Medical Marijuana Laws, Traffic Fatalities, and Alcohol Consumption

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Abstract

To date, 19 states have passed medical marijuana laws, yet very little is known about their effects. The current study examines the relationship between the legalization of medical marijuana and traffic fatalities, the leading cause of death among Americans ages 5–34. The first full year after coming into effect, legalization is associated with an 8–11 percent decrease in traffic fatalities. The impact of legalization on traffic fatalities involving alcohol is larger and estimated with more precision than its impact on traffic fatalities that do not involve alcohol. Legalization is also associated with sharp decreases in the price of marijuana and alcohol consumption, which suggests that marijuana and alcohol are substitutes. Because alternative mechanisms cannot be ruled out, the negative relationship between legalization and alcohol-related traffic fatalities does not necessarily imply that driving under the influence of marijuana is safer than driving under the influence of alcohol.

1. Introduction

Medical marijuana laws (MMLs) remove state-level penalties for using, possessing, and cultivating medical marijuana. Patients are required to obtain approval or certification from a doctor, and doctors who recommend marijuana to their patients are immune from prosecution. Medical marijuana laws allow patients to designate caregivers who can obtain marijuana on their behalf.

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On May 2, 2013, Maryland became the nineteenth state, along with the District of Columbia, to enact an MML. More than a dozen state legislatures, including those of Illinois, New York, and Pennsylvania, have recently considered medical marijuana bills. If these bills are eventually signed into law, the majority of Americans will live in states that permit the use of medical marijuana.

Opponents of medical marijuana tend to focus on the social issues surrounding substance use. They argue that marijuana is addictive, serves as a gateway drug, has little medicinal value, and leads to criminal activity (Adams 2008; Blankstein 2010). Proponents argue that marijuana is both efficacious and safe and can be used to treat the side effects of chemotherapy as well as the symptoms of AIDS, multiple sclerosis, epilepsy, glaucoma, and other serious illnesses. They cite clinical research showing that marijuana relieves chronic pain, nausea, muscle spasms, and appetite loss (Eddy 2010; Marmor 1998; Watson, Benson, and Joy 2000) and note that neither the link between the use of medical marijuana and the use of other substances nor the link between medical marijuana and criminal activity has been substantiated (Belville 2011; Corry et al. 2009; Hoeffel 2011).

This study begins by using price data collected from back issues of *High Times*, the leading cannabis-related magazine in the United States, to explore the effects of MMLs on the market for marijuana. Our results are consistent with anecdotal evidence that MMLs have led to a substantial increase in the supply of high-grade marijuana (Montgomery 2010). In contrast, the impact of MMLs on the market for low-quality marijuana appears to be modest.

Next, we turn our attention to MMLs and traffic fatalities, the primary relationship of interest. Traffic fatalities are the leading cause of death among Americans ages 5–34.[1] To our knowledge, there has been no previous examination of this relationship. Data on traffic fatalities at the state level are obtained from the Fatality Analysis Reporting System (FARS) for the years 1990–2010. Fourteen states and the District of Columbia enacted an MML during this period. The FARS information includes the time of day the traffic fatality occurred, the day of the week it occurred, and whether alcohol was involved. Using this information, we contribute to the long-standing debate on whether marijuana and alcohol are substitutes or complements.

The first full year after coming into effect, the legalization of medical marijuana is associated with an 8–11 percent decrease in traffic fatalities. However, the effect of MMLs on traffic fatalities involving alcohol is larger and estimated with more precision than the effect of MMLs on traffic fatalities that do not involve alcohol. In addition, we find that the estimated effects of MMLs on fatalities at night and on weekends (when the level of alcohol consumption increases) are larger, and are more precise, than the estimated effects of MMLs on fatalities during the day and on weekdays.

[1] These 2010 data on leading causes of fatalities are from the Centers for Disease Control and Prevention's Web-Based Injury Statistics Query and Reporting System (http://www.cdc.gov/injury/wisqars).

Finally, the relationship between MMLs and more direct measures of alcohol consumption is examined. Using individual-level data from the Behavioral Risk Factor Surveillance System (BRFSS) for the period 1993–2010, we find that MMLs are associated with decreases in the probability of having consumed alcohol in the past month, binge drinking, and the number of drinks consumed.

We conclude that alcohol is the likely mechanism through which the legalization of medical marijuana reduces traffic fatalities. However, this conclusion does not necessarily imply that driving under the influence of marijuana is safer than driving under the influence of alcohol. Alcohol is often consumed in restaurants and bars, while many states prohibit the use of medical marijuana in public. If marijuana consumption typically takes place at home or other private locations, then legalization could reduce traffic fatalities simply because marijuana users are less likely to drive while impaired.

2. Background

2.1. *A Brief History of Medical Marijuana*

Marijuana was introduced in the United States in the early 1600s by Jamestown settlers who used the plant in hemp production; hemp cultivation remained a prominent industry until the mid-1800s (Deitch 2003). During the census of 1850, the United States recorded more than 8,000 cannabis plantations of at least 2,000 acres (Cannabis Campaigners Guide 2011). Throughout this period, marijuana was commonly used by physicians and pharmacists to treat a broad spectrum of ailments (Pacula et al. 2002). From 1850 to 1942, marijuana was included in the *United States Pharmacopoeia,* the official list of recognized medicinal drugs (Bilz 1992).

In 1913, California passed the first marijuana prohibition law aimed at recreational use (Gieringer 1999); by 1936, the remaining 47 states had followed suit (Eddy 2010). In 1937, the Marihuana Tax Act (Pub. L. No. 75-238, ch. 553, 50 Stat. 551 [1937]) effectively discontinued the use of marijuana for medicinal purposes (Bilz 1992), and marijuana was classified as a Schedule I drug in 1970.[2] According to the Controlled Substances Act, a Schedule I drug must have a "high potential for abuse" and "no currently accepted medical use in treatment in the United States" (Eddy 2010, p. 3).

In 1996, California passed the Compassionate Use Act, which removed criminal penalties for using, possessing, and cultivating medical marijuana. It also provided immunity from prosecution to physicians who recommended the use of medical marijuana to their patients. Before 1996, a number of states allowed doctors to prescribe marijuana, but this had little practical effect because of

[2] The Marihuana Tax Act imposed a registration tax and required extensive record keeping and thus increased the cost of prescribing marijuana as compared to other drugs (Bilz 1992).

Table 1
Medical Marijuana Laws, 1990–2010

State	Effective Date
Alaska	March 4, 1999
California	November 6, 1996
Colorado	June 1, 2001
District of Columbia	July 27, 2010
Hawaii	December 28, 2000
Maine	December 22, 1999
Michigan	December 4, 2008
Montana	November 2, 2004
Nevada	October 1, 2001
New Jersey	October 1, 2010
New Mexico	July 1, 2007
Oregon	December 3, 1998
Rhode Island	January 3, 2006
Vermont	July 1, 2004
Washington	November 3, 1998

Note. Arizona, Connecticut, Delaware, Maryland, and Massachusetts legalized medical marijuana after 2010.

federal restrictions.[3] Since 1996, 18 other states and the District of Columbia have joined California in legalizing the use of medical marijuana (Table 1), although it is still classified as a Schedule I drug by the federal government.[4]

2.2. Studies on Substance Use and Driving

Laboratory studies have shown that cannabis use impairs driving-related functions such as distance perception, reaction time, and hand-eye coordination (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009). However, neither simulator nor driving-course studies provide consistent evidence that these impairments to driving-related functions lead to an increased risk of collision (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009), perhaps because drivers under the influence of tetrahydrocannabinol (THC), the primary psychoactive substance in marijuana, engage in compensatory behaviors such as reducing their velocity, avoiding risky maneuvers, and increasing their following distances (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009).

Like marijuana, alcohol impairs driving-related functions such as reaction time and hand-eye coordination (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009). Moreover, simulator and driving-course studies provide une-

[3] Federal regulations prohibit doctors from writing prescriptions for marijuana. In addition, even if a doctor were to illegally prescribe marijuana, it would be against federal law for pharmacies to distribute it. Doctors in states that have legalized medical marijuana avoid violating federal law by recommending marijuana to their patients rather than prescribing its use.

