

NIH Public Access Author Manuscript

Drug Alcohol Depend. Author manuscript; available in PMC 2015 July 01

Published in final edited form as:

Drug Alcohol Depend. 2014 July 1; 140: 137–144. doi:10.1016/j.drugalcdep.2014.04.008.

Trends in fatal motor vehicle crashes before and after marijuana commercialization in Colorado^{*}

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Abstract

Background—Legal medical marijuana has been commercially available on a widespread basis in Colorado since mid-2009; however, there is a dearth of information about the impact of marijuana commercialization on impaired driving. This study examined if the proportions of drivers in a fatal motor vehicle crash who were marijuana-positive and alcohol-impaired, respectively, have changed in Colorado before and after mid-2009 and then compared changes in Colorado with 34 non-medical marijuana states (NMMS).

Methods—Thirty-six 6-month intervals (1994–2011) from the Fatality Analysis Reporting System were used to examine temporal changes in the proportions of drivers in a fatal motor vehicle crash who were alcohol-impaired (0.08 g/dl) and marijuana-positive, respectively. The pre-commercial marijuana time period in Colorado was defined as 1994–June 2009 while July 2009–2011 represented the post-commercialization period.

Results—In Colorado, since mid-2009 when medical marijuana became commercially available and prevalent, the trend became positive in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive (change in trend, 2.16 (0.45), p < 0.0001); in contrast, no significant changes were seen in NMMS. For both Colorado and NMMS, no significant changes were seen in the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired.

^{*}Supplementary material can be found by accessing the online version of this paper at http://dx.doi.org and by entering doi:... © 2014 Elsevier Ireland Ltd. All rights reserved.

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Author Contributions: Drs. Salomonsen-Sautel, Sakai, and Hopfer drafted the original study aims. Dr. Salomonsen-Sautel acquired and set up all the data. Dr. Min led the analytic analyses with assistance from Dr. Salomonsen-Sautel. Dr. Salomonsen-Sautel wrote the manuscript, while all authors provided critical revisions of important intellectual content. All authors contributed to and approved the final manuscript.

Conflicts of Interest: Dr. Sakai received reimbursement in 2012 for completing a policy review for the WellPoint Office of Medical Policy & Technology Assessment (OMPTA), WellPoint, Inc., Thousand Oaks, CA. He also serves as a board member of the ARTS Foundation. All other authors report no biomedical financial interests or potential conflicts of interest.

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Conclusions—Prevention efforts and policy changes in Colorado are needed to address this concerning trend in marijuana-positive drivers. In addition, education on the risks of marijuana-positive driving needs to be implemented.

Keywords

medical marijuana; traffic fatalities; alcohol-impaired driving; marijuana-positive driving; drugged driving

1. INTRODUCTION

Traffic fatalities are a major public health issue; 32,367 individuals died in motor vehicle crashes in the United States in 2011 and 31% of these fatal accidents involved drivers who tested positive for alcohol (U.S. Department of Transportation National Highway Traffic Safety Administration, 2013). Alcohol use has been associated with driving-related problems including: divided attention; drowsiness; vigilance; perception; visual functions; tracking; cognitive tasks; psychomotor skills; and choice reaction time (Moskowitz and Fiorentino, 2000). In a review by Moskowitz and Fiorentino (2000), the majority of studies found serious impairment due to alcohol by a blood alcohol concentration (BAC) of 0.08 g/dl.

Although in 2009 18% of all fatally injured drivers tested positive for drug involvement (U.S. Department of Transportation National Highway Traffic Safety Administration, 2010), far less research has been conducted on marijuana compared with alcohol. According to a recent review, drivers who used marijuana compensate by driving slower; however, their control deteriorates with increasing task complexity (Hartman and Huestis, 2013). Marijuana use increases lane weaving, decreases mean speed, increases mean and variability in headways, and impairs cognitive function, critical tracking tests, reaction times, divided attention tasks, expected practice effects, and lane position variability (Anderson et al., 2010; Downey et al., 2013; Hartman and Huestis, 2013; Lenne et al., 2010). The increased risk of impaired driving skills occurs for both lower and higher levels of delta-9tetrahydrocannabinol (THC) concentrations (Bramness et al., 2010). A double-blind, placebo-controlled, randomized, three-way crossover study administered placebo and dronabinol (10mg and 20mg; medical tetrahydrocannabinol) to current marijuana users. The researchers found that dronabinol impairs driving performance in a dose dependent manner in both occasional and heavy marijuana users but to a lesser degree in heavy users (Bosker et al., 2012). Therefore, substantial scientific evidence demonstrates that THC use impairs driving-related skills. Although the link between marijuana use and driving impairment is less well studied, Li et al. (2013) recently concluded that drivers involved in a fatal motor vehicle crash were 1.83 times more likely to be positive for marijuana than drivers not involved in a fatal motor vehicle crash.

