited roadway networks of Alaska and Hawaii, as well as their separation from the other states, may lead to different patterns in their crash rates. To avoid the effects of such differences, analyses were conducted with Alaska and Hawaii excluded.

Table 1. Effective dates of laws regarding recreational marijuana, Western U.S. states, 2009–2019

State	Recreational use	Retail sales
Colorado	December 10, 2012	January 1, 2014
Washington	December 6, 2012	July 8, 2014
Oregon	July 1, 2015	October 1, 2015
California	November 9, 2016	January 1, 2018
Nevada	January 1, 2017	July 1, 2017

Note: Recreational use was not legalized in the remaining western states: Arizona, Idaho, Montana, New Mexico, Utah, and Wyoming.

The choice of comparison states is one of the features differentiating earlier studies of marijuana legalization. Some researchers have chosen to include only states geographically adjacent to the study states, while others have included all U.S. states that did not change marijuana policies. Others have defined the comparison states to be those that exhibited crash trends consistent with the study states during the period before legalization. All these approaches have merit, but none are perfect. The four regions defined by the U.S. Census Bureau are based

on state-by-state similarities including "historical development, population characteristics, [and] economy" (U.S. Department of Commerce, 1994). So, the states in the western region share many characteristics that likely affect highway travel patterns. In addition, the western region, except for Alaska and Hawaii, is comprised of states that each border at least one study state. Finally, all these states are contained within the Mountain and Pacific time zones.

The covariates considered in the statistical model were time (i.e., quarters since the 2009 starting point), unemployment rate, maximum posted speed limit, seat belt use rate, and per capita alcohol consumption. U.S. traffic fatality rates have been shown to be negatively correlated with the unemployment rate and seat belt use rate (Longthorne et al., 2010) and positively correlated with maximum speed limits and alcohol consumption (Patterson et al., 2002; Voas & Lacey, 2011). Logarithms of quarterly crash rates per VMT in each state were modeled as a function of the six state groups (five study states and one comparison group) and the covariates.

Separate analyses were conducted for fatal crashes and other injury crashes. Crashes not involving injury were excluded because, although all states report crashes involving injury, they differ in their requirements for reporting property-damage-only crashes. Also, the reporting requirements for a state may change over time. For example, Oregon reported all crashes involving property damage of at least $1,500 from 2009 through 2017, but the cutoff increased to $2,500 in 2018.

The statistical models also included two indicator variables related to marijuana legalization. One indicator variable was equal to zero for all quarters prior to legalization of recreational marijuana use and equal to one for all quarters thereafter. This allowed for the possibility of a step change in the crash rate when recreational use was legalized. The second

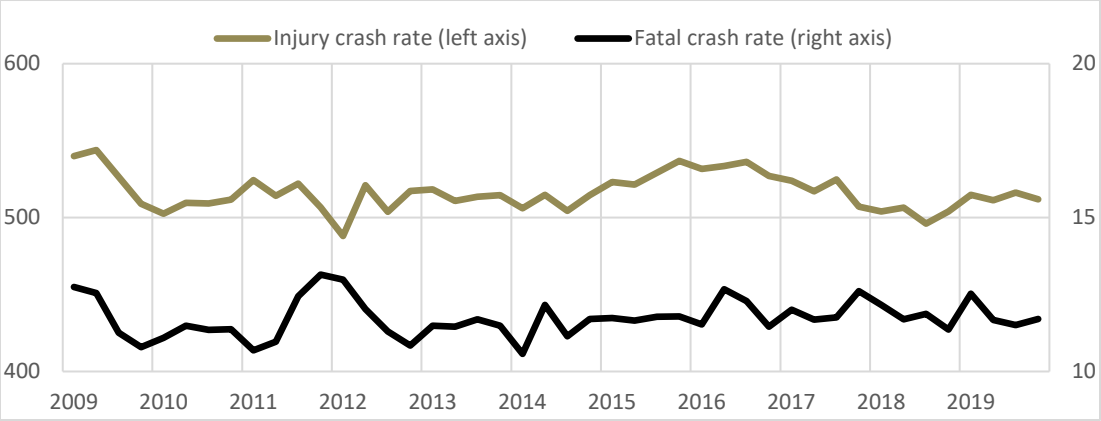
indicator variable was defined to be zero for all quarters prior to legalization of retail marijuana sales and equal to one for all quarters thereafter (i.e., a step change when retail sales were allowed).