[4] Information on when medical marijuana laws (MMLs) were passed was obtained from a Congressional Research Services Report by Eddy (2010). Although the New Jersey medical marijuana law went into effect on October 1, 2010, implementation has been delayed (Brittain 2012). Coding New Jersey as a state without medical marijuana in 2010 has no appreciable impact on our results.

quivocal evidence that alcohol consumption leads to an increased risk of collision (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009). Even at low doses, drivers under the influence of alcohol tend to underestimate the degree to which they are impaired (MacDonald et al. 2008; Marczinski, Harrison, and Fillmore 2008; Robbe and O'Hanlon 1993; Sewell, Poling, and Sofuoglu 2009), drive at faster speeds, and take more risks (Burian, Liguori, and Robinson 2002; Ronen et al. 2008; Sewell, Poling, and Sofuoglu 2009). When used in conjunction with marijuana, alcohol appears to have an "additive or even multiplicative" effect on driving-related functions (Sewell, Poling, and Sofuoglu 2009, p. 186), although chronic marijuana users may be less impaired by alcohol than infrequent users (Jones and Stone 1970; Marks and MacAvoy 1989; Wright and Terry 2002).[5]

2.3. The Relationship between Marijuana and Alcohol

Although THC has not been linked to an increased risk of collision in simulator and driving-course studies, MMLs could impact traffic fatalities through the consumption of alcohol. While a number of studies have found evidence of complementarity between marijuana and alcohol (Pacula 1998; Farrelly et al. 1999; Williams et al. 2004), others lend support to the hypothesis that marijuana and alcohol are substitutes. For instance, Chaloupka and Laixuthai (1997) and Saffer and Chaloupka (1999) found that marijuana decriminalization led to decreased alcohol consumption, while DiNardo and Lemieux (2001) found that increases in the minimum legal drinking age were positively associated with the use of marijuana.

Two recent studies used a regression discontinuity approach to examine the effect of the minimum legal drinking age on marijuana use but came to different conclusions. Crost and Guerrero (2012) analyzed data from the National Survey on Drug Use and Health (NSDUH). They found that marijuana use decreased sharply at 21 years of age, evidence consistent with substitutability between alcohol and marijuana. In contrast, Yörük and Yörük (2011), who drew on data from the National Longitudinal Survey of Youth 1997 (NLSY97), concluded that alcohol and marijuana were complements. However, these authors appear to have inadvertently conditioned on having used marijuana at least once since the last interview. When Crost and Rees (2013) applied Yörük and Yörük's (2011) research design to the NLSY97 data without conditioning on having used marijuana since the last interview, they found no evidence that alcohol and marijuana were complements.

[5] A large body of research in epidemiology attempts to assess the effects of substance use on the basis of observed tetrahydrocannabinol and alcohol levels in the blood of drivers who have been in accidents. For marijuana, the results have been mixed, while the likelihood of an accident occurring clearly increases with blood alcohol concentration (BAC) levels (Sewell, Poling, and Sofuoglu 2009).

3. Medical Marijuana Laws and the Marijuana Market

Medical marijuana laws should, in theory, increase both the supply of marijuana and the demand for marijuana, unambiguously leading to an increase in consumption (Pacula et al. 2010). They afford suppliers some protection against prosecution and allow patients to buy medical marijuana without fear of being arrested or fined, which lowers the full cost of obtaining marijuana.[6] Because it is prohibitively expensive for the government to ensure that all medicinal marijuana ends up in the hands of registered patients (especially in states that permit home cultivation), diversion to nonpatients almost certainly occurs.[7]

The NSDUH is the best source of information on marijuana consumption by adults living in the United States. However, the NSDUH does not provide individual-level data with state identifiers to researchers and did not publish state-level estimates of marijuana use prior to 1999.[8] Because five states (including California, Oregon, and Washington) legalized medical marijuana during the period 1996–99, we turn to back issues of *High Times* magazine in order to gauge the impact of legalization on the marijuana market. Begun in 1975, *High Times* is published monthly and covers topics ranging from marijuana cultivation to politics. Each issue also contains a section entitled "Trans High Market Quotations" in which readers provide marijuana prices from across the country. In addition to price, a typical entry includes information about where the marijuana was purchased, its strain, and its quality.

We collected price information from *High Times* for the period 1990–2011. Jacobson (2004), who collected information on the price of marijuana from *High*

[6] The majority of MMLs allow patients to register on the basis of medical conditions that cannot be objectively confirmed (for example, chronic pain and nausea). In fact, chronic pain is the most common medical condition among patients seeking treatment (see Table A1). According to recent Arizona registry data, only seven of 11,186 applications for medical marijuana have been denied approval. Sun (2010) described "quick-in, quick-out mills," where physicians provide recommendations for a nominal fee. Cochran (2010) reported on doctors providing medical marijuana recommendations to patients via brief Web interviews on Skype.

[7] Aside from Washington, D.C., and New Jersey, all MMLs enacted during the period 1990–2010 allowed for home cultivation, and eight of 15 allowed patients or caregivers to cultivate collectively (see Table A2). A recent investigation concluded that thousands of pounds of medical marijuana grown in Colorado are diverted annually to the recreational market (Wirfs-Brock, Seaton, and Sutherland 2010). Thurstone, Lieberman, and Schmiege (2011) interviewed 80 adolescents (15–19 years of age) undergoing outpatient substance abuse treatment in Denver. Thirty-nine of the 80 reported having obtained marijuana from someone with a medical marijuana license. Florio (2011) described the story of four eighth graders in Montana who received marijuana-laced cookies from a registered medical marijuana patient.

[8] Using these estimates, Wall et al. (2011, p. 714) found that rates of marijuana use among 12–17-year-olds were higher in states that had legalized medical marijuana than in states that had not, but they noted that "in the years prior to MML passage, there was already a higher prevalence of use and lower perceptions of risk" in states that had legalized medical marijuana. Using NSDUH data for the years 2002–9, Harper, Strumpf, and Kaufman (2012) found that legalization was associated with a small reduction in the rate of marijuana use among 12–17-year-olds. Using data for the period 1995–2002 from Denver, Los Angeles, Portland, San Diego, and San Jose, Gorman and Huber (2007) found little evidence that marijuana consumption increased among adult arrestees as a result of legalization.

Table 2
Medical Marijuana Laws and the Price of High-Quality Marijuana, 1990–2011

	(1)	(2)	(3)	(4)	(5)
MML	−.304**	−.103+			
	(.037)	(.058)			
3 Years before MML					.022
					(.074)
2 Years before MML					.003
					(.075)
1 Year before MML					−.037
					(.076)
Year of law change			−.117+	−.059	−.060
			(.061)	(.069)	(.096)
1 Year after MML			−.156**	−.082	−.084
			(.044)	(.070)	(.097)
2 Years after MML			−.203**	−.110	−.113
			(.074)	(.082)	(.120)
3 Years after MML			−.211**	−.128	−.130
			(.062)	(.084)	(.118)
4 Years after MML			−.387**	−.283*	−.286*
			(.123)	(.115)	(.125)
5+ Years after MML			−.439**	−.257*	−.262+
			(.048)	(.116)	(.145)
R^2	.224	.310	.241	.315	.315
State-specific linear time trends	No	Yes	No	Yes	Yes

Note. The dependent variable is equal to the natural log of the median price of marijuana in state *s* and year *t*. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, and state covariates are included in all specifications. MML = medical marijuana law. N = 920.
+ Statistically significant at the 10% level.
* Statistically significant at the 5% level.
** Statistically significant at the 1% level.