Policies and cultural or attitudinal shifts can affect rates of substance-impaired driving (Fell and Voas, 2006). In recent years, Colorado has undergone a sharp policy shift in its approach to marijuana. Colorado voters approved Amendment 20 to legalize medical marijuana in 2000; however, very few medical marijuana applications were submitted until 2009. In March of that year, federal policy shifted, ending raids on distributors of medical

marijuana in states where it was legal (Johnston and Lewis, 2009). In October, 2009, the U.S. Department of Justice distributed a memo stating that federal resources should not focus on prosecuting medical marijuana patients and caregivers who were operating in "clear and unambiguous compliance with existing state laws" (Ogden, 2009). Perhaps most relevant to this manuscript, in July 2009, the Colorado Board of Health rejected a limit on the number of patients a caregiver could aid, which greatly loosened restrictions on who could cultivate and distribute medical marijuana. This decision opened the door for large scale retail medical marijuana dispensaries (Ingold, 2009; Sensible Colorado, 2013). Therefore, this study uses mid-2009 as the beginning of the large scale marijuana commercialization in Colorado.

Figure 1 graphically displays the increase of registered medical marijuana users from 2009 through 2011. As of January 31st, 2009, only 5,051 people were registered medical marijuana users (The Colorado Medical Marijuana Registry, 2009b) but by the end of July, the number more than doubled to 11,094 (The Colorado Medical Marijuana Registry, 2009c). By the end of 2009, the number of licensed registered medical marijuana users increased to 41,039 (The Colorado Medical Marijuana Registry, 2009a).

There has been much debate about the impact of marijuana commercialization on both marijuana-positive and alcohol-impaired driving; however, there is a dearth of empirical research. This study addressed two research questions: 1) Has the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive changed in Colorado since mid-2009 and how do these changes compare with non-medical marijuana states (NMMS)? and 2) Has the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired (BAC 0.08%) changed during this same time in Colorado and how do these changes compare with NMMS?

2. METHODS

This study is based on data from the 1994–2011 Fatality Analysis Reporting System (FARS), which has documented all qualifying fatalities occurring within the 50 United States, the District of Columbia, and Puerto Rico since 1975 (U.S. Department of Transportation National Highway Traffic Safety Administration, 2012a). FARS requires that the crash involves a motor vehicle driving on a road open to the public and that the crashrelated fatality occurs within 30 days (720 hours) of the crash (U.S. Department of Transportation National Highway Traffic Safety Administration, 2012a). State agencies provide information to the National Highway Traffic Safety Administration (NHTSA) on all qualifying fatal crashes identified in various documents, such as police accident reports, death certificates, state vehicle registration files, coroner/medical examiner reports, state driver licensing files, hospital medical reports, state highway department data, emergency medical service reports, and vital statistics (U.S. Department of Transportation National Highway Traffic Safety Administration, 2012a). FARS analysts have automatic checks, safeguards, and a coding manual to ensure and maintain quality data. Even with these quality assurance checks, aggregating data across 50 states can introduce some inconsistencies because states have different laws and policies regarding drug testing practices (Office of National Drug Control Policy, 2011). States also may use different drug

tests and/or have different availability of toxicology lab work (U.S. Department of Transportation National Highway Traffic Safety Administration, 2010).

The FARS data contain approximately 100 data elements including driver (e.g., age, sex, and drug test results), vehicle (e.g., year and model), and crash (e.g., date, atmospheric conditions, and number of fatalities) variables. To adapt to changing vehicle characteristics, highway safety emphasis areas, and user needs, a data element may be slightly modified or a new one will be added. For instance, beginning in 1999, data on Hispanic ethnicity and race started being collected on fatalities. The FARS data do not include any personal identifying information, such as names, addresses, or social security numbers, which allows the data to be publicly available (U.S. Department of Transportation National Highway Traffic Safety Administration, 2012a). Therefore, the Colorado Multiple Institutional Review Board determined that this project is not human subjects research.