Estimation of model parameters and standard errors were accomplished using the Time Series Cross Section Regression (TSCSREG) procedure in SAS (SAS Institute Inc., 2015). This procedure allowed for comparisons both across cross sections (i.e., states) and across time, while accounting for the within-state correlations across time (Chen et al., 2010; Crane et al., 1991). Quarterly crash rates tend to follow a seasonal pattern (e.g., fatal crash rates are lower in winter, higher in summer and fall), so the X11 procedure of SAS was used to adjust for the seasonal trend. The indicator variables in the model represent the difference in the logarithms of the (seasonally adjusted) crash rates before and after legalization. Thus, the percent change in crash rates after legalization was estimated as $100\ (e^{A} - 1)$, where A was the parameter estimate for the indicator variable.

RESULTS

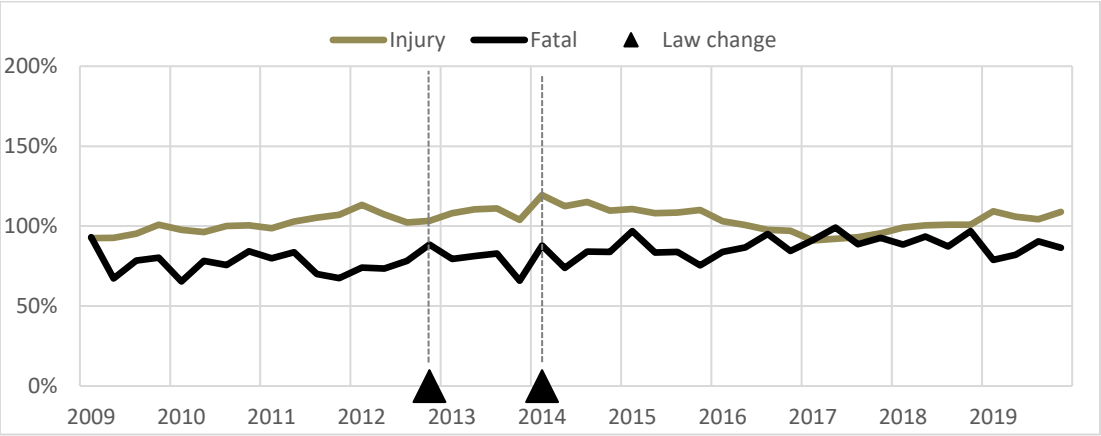
Seasonally adjusted, quarterly traffic crash rates for the group of six comparison states (Arizona, Idaho, Montana, New Mexico, Utah, Wyoming) are plotted in Figure 1. There was no obvious trend over the 11 years, with fatal crash rates ranging from 10.6 to 13.1 per billion VMT and injury crash rates ranging from 488 to 544 per billion VMT.

Figure 1. Quarterly traffic crashes per billion vehicle miles traveled, 2009–2019 (seasonally adjusted): Western U.S. states not legalizing marijuana (Arizona, Idaho, Montana, New Mexico, Utah, Wyoming)



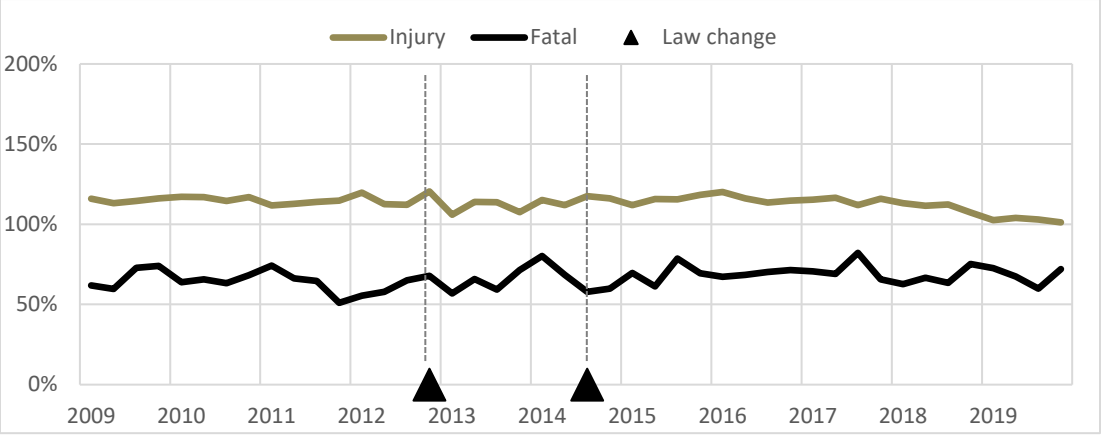
For ease of presentation, quarterly crash rates for each of the five study states were divided by the corresponding rates from the comparison group of states. These relative crash rates are plotted in Figures 2–6. For Colorado, there was a jump in injury crashes beginning in 2011 and a jump in fatal crashes beginning in 2014. Relative fatal crash rates ranged from 65 to 99% and injury crash rates ranged from 91 to 119% (Figure 2).