Times for the period 1975–2000, distinguished between high-quality (a category that included Californian and Hawaiian sinsemilla) and low-quality (a category that included commercial grade Colombian and Mexican weed) marijuana.[9] Following Jacobson (2004), we classified marijuana purchases by quality and calculated the median per-ounce price by state and year.[10] Table 2 presents

[9] The plant variety (that is, strain), which part of the plant is used, the method of storage, and cultivation techniques are all important determinants of quality and potency (McLaren et al. 2008). In recent decades, there has been a marked trend toward indoor cultivation and higher potency in the United States (McLaren et al. 2008). Jacobson (2004) argued that, ideally, prices would be deflated by a measure of potency. Unfortunately, information on potency is not available in the *High Times* data.

[10] A total of 8,271 purchases were coded. Of these, 7,029 were classified as high quality and 1,242 were classified as low quality. Prior to 2004, information on the seller was occasionally included in the "Trans High Market Quotations" section of *High Times*. Although dispensaries were never mentioned, they are a relatively recent phenomenon. The number of dispensaries in California expanded rapidly after 2004 (Jacobson et al. 2011), and the number of dispensaries in Colorado and Montana expanded rapidly after 2008 (Smith 2011, 2012). We compared *High Times* price data for 2011–12 with price data posted on the Internet by 84 dispensaries located in seven states. In four states (California, Michigan, Nevada, and Washington), the prices charged by dispensaries were statistically

estimates of the following equation:

$$\ln(\text{Price of high-quality marijuana}_{st}) = \beta_0 + \beta_1\text{MML}_{st} + \boldsymbol{X}_{st}\beta_2 + \nu_s + w_t + \varepsilon_{st}, \quad (1)$$

where s indexes states and t indexes years. The variable MML_{st} indicates whether medical marijuana was legal in state s and year t, and β_1 represents the estimated relationship between legalization and the per ounce price of high-quality marijuana. The vector $\boldsymbol{X}_{st}$ includes controls for the mean age in state s and year t, the unemployment rate, per capita income, whether the state had a marijuana decriminalization law in place, and the beer tax. State fixed effects, represented by ν_s, control for time-invariant unobservable factors at the state level; year fixed effects, represented by w_t, control for common shocks to the price of high-quality marijuana.[11]

The baseline estimate suggests that the supply response to legalization is larger than the demand response. In particular, legalization is associated with a 26.2 percent ($e^{-.304} - 1 = -.262$) decrease in the price of high-quality marijuana. When we include state-specific linear time trends, intended to control for omitted variables at the state level that evolve at a constant rate, legalization is associated with a 9.8 percent decrease in the price of high-quality marijuana.

Lagging the MML indicator provides evidence that the effect of legalization on the price of high-quality marijuana is not immediate. Controlling for state-specific linear time trends, we see that the estimated coefficients of the MML indicator lagged 1–3 years are negative but not statistically significant. There is

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indistinguishable from the prices provided by *High Times* readers. In Arizona, Colorado, and Oregon, the prices charged by dispensaries were significantly lower than the prices provided by *High Times* readers; however, these differences were generally not large in magnitude. The greatest difference was in Colorado, where dispensaries, on average, charged 24.4 percent less per ounce ($72.80) than the prices provided by *High Times* readers. In Arizona, dispensaries, on average, charged 10.3 percent less per ounce ($36.60) than the prices provided by *High Times* readers; in Oregon, dispensaries, on average, charged 14.9 percent less per ounce ($37.20) than the prices provided by *High Times* readers (for dispensary price data, see WeedMaps.com, Dispensaries [http://www.legalmarijuanadispensary.com]).

[11] Standard errors are corrected for clustering at the state level (Bertrand, Duflo, and Mullainathan 2004). Descriptive statistics are presented in Table A3. The mean age in state s and year t was calculated using census data. The data on beer taxes are from *Brewers Almanac* (Beer Institute 1990–2010). The unemployment and income data are from the Bureau of Labor Statistics and the Bureau of Economic Analysis, respectively. The data on decriminalization laws are from Model (1993) and Scott (2010). During the period under study, the decriminalization indicator captures only two policy changes: Nevada and Massachusetts decriminalized the use of marijuana in 2001 and 2010, respectively. The majority of decriminalization laws were passed prior to 1990. Following Jacobson's approach (2004), the estimates presented in Tables 2 and 3 are unweighted. When the regressions are weighted by the number of observations used to calculate the median price and state-specific linear time trends are included on the right-hand side, estimates of the relationship between legalization and price are smaller and less precise than those reported in Tables 2 and 3. Nevertheless, they continue to show that legalization is associated with a statistically significant reduction in the price of high-quality marijuana after 4 years. When the regressions are weighted by the number of observations used to calculate the median price but state-specific linear time trends are not included on the right-hand side, estimates of the relationship between legalization and price are similar to those reported in Tables 2 and 3.

Table 3

Medical Marijuana Laws and the Price of Low-Quality Marijuana, 1990–2011

	(1)	(2)	(3)	(4)	(5)
MML	−.096	−.075			
	(.105)	(.150)			
3 Years before MML					.135
					(.197)
2 Years before MML					.103
					(.108)
1 Year before MML					−.088
					(.200)
Year of law change			−.035	−.056	−.013
			(.154)	(.193)	(.196)
1 Year after MML			−.250+	−.182	−.106
			(.146)	(.176)	(.136)
2 Years after MML			−.058	−.016	.053
			(.176)	(.190)	(.166)
3 Years after MML			−.244*	−.114	−.028
			(.098)	(.141)	(.138)
4 Years after MML			.032	.046	.131
			(.403)	(.373)	(.429)
5+ Years after MML			−.038	.271	.370
			(.073)	(.335)	(.267)
R^2	.720	.748	.723	.751	.753
State-specific linear time trends	No	Yes	No	Yes	Yes

Note. The dependent variable is equal to the natural log of the median price of marijuana in state *s* and year *t*. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, and state covariates are included in all specifications. MML = medical marijuana law. N = 483.

+ Statistically significant at the 10% level.

* Statistically significant at the 5% level.

a statistically significant 24.6 percent reduction in the price of high-quality marijuana in the fourth full year after legalization. This pattern of results is consistent with state registry data from Colorado, Montana, and Rhode Island showing that patient numbers increased slowly in the years immediately after legalization.[12] Adding leads to the model with state-specific linear time trends produces no evidence that legalization was systematically preceded by changes in tastes or policies related to the market for high-quality marijuana.

Estimates of the relationship between legalization and the price of low-quality marijuana are presented in Table 3. The majority of these estimates are negative. However, with two exceptions, they are statistically insignificant. Given that much of the medicinal crop is grown indoors under ultraviolet lights and that high-

[12] Table A1 presents registry information by state. Montana legalized medical marijuana in November 2004. Two years later, only 287 patients were registered; 7 years later, 30,036 patients were registered. The number of registered patients in Colorado increased from 5,051 in January 2009 to 128,698 in June 2011. Patient numbers also appear to be growing rapidly in Arizona, which passed the Arizona Medical Marijuana Act on November 2, 2010. A total of 11,133 patient applications had been approved as of August 29, 2011; 40,463 patient applications had been approved by June 30, 2012.

potency and high-quality strains such as Northern Lights and Super Silver Haze are favored by medical marijuana cultivators, this imprecision is not surprising.

4. Medical Marijuana Laws and Traffic Fatalities

The estimates discussed above suggest that legalization leads to a substantial decrease in the price of high-quality marijuana and, presumably, a correspondingly large increase in consumption.[13] In this section, we test whether the impact of legalization extends to traffic fatalities.

4.1. Data on Traffic Fatalities

We use data from FARS for the period 1990–2010 to examine the relationship between MMLs and traffic fatalities. These data are collected by the National Highway Traffic Safety Administration and represent an annual census of all fatal injuries suffered in motor vehicle accidents in the United States. Information on the circumstances of each crash and the persons and vehicles involved is obtained from a variety of sources, including police crash reports, driver licensing files, vehicle registration files, state highway department data, emergency medical services records, medical examiners' reports, toxicology reports, and death certificates.