Analyses were completed for Colorado and for all of the 34 states that did not have medical marijuana laws through 2011: Alabama; Arkansas; Connecticut; Florida; Georgia; Idaho; Illinois; Indiana; Iowa; Kansas; Kentucky; Louisiana; Maryland; Massachusetts; Minnesota; Mississippi; Missouri; Nebraska; New Hampshire; New York; North Carolina; North Dakota; Ohio; Oklahoma; Pennsylvania; South Carolina; South Dakota; Tennessee; Texas; Utah; Virginia; West Virginia; Wisconsin; and Wyoming. Colorado was selected because there was a clear point in time when there was a tremendous growth in the commercialization of medical marijuana in the state.

Outcome variables aggregated at each time period were: 1) the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive; the driver had to have a positive blood and/or urine drug test for a cannabinoid, hashish, marijuana, Marinol, or THC and 2) the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired (BAC 0.08%). A cut off criterion for BAC of 0.08 grams per deciliter or greater has been used in prior studies (U.S. Department of Transportation National Highway Traffic Safety Administration, 2009, , 2012c). For example, to create the first outcome variable, the number of marijuana-positive drivers was divided by the total number of drivers involved in fatal motor vehicle crashes; this denominator included drivers who tested qualitatively positive or negative for any marijuana and those who were not tested for drugs (see Supplemental Figure 1 for Colorado and Supplemental Figure 2 for the 34 NMMS¹). To be included in the outcome variables, drivers had to be involved in a fatal motor vehicle crash in Colorado or in the 34 NMMS between 1994 and 2011. Drivers involved in a fatal motor vehicle crash were included in the outcome variables for the following reasons: 1) one fatal crash can involve one to many drivers; 2) in a few cases, the driver of the first vehicle was not positive for marijuana; although, a driver in a subsequent numbered vehicle was positive for marijuana; and 3) in a few fatal motor vehicle crashes, both drivers were positive for marijuana. Approximately only one and a half percent of the total number of drivers were both marijuana-positive and alcohol-impaired.

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To account for missing BAC values, the multiple imputation method was used as recommended by the National Center for Statistics and Analysis (U.S. Department of Transportation National Highway Traffic Safety Administration, 2002) and as various previous studies have done (Roudsari et al., 2009; U.S. Department of Transportation National Highway Traffic Safety Administration, 2009, 2011, 2012b). To create the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired, the proportions of the 10 imputed BAC values were calculated and then these proportions were averaged to get the final proportion of interest (U.S. Department of Transportation National Highway Traffic Safety Administration, 2002).

The study years 1994–2011 were divided into thirty-six 6-month intervals to determine trends. The *a priori* definition of the period of pre-commercial medical marijuana is 1994–June 2009 and post-commercial medical marijuana is July, 2009–2011. Only linear trends were examined because five time periods post-commercial medical marijuana were available. Three covariates were considered: proportion of male drivers, proportion of drivers 21–24 years old, and proportion tested for drugs or alcohol, as appropriate. Studies have revealed that drivers who were 21–24 years old as well as being male were more likely to be involved in alcohol-impaired fatal motor vehicle crashes (Roudsari et al., 2009; U.S. Department of Transportation National Highway Traffic Safety Administration, 2011). In addition, FARS data have shown that between the years 2005–2009, the proportion of fatally injured drivers testing for drugs has increased (U.S. Department of Transportation National Highway Traffic Safety Administration National Highway Traffic Safety Administration, 2010).

To answer the two research questions, four linear models including time and time spline term at the knot January - June, 2011 as predictors with autoregressive covariance structures of order 1 (AR(1)) to account for the autocorrelation among data points were first fitted to examine possible changes in trends after mid-2009 for Colorado and the 34 NMMS on the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive and on the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired and additionally to estimate covariance parameters. All four models included the above three covariates. Next, estimated generalized least squares (EGLS) methods were applied to the two models with state (Colorado vs. the 34 NMMS) and its interactions with time terms as additional predictors pooling data from Colorado and the 34 NMMS to compare trends from Colorado and the 34 NMMS utilizing AR(1) covariance parameter estimates from the first autoregressive models. In other words, the first four models compared the trend before and after the commercialization of medical marijuana within Colorado or the 34 NMMS on the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive or on the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired. The last two models compared the trend before and after the commercialization of medical marijuana between Colorado and the 34 NMMS on the two outcome variables. Analyses were completed in SAS 9.3 (SAS Institute Inc., 2012) and R (R Core Team, 2013).