Figure 2. Quarterly crash rates relative to comparison states, 2009–2019: Colorado



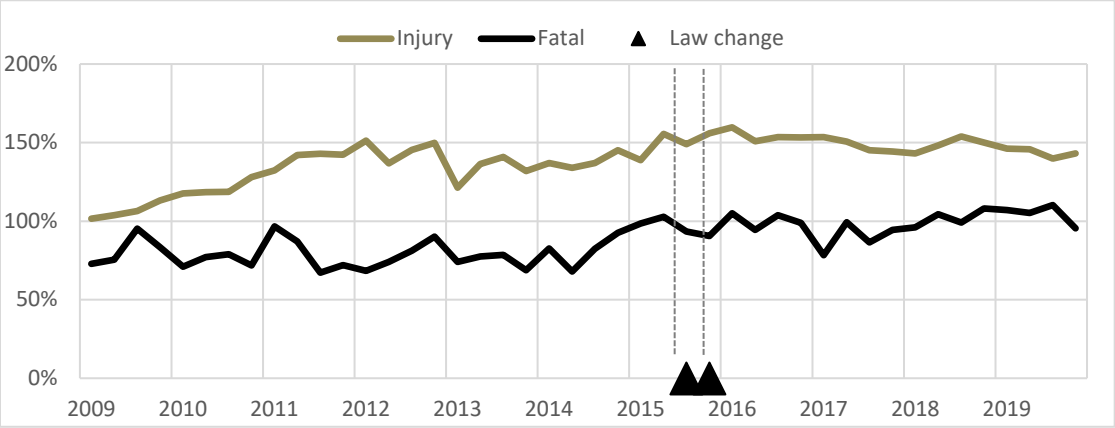
For Washington, the trend was flat during 2009–2013, with a jump in fatal crashes in 2013. Relative fatal crash rates ranged from 51 to 82% and injury crash rates ranged from 101 to 120% (Figure 3).

Figure 3. Quarterly crash rates relative to comparison states, 2009–2019: Washington



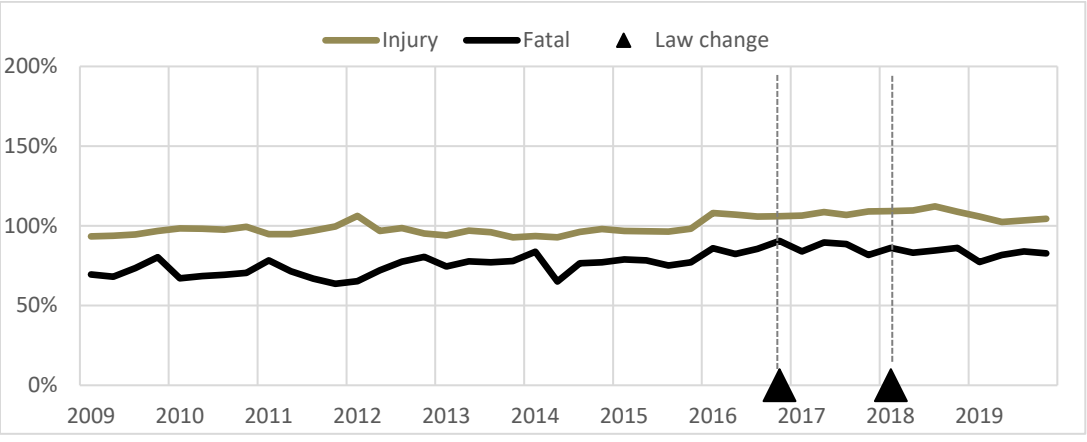
For Oregon, there was an increase in both injury and fatal crashes in 2014–2015, followed by a leveling off. Relative fatal crash rates ranged from 67 to 110% and injury crash rates ranged from 102 to 160% (Figure 4).