Table 4 presents descriptive statistics and definitions for our outcome measures. The variable Fatalities Total_{st} is equal to the number of traffic fatalities per 100,000 people of state *s* in year *t*.[14] The variables Fatalities $(\text{BAC} > 0)_{st}$ and Fatalities $(\text{BAC} \geq .10)_{st}$ allow us to examine the effects of legalization by alcohol involvement. The variable Fatalities $(\text{BAC} > 0)_{st}$ is equal to the number of traffic fatalities per 100,000 people resulting from accidents in which at least one driver had a positive blood alcohol concentration (BAC). The variable Fatalities $(\text{BAC} \geq .10)_{st}$ is defined analogously, but at least one driver had to have a BAC greater than or equal to .10. The variable Fatalities $(\text{No Alcohol})_{st}$ is equal to the number of fatalities per 100,000 people in which alcohol involvement was not reported.[15]

[13] If we assume, conservatively, that legalization has a negligible impact on demand, then the change in marijuana consumption is equal to the elasticity of demand multiplied by the percentage change in price. Only a handful of researchers have estimated the price elasticity of demand for marijuana. Using data on University of California, Los Angeles, undergraduates, Nisbet and Vakil (1972) estimated a price elasticity of demand between −1.01 and −1.51; using data from Monitoring the Future on high school seniors, Pacula et al. (2001) estimated a 30-day participation elasticity between −.002 and −.69; using data from the Harvard College Alcohol Study, Williams et al. (2004) estimated a 30-day participation elasticity of −.24.

[14] For population data, see National Cancer Institute, US Population Data—1969–2011 (http://seer.cancer.gov/popdata/index.html). According to Eisenberg (2003), traffic fatalities in the Fatality Analysis Reporting System (FARS) are measured with little to no error. We experimented with scaling traffic fatalities by the population of licensed drivers and by the number of miles driven in state *s* and year *t* rather than by the state population. These estimates, which are similar in terms of magnitude and precision to those presented here, are available on request.

[15] The numerator for Fatalities $(\text{No Alcohol})_{st}$ was determined from two sources in FARS. First, either all drivers involved had to have registered a BAC of zero or, if BAC information was missing, the police had to report that alcohol was not involved.

Table 4

Dependent Variables for the Fatality Analysis Reporting System Analysis

Dependent Variable	Mean	Description
Fatalities Total	14.58 (5.05)	Fatalities per 100,000 people
Fatalities (No Alcohol)	9.67 (3.45)	Fatalities per 100,000 people with no indication of alcohol involvement
Fatalities (BAC > 0)	3.97 (1.74)	Fatalities per 100,000 people for which at least one driver involved had a blood alcohol concentration (BAC) > .00
Fatalities (BAC ≥ .10)	3.13 (1.43)	Fatalities per 100,000 people for which at least one driver involved had a BAC > .10
Fatalities, 15–19	24.55 (9.75)	Fatalities per 100,000 people 15–19 years of age
Fatalities, 20–29	23.59 (8.41)	Fatalities per 100,000 people 20–29 years of age
Fatalities, 30–39	15.45 (6.49)	Fatalities per 100,000 people 30–39 years of age
Fatalities, 40–49	14.00 (5.63)	Fatalities per 100,000 people 40–49 years of age
Fatalities, 50–59	13.22 (4.93)	Fatalities per 100,000 people 50–59 years of age
Fatalities, 60+	17.39 (5.28)	Fatalities per 100,000 people 60 years old and above
Fatalities Males	20.48 (7.15)	Fatalities per 100,000 males
Fatalities Females	9.03 (3.29)	Fatalities per 100,000 females
Fatalities Weekdays	8.32 (2.88)	Fatalities per 100,000 people on weekdays
Fatalities Weekends	6.22 (2.25)	Fatalities per 100,000 people on weekends
Fatalities Daytime	7.04 (2.59)	Fatalities per 100,000 people during the day
Fatalities Nighttime	7.42 (2.60)	Fatalities per 100,000 people during the night

Note. The data are weighted means based on the Fatality Analysis Reporting System state-level panel for 1990–2010. Standard deviations are in parentheses.

Alcohol involvement is likely measured with error (Eisenberg 2003), and the possibility exists that some states collected information on BAC levels more diligently than others.[16] Focusing on nighttime and weekend fatal crashes can provide additional insight into the role of alcohol and help address the measurement error issue. As noted by Dee (1999), a substantial proportion of fatal crashes on weekends and at night involve alcohol.

As of 2011, 75 percent of the patients on the Arizona medical marijuana registry were male; 69 percent of the patients on the Colorado registry were male. There is also evidence that many medical marijuana patients are below the age of 40. Forty-eight percent of registered patients in Montana and 42 percent of registered patients in Arizona were between the ages of 18 and 40; the average age of registered patients in Colorado was 40.[17] To the extent that registered patients below the age of 40 are more likely to use medical marijuana recreationally, heterogeneous effects across the age distribution might be expected.

Figures 1–3 compare pre- and postlegalization traffic fatality trends by age

[16] We also experimented with calculating the alcohol-related fatality rates with the imputed BAC levels available in the FARS data. These estimates, which are similar in terms of magnitude and precision to those presented here, are available on request. See Adams, Blackburn, and Cotti (2012) for a discussion of the BAC imputation method.

[17] For links to state registry data, see NORML, Medical Marijuana (http://norml.org/index.cfm?Group_ID = 3391).

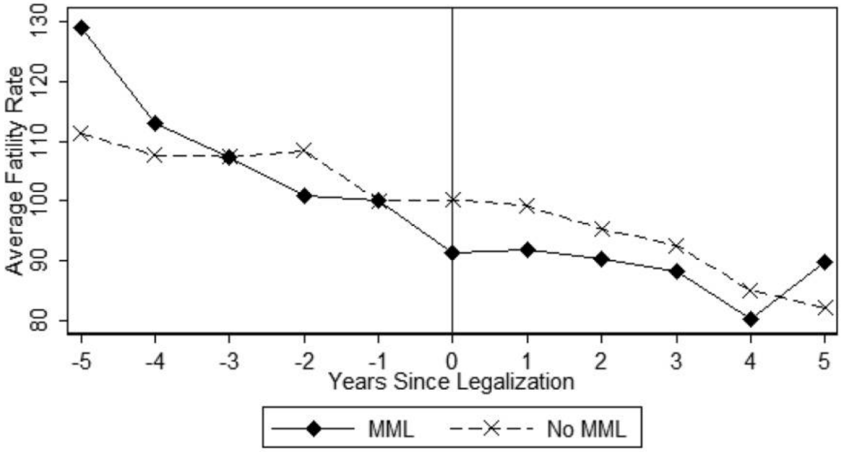

Figure 1. Pre- and postlegalization trends in traffic fatality rates, ages 15–19

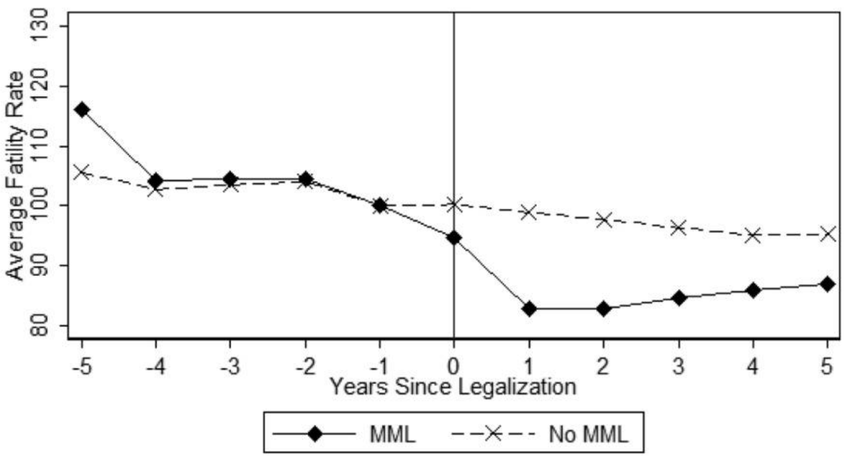

Figure 2. Pre- and postlegalization trends in traffic fatality rates, ages 20–39

group.[18] In each figure, the solid line represents the average traffic fatality rate for the treated states (those that legalized medical marijuana). The dashed line represents the average fatality rate for the control states (those that did not legalize medical marijuana). Year 0 on the horizontal axis represents the year in which legalization took place. Control states were randomly assigned a year of legalization between 1996 and 2010.