3. RESULTS

In Colorado, the proportion of drivers in a fatal motor vehicle crash who were marijuanapositive was 4.5% in the first 6 months of 1994, 5.9% in the first 6 months of 2009, and 10%

at the end of 2011 (see Figure 2, solid line). There was a significant negative linear trend in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive during the pre-commercial marijuana period (see Table 1). There was a significant positive change in the trend during the post-commercial marijuana period resulting in a positive trend for Colorado, after adjusting for the proportion of male drivers, the proportion of drivers 21–24 years old, and the proportion of drivers tested for drugs. In the 34 NMMS, the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive was 1.1% in the first 6 months of 1994, 4.2% in the first 6 months of 2009, and 4.1% at the end of 2011 (see Figure 2, dashed line). There was not a significant trend in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive during the pre-commercial marijuana period, nor a significant change in trend during the post-commercial marijuana period for the 34 NMMS, after adjusting for the three covariates (see Table 1). Colorado had a significantly higher proportion of drivers in a fatal motor vehicle crash who were marijuana-positive compared with the 34 NMMS in 1994 (p = 0.0005). There was a significant difference in trend for the proportion of drivers in a fatal motor vehicle crash who were marijuanapositive during the pre-commercial marijuana period in Colorado compared with the 34 NMMS (see Table 1). After mid-2009, Colorado had a significantly greater positive change in trend compared with NMMS, after adjusting for the three covariates.

In Colorado, the proportion of drivers in a fatal motor vehicle crash who were alcoholimpaired was 26.9% in the first 6 months of 1994, 25.2% in the first 6 months of 2009, and 23.4% at the end of 2011 (see Figure 3, solid line). There was not a significant trend in the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired during the pre-commercial marijuana period, nor a significant change in trend during the postcommercial marijuana period in Colorado, after adjusting for the proportion of male drivers, the proportion of drivers 21-24 years old, and the proportion of drivers tested for alcohol (see Table 1). In the 34 NMMS, the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired was 22.8% in the first 6 months of 1994, 23.0% in the first 6 months of 2009, and 21.0% at the end of 2011 (see Figure 3, dashed line). There was a nonsignificant negative trend during the pre-commercial marijuana period for the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired and there was not a significant change in trend during the post-commercial marijuana period for the 34 NMMS, after adjusting for the three covariates (see Table 1). Additionally, there were no significant differences comparing Colorado and NMMS in trend during the pre-commercial marijuana period and in the change in trend during the post-commercial marijuana period on the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired, after adjusting for the three covariates (see Table 1).

4. DISCUSSION

The primary results of this study are that 1) the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive in Colorado was decreasing during the pre-marijuana commercialization period, but is now increasing, 2) similar changes are not seen in NMMS, 3) during the post-marijuana commercialization period, the increasing trend in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive is higher in

Colorado compared to NMMS, and 4) no significant changes in the proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired was seen in Colorado or in NMMS.

Some recent research supports the proposition that the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive may increase with medical marijuana commercialization. A recent study by Johnson et al. (2012) randomly sampled 900 weekend nighttime drivers from six jurisdictions in California, the first state where medical marijuana became legal. This study found that 14.4% of weekend nighttime drivers tested positive for illegal drugs and of those, 8.5% tested positive for THC. A very similar study was completed three years earlier by the same authors and compared to the recent study; that comparison revealed an increase from 4.9% to 7.8% in THC positive drivers with no increases in drivers under the influence of other illegal drugs. In addition, drivers who were positive for marijuana did not think they consumed anything that impaired their driving skills (Johnson et al., 2012).

The fourth result stands in contrast to work by Anderson et al. (2013), which found that legalizing medical marijuana was associated with a 13.2% decrease in any alcohol-related fatality (BAC > 0) and a 15.5% decrease in fatalities in which at least one driver had a BAC > 0.10. However, these discrepant results likely stem from several important differences in study design. First, Anderson et al. examined changes prior to and following the enactment of medical marijuana laws; instead this study used not the year Colorado enacted its medical marijuana law (2001) but July 2009 when medical marijuana commercialization quickly grew in Colorado. Second, Anderson et al. included multiple states where medical marijuana is legal, where this study focused on Colorado. This study used a BAC level of 0.08 as the cut off criterion, which has been used in prior studies (U.S. Department of Transportation National Highway Traffic Safety Administration, 2009, 2012c) and is the threshold for determining if a driver was under the influence of alcohol in Colorado (House Committees, 2013). Finally the two studies employed different covariates. Therefore, it is not surprising that the two studies provide differing results.