Figure 4. Quarterly crash rates relative to comparison states, 2009–2019: Oregon



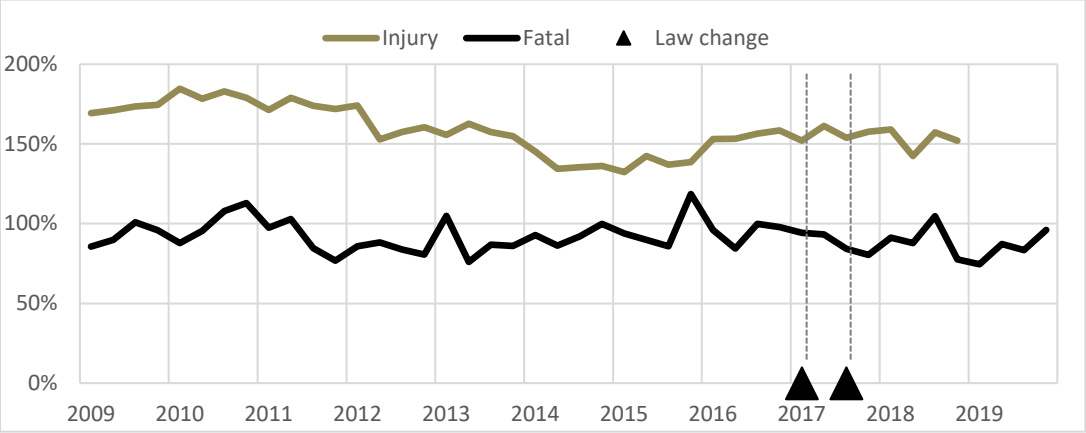
For California, the trend was flat during 2009–2015, with increases in 2016, followed by a leveling off or possible decline. Relative fatal crash rates ranged from 64 to 91% and injury crash rates ranged from 93 to 112% (Figure 5).

Figure 5. Quarterly crash rates relative to comparison states, 2009–2019: California



For Nevada, there was no clear trend in crash rates. Relative fatal crash rates ranged from 74 to 119% and injury crash rates ranged from 132 to 185% (Figure 6).

Figure 6. Quarterly crash rates relative to comparison states, 2009–2019: Nevada



Note: Injury crash rates for 2019 were not available.

An initial look at the correlations of potential covariates with the seasonally adjusted crash rates is summarized in Table 2. Increases in unemployment and seat belt use were associated with decreases in fatal crash rates, while increases in speed limits and alcohol use were associated with increases in fatal crash rates.

Table 2. Pearson correlations of covariates with seasonally adjusted crash rates[1]

Covariate	Injury crash rate	Fatal crash rate
Unemployment rate (%)	.1837	−.2869
Maximum speed limit (mph)	−.1846	.4590
Percent seat belt use	.3651	−.3962
Per capita alcohol use (liters)	.7248	.2689

[1] All correlations are statistically significant at the .01 significance level.

The statistical modeling of the time series involved 44 time points for each of the six cross sections. Legalization of recreational marijuana use was associated with increased injury crash rates (+6.6%), while the subsequent legalization of retail sales was associated with a decrease (−0.6%), but only the former was statistically significant (Table 3). Thus, the

combined effect of legalizing use and sales was a 5.9% increase in injury crash rates (i.e., 100 ($e^{0.0640 - 0.0063} - 1$)), and this combined effect was statistically significant ($p = .0381$).

Table 3. Time-series cross section regression of state-by-state injury crash rates, 2009–2019

Parameter	Estimate	Effect (%)	Lower CL	Upper CL	*p* value
Unemployment rate (%)	0.0059	0.6	0.04	1.14	.0368
Maximum speed limit (mph)	−0.0001	0.0	−0.77	0.77	.9880
Percent seat belt use	0.0020	0.2	−0.39	0.79	.5084
Per capita alcohol use (liters)	0.0444	4.5	0.41	8.83	.0319
Indicator of recreational use (step)	0.0640	6.6	2.67	10.70	.0010
Indicator of retail sales (step)	−0.0063	−0.6	−4.43	3.34	.7545
Combined effect of legalization	0.0577	5.9	0.35	11.85	.0381

Note: CL= 95% confidence limit, $R^2 = .1396$.