[18] Figures 1–3 are based on FARS data for the period 1990–2010. Fatality rates are expressed relative to year −1 and are weighted by the relevant population in state *s* and year *t*.

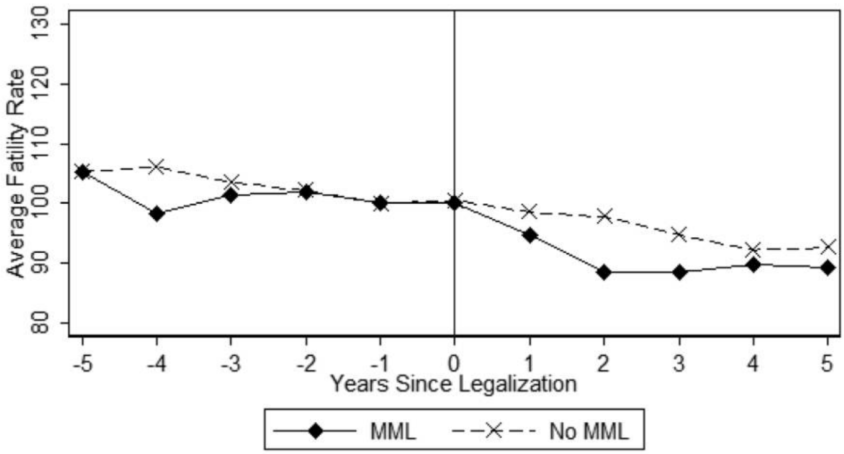

Figure 3. Pre- and postlegalization trends in traffic fatality rates, ages 40 and older

Among teenagers (ages 15–19), young adults (ages 20–39), and older adults (ages 40 and above), average traffic fatality rates in the treated states closely follow those in the control states through year −1. This finding is important because it suggests that legalization was not preceded by, for instance, new anti-drunk-driving policies, increased spending on law enforcement, or highway improvements. In the years immediately after legalization, average traffic fatality rates in MML states fall faster than average traffic fatality rates in the control states. This divergence is most pronounced among those 20–39. Among teenagers and older adults, average traffic fatality rates in the MML states converge with average traffic fatality rates in the control states 4–5 years after legalization.

4.2. The Empirical Model

To further explore the relationship between legalization and traffic fatalities, we estimate the following baseline equation:

$$\ln(\text{Fatalities Total}_{st}) = \beta_0 + \beta_1 \text{MML}_{st} + \boldsymbol{X}_{st}\beta_2 + v_s + w_t + \varepsilon_{st}, \tag{2}$$

where *s* indexes states and *t* indexes years. The coefficient of interest, β_1, represents the effect of legalizing medical marijuana.[19] In alternative specifications, we replace Fatalities Total_{st} with the remaining outcomes listed in Table 4.

The vector $\boldsymbol{X}_{st}$ is composed of the controls described in Table 5, and v_s and w_t are state and year fixed effects, respectively. Previous studies provide evidence that a variety of state-level policies can impact traffic fatalities. For instance, graduated driver-licensing regulations and stricter seat belt laws are associated

[19] This specification is based on Dee (2001), who examined the relationship between .08 BAC laws (making it illegal for drivers to have a BAC of .08 percent or higher) and traffic fatalities.

Table 5

Independent Variables for the Fatality Analysis Reporting System Analysis

Independent Variable	Mean	Description
MML[a]	.130 (.334)	Equals one if a state had a medical marijuana law in a given year and zero otherwise
Mean Age	35.90 (1.66)	Mean age of the state population
Unemployment	5.87 (1.87)	State unemployment rate
Income	10.27 (.156)	Natural logarithm of state real income per capita (2000 $)
Miles Driven	14.13 (2.05)	Vehicle miles driven per licensed driver (thousands of miles)
Decriminalized[a]	.330 (.470)	Equals one if a state had a marijuana decriminalization law in a given year and zero otherwise
Drug Per Se	.142 (.345)	Equals one if a state had a drug per se law in a given year and zero otherwise
GDL[a]	.522 (.493)	Equals one if a state had a graduated driver-licensing law with an intermediate phase in a given year and zero otherwise
Primary Seat Belt[a]	.461 (.494)	Equals one if a state had a primary seat belt law in a given year and zero otherwise
Secondary Seat Belt[a]	.518 (.494)	Equals one if a state had a secondary seat belt law in a given year and zero otherwise
BAC .08[a]	.584 (.485)	Equals one if a state had a .08 BAC law in a given year and zero otherwise
ALR[a]	.721 (.445)	Equals one if a state had an administrative license revocation law in a given year and zero otherwise
Zero Tolerance[a]	.763 (.417)	Equals one if a state had a zero-tolerance drunk-driving law in a given year and zero otherwise
Beer Tax	.245 (.207)	Real beer tax (2000 $)
Speed 70	.462 (.499)	Equals one if a state had a speed limit of 70 mph or greater in a given year and zero otherwise
Texting Ban	.041 (.185)	Equals one if a state had a cell phone texting ban in a given year and zero otherwise
Hands Free	.025 (.150)	Equals one if a state had a hands-free cell phone law in a given year and zero otherwise

Note. The data are weighted means using state populations based on the Fatality Analysis Reporting System state-level panel for 1990–2010. Standard deviations are in parentheses.

[a] Takes on fractional values for the years in which laws changed.

with fewer traffic fatalities (Cohen and Einav 2003; Dee, Grabowski, and Morrisey 2005; Freeman 2007; Carpenter and Stehr 2008). Other studies have examined the effects of speed limits (Ledolter and Chan 1996; Farmer, Retting, and Lund 1999; Greenstone 2002; Dee and Sela 2003), administrative license revocation laws (Freeman 2007), BAC laws (Dee 2001; Eisenberg 2003; Young and Bielinska-Kwapisz 2006; Freeman 2007), zero-tolerance laws (Carpenter 2004; Liang and Huang 2008; Grant 2010), and cell phone bans (Kolko 2009). The relationship between beer taxes and traffic fatalities has also received attention from economists (Chaloupka, Saffer, and Grossman 1991; Ruhm 1996; Dee 1999; Young and Likens 2000; Young and Bielinska-Kwapisz 2006).[20] In addition to these policies, we include the mean age in state *s* and year *t*, the unemployment rate, real per capita income, vehicle miles driven per licensed driver, and indicators for marijuana decriminalization and whether a drug per se law was in place.[21]

4.3. *The Relationship between Medical Marijuana Laws and Traffic Fatalities*

Table 6 presents ordinary least squares (OLS) estimates of the relationship between MMLs and traffic fatalities. The regressions are weighted by the population of state *s* in year *t*, and the standard errors are corrected for clustering at the state level (Bertrand, Duflo, and Mullainathan 2004). The baseline estimate suggests that legalization leads to a 10.4 percent decrease in the fatality rate.[22] When we include state-specific linear time trends, the estimate of β_1 retains its magnitude but is no longer statistically significant at conventional levels ($p =$ .139).

In columns 3–5, we lag the MML indicator. The MML lags are jointly significant and are, without exception, negative. However, there is evidence that the impact of legalization eventually wanes. The first full year after coming into effect, legalization is associated with an 8–11 percent reduction in the fatality

[20] For information on graduated driver licensing laws and seat belt requirements, see Dee, Grabowski, and Morrisey (2005), Cohen and Einav (2003), and Insurance Institute for Highway Safety, Laws and Regulations (http://www.iihs.org/laws.default.aspx). For information on administrative license revocation laws and BAC limits, see Freeman (2007). The FARS accident files were used to construct the variable Speed 70. Data on beer taxes are from *Brewers Almanac* (Beer Institute 1990–2010). For data on whether texting while driving was banned and whether using a handheld cell phone while driving was banned, see HandsFreeInfo.com, Cell Phone Laws, Legislation by State (http://www.handsfreeinfo.com/index-cell-phone-laws-legislation-by-state).