Although the results of this study raise important concerns about the increase in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive, the study must be viewed within the context of several limitations. First, data on Hispanic ethnicity and race were only collected since 1999 and only collected on fatalities, not necessarily the impaired driver (U.S. Department of Transportation National Highway Traffic Safety Administration, 2012a). Therefore, Hispanic ethnicity and race could not be included as covariates in the analyses. Second, marijuana-positive means that a driver had a positive drug test for a cannabinoid, hashish, marijuana, Marinol, or THC, which does not prove impairment or indicate that marijuana use was the cause of the crash (U.S. Department of Transportation National Highway Traffic Safety Administration, 2010). Third, unlike the alcohol data, quantitative marijuana levels are not systematically measured. Finally, differing state laws, policies, and practices regarding drug test practices can introduce inconsistencies. For instance, states may use different test types and/or employ different concentration thresholds for determining a qualitatively positive test result. States also have different availability of toxicology lab work (U.S. Department of Transportation National Highway Traffic Safety Administration, 2010). However, concern regarding this last

limitation is reduced because the analyses included a covariate, the proportion of drivers tested for drugs, to help account for these differences.

Unfortunately, this study cannot determine cause and effect relationships, such as whether marijuana-positive drivers contributed to/caused the fatal motor vehicle crashes. As seen in Figure 1, Colorado experienced a rapid increase in medical marijuana registered users in the middle of 2009 and this increase continued throughout the study period of 2010 and most of 2011. In contrast, there was a decreasing trend in fatal motor vehicle crashes in Colorado since 2004 as displayed in Figure 4 (Figure 5 depicts a similar trend for the number of motor vehicle-related fatalities in the 34 NMMS). Therefore, the primary result of this study may simply reflect a general increase in marijuana use during this same time period in Colorado.

After using marijuana, THC metabolites are detectable in an individual's blood or urine for several days and sometimes weeks for heavy marijuana users (National Institute on Drug Abuse, 2013). Therefore, Colorado may have an increased number of drivers, in general, who were using marijuana, not just an increase in the proportion who were involved in fatal motor vehicle crashes. The FARS data only contain a qualitatively positive or negative blood or urine test result for a cannabinoid, hashish, marijuana, Marinol, or THC. A comprehensive approach would be for State agencies to test drivers' blood and provide the NHTSA with the drivers' quantitative levels of THC nanograms per milliliter of whole blood. If a future study could obtain or measure the levels of THC in drivers' blood, then the study could draw conclusions using quantitative THC levels or a set threshold for "impairment" (e.g., defined as having five nanograms or more of THC per milliliter of whole blood). Then a future study could replicate this study with only marijuana-impaired drivers. Additionally to further understand the relationship between the increase in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive after the expansion of medical marijuana commercialization, future research could be completed to examine the causes of the motor vehicle crash and roadside surveys of drivers could be completed to obtain drug use and other information on a random sample of motorists, such as described in Johnson et al. (2012).

Even though this study cannot discover the cause, this study reveals that there has been an increase in the proportion of drivers in a fatal motor vehicle crash who were marijuana-positive since the expansion of medical marijuana commercialization in Colorado. To manage drug-impaired drivers and to prevent drug-impaired driving, there are programs that can be implemented. Voas et al. (2011) proposed a national model to manage drug and alcohol-impaired drivers. Their program suggests seven features that include low cost monitoring systems and alcohol and/or substance use treatment. Other programs aim to prevent drug-impaired driving. The "Why Drive High?" program is a social marketing campaign that is youth led and adult guided and has the primary goal to increase youth awareness and knowledge about the adverse effects of marijuana while driving (Marko and Watt, 2011).

Another possible approach to decrease drugged driving is to set limits for driving while intoxicated. On May 28th, 2013, Colorado House Bill 13-1325 set the limit for impaired driving. If a driver's blood at the time of driving, or within a reasonable time thereafter,

contains five nanograms or more of THC per milliliter of whole blood, then this gives rise to a permissible inference that the driver was under the influence of at least one drug (House Committees, 2013). An international group of scientists evaluated evidence from experimental and epidemiological research to develop limits for driving under the influence of marijuana. The group suggested a range of seven to ten nanograms per milliliter of THC in the blood to determine impairment in drivers; although, a lower limit of THC may be appropriate with a BAC exceeding 0.03% or 0.05% (Grotenhermen et al., 2007). On the other hand, some scientists propose zero tolerance laws for drugged driving. These scientists assert that legislation for any illegal drug-impaired driving should include statements that if a drug is present in a driver who is suspected of impairment, then that should constitute *per se* evidence of drugged driving (Reisfield et al., 2012). In addition, DuPont et al. (2012) also support drugged driving "*per se* laws that make any amount of an illegal substance in the body of a driver a criminal offense, including drugs that are illegal under federal law and/or illicit use of medical drugs without a valid prescription" (p. 40).