Legalization of recreational marijuana use was associated with slightly increased fatal crash rates (+2.3%), while the subsequent legalization of retail sales was associated with another slight increase (+1.4%), but neither estimate was statistically significant (Table 4). The combined effect of legalizing use and sales was a 3.8% increase in fatal crash rates, but this combined effect was not statistically significant ($p = .3128$).

Table 4. Time-series cross section regression of state-by-state fatal crash rates, 2009–2019

Parameter	Estimate	Effect (%)	Lower CL	Upper CL	*p* value
Unemployment rate (%)	−0.0105	−1.0	−1.76	−0.33	.0046
Maximum speed limit (mph)	0.0026	0.3	−0.73	1.26	.6115
Percent seat belt use	−0.0018	−0.2	−0.94	0.58	.6360
Per capita alcohol use (liters)	0.0551	5.7	0.20	11.43	.0431
Indicator of recreational use (step)	0.0229	2.3	−2.63	7.52	.3659
Indicator of retail sales (step)	0.0140	1.4	−3.69	6.77	.5952
Combined effect of legalization	0.0369	3.8	−3.40	11.45	.3128

Note: CL= 95% confidence limit, $R^2 = .7141$.

To get a sense of the variability across states, the analyses were performed separately for each study state (Table 5). That is, each analysis involved 44 time points for each of two cross sections (one study state and the comparison group). Legalization of recreational marijuana use

in Colorado was associated with a significant increase in injury crash rates (+14.2%) and a nonsignificant decrease in fatal crash rates (−5.2%). Legalization of retail sales was associated with nonsignificant increases in injury (+3.2%) and fatal crash rates (+6.4%). The estimated combined effect of legalizing use and sales in Colorado was a significant 17.8% increase in injury crash rates and a nonsignificant 0.9% increase in fatal crash rates.

Legalization of recreational marijuana use in Washington was associated with a significant increase in injury crash rates (+5.3%) and a nonsignificant increase in fatal crash rates (+4.9%). Legalization of retail sales was associated with a nonsignificant increase in injury crash rates (+3.0%) and a nonsignificant decrease in fatal crash rates (−6.7%). The estimated combined effect of legalizing use and sales in Washington was a significant 8.4% increase in injury crash rates and a nonsignificant 2.1% decrease in fatal crash rates.

Table 5. Time-series cross section regression of state-by-state crash rates, 2009–2019

		Injury crashes			Fatal crashes		
State	Parameter	Effect (%)	CI	*p* value	Effect (%)	CI	*p* value
CO	Indicator of recreational use (step)	14.2	(9.1, 19.6)	< .0001	−5.2	(−12.8, 3.0)	.2119
	Indicator of retail sales (step)	3.2	(−1.3, 7.9)	.1744	6.4	(−1.9, 15.5)	.1370
	Combined effect of legalization	17.8	(10.5, 25.7)	< .0001	0.9	(−10.2, 13.4)	.8807
WA	Indicator of recreational use (step)	5.3	(0.9, 9.9)	.0201	4.9	(−3.5, 14.1)	.2669
	Indicator of retail sales (step)	3.0	(−1.2, 7.4)	.1661	−6.7	(−14.0, 1.3)	.1040
	Combined effect of legalization	8.4	(2.2, 15.1)	.0080	−2.1	(−12.9, 10.1)	.7282
OR	Indicator of recreational use (step)	3.9	(−7.3, 16.5)	.5141	8.0	(−7.9, 26.7)	.3448
	Indicator of retail sales (step)	5.1	(−9.4, 22.0)	.5113	−4.1	(−22.0, 18.0)	.6954
	Combined effect of legalization	9.2	(−9.4, 31.8)	.3571	3.6	(−20.2, 34.6)	.7886
CA	Indicator of recreational use (step)	4.8	(1.4, 8.4)	.0075	8.2	(2.3, 14.4)	.0070
	Indicator of retail sales (step)	0.9	(−3.9, 5.9)	.7311	−11.9	(−18.6, −4.5)	.0027
	Combined effect of legalization	5.7	(−0.3, 12.2)	.0652	−4.6	(−13.5, 5.1)	.3398
NV	Indicator of recreational use (step)	−3.0	(−14.6, 10.3)	.6479	−0.8	(−18.1, 20.1)	.9320
	Indicator of retail sales (step)	−3.8	(−11.7, 4.8)	.3768	−7.6	(−18.2, 4.4)	.2078
	Combined effect of legalization	−6.7	(−20.0, 8.9)	.3823	−8.4	(−27.0, 15.0)	.4507

Note: CI= 95% confidence interval.