[21] The mean age in state *s* and year *t* was calculated using U.S. census data. Information on vehicle miles driven per licensed driver is from *Highway Statistics* (U.S. Department of Transportation 1990–2010). We recognize that legalization of medical marijuana could have a direct impact on miles driven but follow previous research on traffic fatalities by including it as a control variable (Dills 2010; Eisenberg 2003; Young and Likens 2000). The unemployment and income data are from the Bureau of Labor Statistics and the Bureau of Economic Analysis, respectively. The data on decriminalization laws are from Model (1993) and Scott (2010). The data on drug per se laws, which prohibit the operation of a motor vehicle with drugs (or drug metabolites) in the system, are from the National Highway Traffic Safety Administration (2010).

[22] Controlling for economic conditions and policies (such as whether a primary seat belt law was in effect or whether a state had a .08 BAC law) has only a small impact on our estimate of β_1. In fact, when the covariates listed in Table 5 are excluded from the regression, the estimated coefficient reported in column 1 of Table 6 changes from −.110 to −.118.

Table 6

Medical Marijuana Laws and Total Traffic Fatalities, 1990–2010

	(1)	(2)	(3)	(4)	(5)
MML	−.110**	−.098			
	(.030)	(.065)			
3 Years before MML					−.004
					(.018)
2 Years before MML					−.001
					(.030)
1 Year before MML					−.008
					(.024)
Year of law change			−.049*	−.026	−.029
			(.023)	(.029)	(.028)
1 Year after MML			−.115**	−.087+	−.090+
			(.036)	(.051)	(.048)
2 Years after MML			−.125*	−.095	−.099
			(.059)	(.080)	(.074)
3 Years after MML			−.137**	−.107	−.111+
			(.051)	(.071)	(.065)
4 Years after MML			−.138**	−.108+	−.112+
			(.038)	(.063)	(.058)
5+ Years after MML			−.102**	−.042	−.047
			(.026)	(.062)	(.059)
Joint significance of lags (*p*-value)			.000**	.089+	.060+
R^2	.969	.979	.969	.979	.979
State-specific linear time trends	No	Yes	No	Yes	Yes

Note. The dependent variable is equal to the natural log of the total fatalities per 100,000 people. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, and state covariates are included in all specifications. MML = medical marijuana law. N = 1,071.

+ Statistically significant at the 10% level.

* Statistically significant at the 5% level.

** Statistically significant at the 1% level.

rate.[23] The estimated coefficients increase in absolute magnitude until the fourth full year after legalization, when there is a 10–13 percent reduction in the fatality rate. After 5 years, the reduction is between 4 and 10 percent and is significant

[23] In comparison, Dee (1999) found that increasing the minimum legal drinking age (MLDA) to 21 reduced traffic fatalities by at least 9 percent among 18–20-year-olds. Kaestner and Yarnoff (2011) analyzed the long-term effects of MLDA laws. They found that raising the MLDA to 21 was associated with a 10 percent reduction in traffic fatalities among adult males. Carpenter and Stehr (2008) found that mandatory seat belt laws decreased traffic fatalities among 14–18-year-olds by approximately 8 percent; Dee, Grabowski, and Morrisey (2005) found that graduated driver licensing laws decreased traffic fatalities among 15–17-year-olds by nearly 6 percent. Because all states raised their MLDA to 21 prior to 1990, we do not include it as a control. However, our estimates suggest that mandatory seat belt laws decrease traffic fatalities among 15–19-year-olds by approximately 11 percent, and graduated driver-licensing laws decrease traffic fatalities among 15–19-year-olds by approximately 6 percent. While the estimated relationship between .08 BAC laws and traffic fatalities is generally negative and often large, it is never statistically significant at conventional levels. This is consistent with the results of Young and Bielinska-Kwapisz (2006) and Freeman (2007), who found little evidence that .08 BAC laws reduced traffic fatalities. Finally, consistent with the results of Grant (2010), we find little evidence that zero-tolerance laws reduce traffic fatalities.

Table 7
Medical Marijuana Laws and Traffic Fatalities: The Role of Alcohol

	Fatalities (No Alcohol)		Fatalities (BAC > 0)		Fatalities (BAC ≥ .10)	
	(1)	(2)	(3)	(4)	(5)	(6)
MML	−.075		−.141^{+}		−.168*	
	(.062)		(.077)		(.082)	
Year of law change		−.026		−.011		−.041
		(.031)		(.040)		(.051)
1 Year after MML		−.071		−.103		−.124
		(.047)		(.068)		(.086)
2 Years after MML		−.085		−.091		−.117
		(.079)		(.083)		(.081)
3 Years after MML		−.065		−.237**		−.292**
		(.077)		(.083)		(.100)
4 Years after MML		−.076		−.223*		−.256*
		(.063)		(.092)		(.105)
5+ Years after MML		−.024		−.138^{+}		−.197*
		(.062)		(.081)		(.090)
Joint significance of lags (*p*-value)		.244		.002**		.082^{+}
R^2	.964	.964	.905	.906	.906	.906

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. MML = medical marijuana law. N = 1,071.
$^{+}$ Statistically significant at the 10% level.
* Statistically significant at the 5% level.
** Statistically significant at the 1% level.

only when the state-specific linear time trends are omitted. In column 5 of Table 6, we add a series of leads to the model. Consistent with the evidence in Figures 1–3, the estimated coefficients are small and jointly insignificant.

In Table 7, we replace Fatalities Total_{st} with Fatalities $(\text{No Alcohol})_{st}$, Fatalities $(\text{BAC} > 0)_{st}$, and Fatalities $(\text{BAC} \geq .10)_{st}$. The results suggest that MMLs are related to traffic fatalities through the consumption of alcohol. The estimate of β_1 is negative when fatalities not involving alcohol are considered, but it is relatively small and statistically indistinguishable from zero. In contrast, the legalization of medical marijuana is associated with a 13.2 percent decrease in fatalities involving alcohol and a 15.5 percent decrease in fatalities resulting from accidents in which at least one driver had a BAC over .10. Lagging the MML indicator produces a similar pattern of results: the MML lags jointly predict crashes involving alcohol but are insignificant in the Fatalities $(\text{No Alcohol})_{st}$ equation.[24]

[24] When we restrict our attention to crashes in which at least one driver had a BAC greater than zero, legalization is associated with a (statistically insignificant) 11.6 percent decrease in fatalities among drunk drivers (BAC > 0) and their passengers. This estimate is similar in magnitude to the estimate in column 3 of Table 7. Nonetheless, we find evidence of third-party effects: legalization is associated with a 23.4 percent reduction in fatalities among sober drivers and their passengers and a 19.9 percent reduction in fatalities among pedestrians, cyclists, and individuals in other types of nonmotorized vehicles.

Table 8

Medical Marijuana Laws and Traffic Fatalities by Day and Time

	Fatalities Weekdays	Fatalities Weekends	Fatalities Daytime	Fatalities Nighttime
MML	−.083	−.115+	−.076	−.117+
	(.069)	(.061)	(.066)	(.069)
R^2	.970	.961	.968	.966

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.

+ Statistically significant at the 10% level.

Table 8 shows the relationship between MMLs and traffic fatalities by day of the week. Legalization is associated with an 8.0 percent decrease in the weekday traffic fatality rate; in comparison, it is associated with a 10.9 percent decrease in traffic fatalities occurring on the weekend, when the consumption of alcohol rises (Haines et al. 2003). The former estimate is not significant at conventional levels, while the latter is significant at the 10 percent level.[25]

Table 8 also shows the relationship between MMLs and traffic fatalities by time of day. Legalization is associated with a 7.3 percent decrease in the daytime traffic fatality rate; in comparison, it is associated with an 11.0 percent decrease in traffic fatalities occurring at night, when fatal crashes are more likely to involve alcohol (Dee 1999). The former estimate is not significant at conventional levels, while the latter is significant at the 10 percent level.[26]

Table 9 presents estimates of the relationship between MMLs and traffic fatalities by age. Among 15–19-year-olds, the estimate of β_1 is negative but small in magnitude and statistically insignificant. However, legalization is associated with a 16.7 percent decrease in the fatality rate of 20–29-year-olds, and a 16.1 percent decrease in the fatality rate of 30–39-year-olds. Although registry data indicate that many medical marijuana patients are over the age of 40, estimates of β_1 are smaller and statistically insignificant among 40–49-year-olds, 50–59-year-olds, and individuals 60 and over.