In conclusion, in 1994, Colorado had a higher proportion of drivers in a fatal motor vehicle crash who were marijuana-positive compared with the 34 NMMS. Colorado experienced a significant positive change in trend post-commercial marijuana and this change was significantly different than that seen in NMMS. Prevention programs and education should be implemented to inform individuals about the risks of impaired driving, particularly in Colorado. Future studies should examine the influence of Colorado's recent move to legalize recreational marijuana and the potential impact of Colorado House Bill 13-1325 on marijuana-positive driving.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Role of Funding Source: Dr. Salomonsen-Sautel was supported by NIAAA T32AA007464. Dr. Sakai is supported by R01DA031761, P60DA011015, R01DA029258 and the Kane Family Foundation. Dr. Hopfer is supported by 1K24DA032555. The NIAAA and the NIDA had no further role in study design; in the collection, analysis and interpretation of data, in the writing of the report, or in the decision to submit the paper for publication.

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Figure 2.

Proportion of drivers in a fatal motor vehicle crash who were marijuana-positive in Colorado and 34 states without medical marijuana laws from 1994–2011



Figure 3.

Proportion of drivers in a fatal motor vehicle crash who were alcohol-impaired in Colorado and 34 states without medical marijuana laws from 1994–2011



Figure 4. Number of motor vehicle-related fatalities in Colorado from 1994–2011





Number of motor vehicle-related fatalities in 34 states without medical marijuana laws from 1994–2011

Table 1

generalized least squares models comparing Colorado and the 34 NMMS on the proportion of drivers in a fatal motor vehicle crash who were marijuanamid-2009, NMMS change in trend after mind-2009, and difference between 34 NMMS intercept and Colorado intercept for Colorado vs. 34 NMMS Results of linear models with AR(1) covariance structures examining changes in trends post mid-2009 for Colorado and 34 NMMS and estimated positive and/or alcohol-impaired (not shown – intercept for Colorado models and 34 NMMS models; and NMMS intercept, NMMS trend before models)

	Proportion of Drivers in a Fat Marijua	al Motor Vehicle C ina-Positive	rash who were	Proportion of Drivers in a Fat Alcoho	tal Motor Vehicle C d-Impaired	rash who were
	beta (standard error)	ţ	d	beta (standard error)	1	d
Colorado						
Trend before mid-2009	-0.19(0.08)	-2.40	0.0227	0.09 (0.12)	0.74	0.4654
Change in trend after mid-2009	2.16 (0.45)	4.76	0.0001	0.06 (0.97)	0.07	0.9476
Proportion of male drivers	-0.11 (0.09)	-1.18	0.2484	-0.15 (0.22)	-0.68	0.5002
Proportion of drivers 21–24 years old	-0.12 (0.10)	-1.22	0.2328	0.06 (0.23)	0.27	0.7889
Proportion tested for drugs or alcohol	0.11 (0.04)	2.99	0.0056	0.39 (0.10)	4.03	0.0004
34 NMMS						
Trend before mid-2009	0.02 (0.05)	0.35	0.7304	-0.06 (0.05)	-1.12	0.2705
Change in trend after mid-2009	0.11 (0.18)	0.61	0.5447	-0.01 (0.29)	-0.05	0.9619
Proportion of male drivers	-0.10 (0.10)	-1.05	0.3042	0.39 (0.21)	1.88	0.0693
Proportion of drivers 21–24 years old	-0.02 (0.14)	-0.15	0.8810	0.53 (0.28)	1.90	0.0667
Proportion tested for drugs or alcohol	0.13(0.03)	4.59	0.0001	0.23 (0.09)	2.65	0.0128
Colorado vs. 34 NMMS						
Difference in trend before mid-2009	-0.22 (0.06)	-3.65	0.0005	0.17 (0.20)	0.85	0.3972
Difference in change in trend after mid-2009	2.06 (0.48)	4.30	0.0001	0.49 (1.64)	0.30	0.7658
Proportion of male drivers	-0.10 (0.06)	-1.69	0.0956	0.33~(0.14)	2.35	0.0217
Proportion of drivers 21–24 years old	-0.09 (0.08)	-1.17	0.2466	0.45 (0.20)	2.30	0.0245
Proportion tested for drugs or alcohol	0.13 (0.02)	5.83	0.0001	0.22 (0.06)	3.60	0.0006