Legalization of recreational marijuana use in Oregon was associated with a nonsignificant increase in injury crash rates (+3.9%) and a nonsignificant increase in fatal crash rates (+8.0%). Legalization of retail sales was associated with a nonsignificant increase in injury crash rates (+5.1%) and a nonsignificant decrease in fatal crash rates (−4.1%). The estimated combined effect of legalizing use and sales in Oregon was nonsignificant increases in injury crash rates (+9.2%) and fatal crash rates (+3.6%).

Legalization of recreational marijuana use in California was associated with significant increases in injury crash rates (+4.8%) and fatal crash rates (+8.2%). Legalization of retail sales was associated with a nonsignificant increase in injury crash rates (+0.9%) and a significant decrease in fatal crash rates (−11.9%). The estimated combined effect of legalizing use and sales in California was a nonsignificant 5.7% increase in injury crash rates and a nonsignificant 4.6% decrease in fatal crash rates.

Legalization of recreational marijuana use in Nevada was associated with nonsignificant decreases in injury crash rates (−3.0%) and fatal crash rates (−0.8%). Legalization of retail sales was associated with nonsignificant decreases in injury crash rates (−3.8%) and fatal crash rates (−7.6%). The estimated combined effect of legalizing use and sales in Nevada was nonsignificant decreases in injury crash rates (−6.7%) and fatal crash rates (−8.4%).

DISCUSSION

Legalization of the recreational use of marijuana in five U.S. states was on average associated with a 6.6% increase in injury crash rates and a 2.3% increase in fatal crash rates. Following this increase, however, the onset of retail marijuana sales did not induce substantial additional changes to injury or fatal crash rates. Overall, the legalization of recreational marijuana was associated with a statistically significant 5.9% increase in injury crash rates and a nonsignificant 3.8% increase in fatal crash rates.

The effect of marijuana legalization on injury crash rates was more pronounced for the first three states to legalize compared with the two later states. In Colorado, Washington, and Oregon, injury crash rates rose by 4 to 14% after marijuana use was legalized, then increased again after retail sales began; overall increases ranged from 8 to 18%. In contrast, California saw a 5% increase in injury crash rates following legalization, and a 1% increase after retail sales began. Nevada saw decreases in injury crash rates both after marijuana use was legalized and again after retail sales began. Similarly, the effect of marijuana legalization on fatal crash rates was less severe for California and Nevada. California and Nevada saw decreases in fatal crash rates of 5% and 8%, respectively, although both estimates are statistically nonsignificant.

The differing crash effects in California and Nevada could be due to lessons learned from the earlier states, but evidence of this is not yet available. Blake and Finlaw (2014) cautioned states about the difficulties that Colorado experienced defining when drivers are legally impaired by marijuana. Defining marijuana impairment is not as simple as it is with alcohol; the impairing effects of both alcohol and marijuana depend on the level of use (quantity and duration) as well as individual tolerances, but marijuana does not dissipate from the blood at a consistent rate. Ghosh et al. (2017) discussed the need to standardize laboratory testing of marijuana products.

They recommended establishing a state reference laboratory to validate that individual laboratories accurately test for both marijuana concentrations and potentially harmful contaminants. Other reports have catalogued lessons learned regarding enhanced enforcement against marijuana-impaired driving and preventing marijuana access to minors (National Highway Traffic Safety Administration, 2020; Smart Approaches to Marijuana, 2019). For example, the increased availability of marijuana edibles has been linked to increased marijuana use among minors. There also has been work developing more effective public service announcements about responsible use of marijuana (Colorado Department of Transportation, 2020; Davis et al., 2016; Governors Highway Safety Association, 2018).

Some authors (e.g., Rogeberg & Elvik, 2016) have suggested that stricter laws and enforcement efforts against driving under the influence of marijuana will likely accompany recreational legalization. Such interventions have helped to control the effects of driving under the influence of alcohol (Shults et al., 2001), and they might also do so for marijuana. To address the increased incidence of drugged driving, both public and private highway safety groups have expanded their anti-drink-driving enforcement and education campaigns to include drugs other than alcohol. For example, We Save Lives, a nonprofit organization formed in 2014, has adopted the slogan “Driving high means a DUI.” In the summer of 2017, the Colorado Department of Transportation began a campaign they called *The Cannabis Conversation* (Colorado Department of Transportation, 2020). Its objective was to develop effective messages against drugged driving based on feedback from marijuana users. In 2018, the Ad Council and the U.S. Department of Transportation launched an initiative against impaired driving under the slogan “If you feel different, you drive different.”