Table 10 presents estimates of the relationship between MMLs and traffic fatalities by sex. They provide some evidence that MMLs have a greater impact on fatalities among males. In particular, legalization is associated with a 10.8 percent decrease in the male traffic fatality rate as compared with a 6.9 percent decrease in the female fatality rate. The former estimate is significant at the 10 percent level, while the latter is not significant at conventional levels.[27] This

[25] The hypothesis that these estimates are equal can be rejected at the 10 percent level.

[26] It should be noted, however, that we cannot formally reject the hypothesis that these estimates are equal.

[27] The hypothesis that these estimates are equal can be rejected at the 5 percent level. Tables A4 and A5 present estimates of β_1 by age and sex. The estimated effect of legalization on traffic fatalities is largest among males 20–29 years of age and females 30–39 years of age. There is evidence that legalization leads to reduced traffic fatalities among males over the age of 59.

Table 9
Medical Marijuana Laws and Traffic Fatalities by Age

	Fatalities, 15–19	Fatalities, 20–29	Fatalities, 30–39	Fatalities, 40–49	Fatalities, 50–59	Fatalities, 60+
MML	−.022	−.183*	−.175+	−.094	−.038	−.048
	(.083)	(.073)	(.096)	(.070)	(.056)	(.048)
R^2	.915	.940	.943	.939	.874	.921

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using the relevant state-by-age populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.
+ Statistically significant at the 10% level.
* Statistically significant at the 5% level.

pattern of results is consistent with registry data showing that the majority of medical marijuana patients are male.[28]

4.4. Tests of Endogeneity

Until this point in the analysis, we have employed a rich set of controls to address the possibility that legalization went hand in hand with other behaviors or policies related to traffic fatalities. Table 11 presents our attempts to tackle the endogeneity issue head on.

First, we ran a series of regressions in which a placebo MML was randomly assigned to each control state.[29] Because 14 states and the District of Columbia legalized medical marijuana during the period 1990–2010, we assigned 15 placebos per trial. The estimated coefficient of the placebo MML was negative and statistically significant at the 10 percent level only 10 times out of 300 trials.

Next, we estimated the relationship between MMLs and traffic fatalities in which either tire or wheel failure was cited as a potential cause of the crash. Although road improvements, increased spending on road maintenance, and increased commercial vehicle inspections could reduce tire or wheel failure, we found little evidence of a relationship between legalization and this outcome. In fact, the estimated coefficient of the MML indicator was positive.

We also examined the relationship between MMLs and three variables that could have influenced traffic fatalities: per capita police expenditures, per capita highway law enforcement expenditures, and per capita highway service and main-

[28] Roughly half of the states that have legalized medical marijuana permit collective cultivation, also known as group growing. However, Alaska, Hawaii, Maine, New Jersey, New Mexico, and Vermont limit caregivers to one patient, prohibit collective cultivation by caregivers, or prohibit home cultivation altogether (see Table A2). In these states, possession limits are easier to enforce, and illegal suppliers are easier to identify (Selecky 2008). Estimates (available on request) suggest that the relationship between legalization and traffic fatalities is strongest when collective cultivation is permitted. Although negative, the estimated effect of legalization on traffic fatalities is smaller and statistically insignificant among states that prohibit collective cultivation.

[29] This approach is similar to that of Luallen (2006), who examined the relationship between teacher strike days and juvenile crime. Assignment of the placebo MML was based on random numbers drawn from the uniform distribution.

Table 10
Medical Marijuana Laws and Traffic Fatalities by Sex

	Fatalities Males	Fatalities Females
MML	−.114+	−.072
	(.065)	(.073)
R^2	.974	.960

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using the relevant state-by-sex populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.
+ Statistically significant at the 10% level.

tenance expenditures.[30] Again, the results provided little evidence of policy endogeneity: the estimated coefficient of the MML indicator was small and insignificant in all three of these regressions.

Finally, we examined whether the policy variables included in the vector $\boldsymbol{X}_{st}$ predict the passage of MMLs. The results are reported in Table 12. In column 2, we focus on alcohol-related policies, such as the beer tax and whether a .08 BAC law (making it illegal for drivers to have a BAC of .08 percent or higher) was in effect. In column 3, we include marijuana decriminalization and drug per se laws, which prohibit the operation of a motor vehicle with drugs (or drug metabolites) in the system. Neither the alcohol- nor the drug-related policies predict the legalization of medical marijuana. However, when the full set of policy variables is included, we find evidence of a negative relationship between banning the use of handheld cell phones while driving and the probability of legalizing medical marijuana (column 4). This result raises the possibility that other, more difficult to measure policies affecting traffic fatalities may be related to legalization.

5. Medical Marijuana Laws and Alcohol Consumption

5.1. Evidence from the Behavioral Risk Factor Surveillance System

In this section, we use individual-level data from the BRFSS to examine the effects of MMLs on direct measures of alcohol consumption. Begun in 1984 and administered by state health departments in collaboration with the Centers for Disease Control and Prevention, the BRFSS is designed to measure behavioral risk factors for the adult population (18 years of age or older). In 1993, the

[30] The data on per capita police expenditures are from *Justice Expenditure and Employment* (Bureau of Justice Statistics 1990–2009). The data on per capita highway law enforcement expenditures and per capita highway service and maintenance expenditures are from *Highway Statistics* (U.S. Department of Transportation 1990–2010). The data on police expenditures are not available for the years 2001, 2003, and 2010; the data on highway expenditures are not available for the District of Columbia.

Table 11
Tests of Endogeneity

	Placebo MML			Falsification Test:	Spending on Enforcement and Highway Services		
	Fatalities Total	Fatalities (BAC > 0)	Fatalities (BAC ≥ .10)	Tire or Wheel Failure a Factor	Police	Highway Law Enforcement	Highway Maintenance
Average placebo MML estimate	.003	.011	.012				
MML				.018	−.009	−.004	−.092
				(.147)	(.020)	(.051)	(.068)
N	1,071	1,071	1,071	1,020	919	1,050	1,050
Number of trials	100	100	100				
Placebo coefficient < 0	42	44	42				
Placebo coefficient < 0 and significant at 5% level	2	3	3				
Placebo coefficient < 0 and significant at 10% level	2	4	4				

Note. In the regressions with placebo medical marijuana laws (MMLs), the dependent variable is equal to the natural log of fatalities per 100,000 people. In the falsification test, the dependent variable is equal to the natural log of fatalities per 100,000 people from crashes in which tire or wheel failure was cited as a potential contributing factor to the accident. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in the placebo MML regressions and the falsification test. In the spending regressions, the dependent variable is equal to the natural log of the indicated spending measure. The covariates are the state unemployment rate and income per capita. All regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, the state unemployment rate, income per capita, and state-specific trends are included in the spending regressions.

Table 12
Medical Marijuana Laws and State-Level Covariates

	(1)	(2)	(3)	(4)
Mean Age	.035	.035	.041	.037
	(.131)	(.148)	(.152)	(.139)
Unemployment	−.011	−.015	−.014	.007
	(.037)	(.039)	(.039)	(.027)
Income	.231	.187	.241	.255
	(.362)	(.359)	(.348)	(.363)
Miles Driven	.004	.006	.005	.015
	(.008)	(.009)	(.009)	(.013)
BAC .08		.062	.052	.061
		(.047)	(.045)	(.048)
ALR		−.034	−.027	−.027
		(.063)	(.061)	(.069)
Zero Tolerance		−.091	−.090	−.075
		(.066)	(.065)	(.053)
Beer Tax		.375	.364	.119
		(.643)	(.636)	(.286)
Decriminalized			.212	.180
			(.245)	(.282)
Drug Per Se			.035	.015
			(.049)	(.039)
GDL				.035
				(.031)
Primary Seat Belt				.010
				(.057)
Secondary Seat Belt				.020
				(.040)
Speed 70				.060
				(.066)
Texting Ban				.013
				(.049)
Hands Free				−.348*
				(.164)
R^2	.869	.873	.874	.884
Alcohol policies	No	Yes	Yes	Yes
Drug policies	No	No	Yes	Yes
Other traffic policies	No	No	No	Yes

Note. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, and state-specific trends are included in all specifications. $N = 1{,}071$.
* Statistically significant at the 5% level.