Drivers impaired by marijuana have been observed to compensate for their impairment by slowing down and increasing following distance (Brooks-Russell et al., 2019; Hartman et al., 2016). It is reasonable to expect that such behaviors will reduce the severity of crashes that result. In that sense, past research suggests that fatal crash rates may be less affected by marijuana legalization than less severe crash rates. That is, the compensation exhibited by marijuana-impaired drivers, especially lower speeds, may not be sufficient to avoid a crash, but it may be enough to reduce the severity of that crash. Although the differences are small, the current study estimates a lesser affect for fatal crashes (+3.8%) compared with injury crashes (+5.9%). Similarly, Monfort (2018) reported a 5.2% increase in police-reported crashes of all severities in Colorado, Washington, and Oregon, while the Highway Loss Data Institute (2018) reported a 6% increase in collision insurance claims (the latter typically being less severe than the former).

The current study has several limitations. Although all the states in this study are in the western region of the U.S., their crash rates during the years 2009–2019 may have been affected by unique factors not addressed here. These factors could affect the suitability of the states selected as a comparison group to the states legalizing marijuana. Secondly, data were only available through 2019, which may not be sufficient to detect changes in trends. The data for California cover only 2 years after retail marijuana sales began. Also, although the counts of fatal crashes are reliable, the counts of injury crashes may be suspect. Traffic injuries can be undercounted in police-reported statistics (Barancik & Fife, 1985; Janstrup et al., 2016). Finally, counties within each of the study states have the option of restricting and prohibiting marijuana processing and retail centers, and many counties have exercised that option. It is possible that the effects of marijuana legalization have been lower in these counties. Future analyses should

include more recent and more complete data and should attempt to separate counties that have opted out.

Increased availability of marijuana does not necessarily imply increased use of marijuana. However, research suggests that there is a significant correlation between U.S. trends in marijuana laws and policies and trends in self-reported use of marijuana (Yu et al., 2020). Further, retail sales of marijuana have been steadily increasing in each of the study states since sales were legalized (American Marijuana, 2020). In the same way, increased marijuana use does not necessarily imply increased use before driving. A study of trauma center patients involved in motor vehicle crashes concluded that changes in marijuana legalization did not impact the incidence of crashing while under the influence of marijuana (Kruse et al., 2021). However, several studies have reported a higher incidence of drivers testing positive for marijuana after the liberalization of state marijuana policies (Eichelberger, 2019; Ramirez et al., 2016; Tefft & Arnold, 2020). Thus, the evidence suggests that the legality and availability of marijuana are related to the frequency of its use before driving.

Even if legalization leads to a higher prevalence of driving after marijuana use, the increased crash rates may be due to other unobserved factors. Marijuana users may be riskier drivers even when not impaired, and the legalization of marijuana may encourage more travel by these risky drivers. For example, marijuana users in counties that do not allow retail sales may drive to counties where such sales are permitted. Some states have used the legalization of marijuana as part of their tourism promotions, bringing in more potentially risky drivers (Kang et al., 2016). Thus, the results of this study do not necessarily imply that marijuana use before driving increases the risk of a crash.

In conclusion, the estimated increase in traffic crash rates after marijuana legalization is consistent with earlier studies: a significant 5.9% increase in injury crash rates and a nonsignificant 3.8% increase in fatal crash rates. Overall, we also found legalization of recreational use to have a more substantial effect on crash rates than the onset of retail sales. Our data suggest a large amount of variance in these effects by state, however, and these estimates represent an early look at the time trends. Researchers and policymakers should continue monitoring the data while accounting for the unique considerations for each state. As of July 2021, the recreational use of marijuana was legal in 18 U.S. states and the District of Columbia, and nationwide in Canada and Uruguay. National, state, and local governments considering changes to their marijuana policies should be cautious, proceed slowly and take note of the lessons learned from these initial experiences. Policy changes regarding marijuana use must not hamper the effort to eliminate impaired driving.

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