BRFSS was expanded to include all 50 states. As part of the core questionnaire, BRFSS respondents are asked the following:

1. Have you had any beer, wine, wine coolers, cocktails, or liquor during the past month?
2. During the past month, how many days per week or per month did you drink any alcoholic beverages, on the average?
3. On days when you drink, about how many drinks do you drink on average?

Using the answers to these questions, we constructed a variety of outcome variables, including Drank > 0, an indicator for whether the respondent consumed alcohol in the past month; 30+ Drinks, an indicator for whether the respondent had 30 or more drinks in the past month; 60+ Drinks, an indicator for whether the respondent had 60 or more drinks in the past month; and Number of Drinks, equal to the number of drinks consumed in the past month conditional on drinking.

Table 13 presents estimates of the following equation by age group for the period 1993–2010:

$$Y_{ist} = \beta_0 + \beta_1 \text{MML}_{ist} + \boldsymbol{X}_{st}\beta_2 + \boldsymbol{Z}_{ist}\beta_3 + v_s + w_t + \Theta_s \times t + \varepsilon_{ist}, \qquad (3)$$

where Y_{ist} measures alcohol consumption, $\boldsymbol{X}_{st}$ is a vector of state-level controls, $\boldsymbol{Z}_{ist}$ is a vector of individual-level controls, and state-specific linear time trends are represented by $\Theta_s \times t$.[31]

The estimates in Table 13 offer additional support for the hypothesis that legalization reduces traffic fatalities through its impact on alcohol consumption. They are uniformly negative and often statistically significant at conventional levels. Moreover, the relationship between legalization and alcohol consumption appears to be strongest among young adults, the group for whom the relationship between legalization and traffic fatalities was strongest.

For instance, among 20–29-year-olds, legalization is associated with a 5.3 percent (.031/.589) reduction in the probability of having consumed alcohol in the past month, a 19.6 percent (.011/.056) reduction in the probability of having consumed 60 or more drinks, and a 10.6 percent (2.40/22.71) reduction in the number of drinks consumed (conditional on having had at least one drink).[32] During the period 1990–2010, almost one-fourth of individuals killed in traffic accidents, and more than one-third of individuals killed in traffic accidents involving alcohol, were between the ages of 20 and 29.[33]

Respondents to BRFSS are also asked how many times in the past month they binge drank, defined as having five or more alcoholic beverages on an occasion.[34] The estimates in Table 13 suggest that the legalization of medical marijuana leads

[31] The vector $\boldsymbol{X}_{st}$ includes per capita income, the state unemployment rate, the beer tax, an indicator for whether a zero-tolerance drunk-driving law was in effect, and an indicator for whether a .08 BAC law was in effect. The vector $\boldsymbol{Z}_{ist}$ includes indicators for race, ethnicity, educational attainment, marital status, employment status, and the season in which the Behavioral Risk Factor Surveillance System (BRFSS) interview took place.

[32] Descriptive statistics for the drinking outcomes are presented in Table A6.

[33] Using data on 19–22-year-olds and a regression discontinuity design, Carpenter and Dobkin (2009) found that reaching the MLDA was associated with a 21 percent increase in the number of days on which alcohol is consumed and a 15 percent increase in traffic fatalities. The implied elasticity from these estimates is .71 (that is, .15/.21). Restricting our sample to 19–22-year-olds, we find that the legalization of medical marijuana is associated with a 15.0 percent decrease in the number of drinks consumed ($p = .17$) and a 12.2 percent decrease in traffic fatalities ($p = .16$), for an implied elasticity of .81 (that is, .122/.150).

[34] In 2006, the BRFSS began asking female respondents whether they had had four or more drinks on an occasion. Male respondents were asked whether they had had five or more drinks on an occasion throughout the period under study (1993–2010).

Table 13

Medical Marijuana Laws and Alcohol Consumption in the Past 30 Days, by Age

	All Respondents	18–19	20–29	30–39	40–49	50–59	60+
Drank > 0	−.019+	−.051*	−.031+	−.022	−.017	−.016+	−.012
	(.010)	(.020)	(.017)	(.014)	(.012)	(.009)	(.008)
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
15+ Drinks	−.010+	−.022+	−.015	−.015*	−.009	−.014*	−.004
	(.006)	(.011)	(.011)	(.008)	(.006)	(.005)	(.005)
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
30+ Drinks	−.009+	−.017*	−.018+	−.008	−.010+	−.009*	−.003
	(.005)	(.008)	(.009)	(.007)	(.006)	(.004)	(.004)
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
60+ Drinks	−.004	−.008	−.011*	−.003	−.005	−.003	−.002
	(.003)	(.007)	(.005)	(.005)	(.003)	(.003)	(.002)
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
Binge Drank	−.007+	−.018+	−.012	−.007	−.013*	−.007+	−.002
	(.003)	(.009)	(.010)	(.006)	(.005)	(.004)	(.002)
	[3,928,524]	[55,426]	[383,970]	[621,722]	[746,974]	[767,567]	[1,352,865]
2+ Binges	−.004+	−.010	−.012+	−.002	−.006+	−.005	−.001
	(.002)	(.011)	(.007)	(.004)	(.003)	(.003)	(.002)
	[3,928,524]	[55,426]	[383,970]	[621,722]	[746,974]	[767,567]	[1,352,865]
Number of drinks	−.84	−1.38	−2.40*	−.70	−.66	−.93	−.44
	(.66)	(1.83)	(.97)	(.95)	(.57)	(.57)	(.75)
	[1,900,760]	[19,944]	[222,500]	[350,855]	[414,093]	[386,371]	[506,997]

Note. The data are based on information collected from the Behavioral Risk Factor Surveillance System (BRFSS) for the period 1993–2010. The covariates include indicators for race, ethnicity, sex, marital status, employment status, and educational attainment. In addition, state fixed effects, year fixed effects, state-specific linear time trends, the unemployment rate, per capita income, the state beer tax, and indicators for marijuana decriminalization, .08 BAC laws, and zero-tolerance laws are included. Indicators for age group are included when all BRFSS respondents are used. Standard errors, corrected for clustering at the state level, are in parentheses. Sample sizes are in brackets.

+ Statistically significant at the 10% level.

* Statistically significant at the 5% level.

to sharp reductions in binge drinking, a form of alcohol abuse considered to have "especially high social and economic costs" (Naimi et al. 2003, p. 70). Among 18- and 19-year-olds, legalization is associated with a 9.4 percent (.018/.192) reduction in the probability of binge drinking in the past month; among 40–49-year-olds, legalization is associated with an 8.8 percent (.013/.147) reduction in this probability. Among 20–29-year-olds, legalization is associated with a 7.4 percent (.012/.163) reduction in the probability of binge drinking at least twice in the past month.

5.2. Evidence from Alcohol Sales

Information on alcohol sales is collected by the Beer Institute and published annually in *Brewers Almanac* (Beer Institute 1990–2010). Data on per capita beer sales (in gallons) are available for the period 1990–2010. Data on per capita wine and spirits sales (in gallons) are available for the period 1994–2010. We use these data to estimate the relationship between legalization and alcohol consumption at the state level.

The results, presented in Table 14, are consistent with the hypothesis that marijuana and beer are substitutes. In particular, legalization is associated with an almost 5 percent decrease in the consumption of beer, the most popular beverage among 18–29-year-olds (Jones 2008).[35] Legalization is negatively related to wine sales and positively related to spirits sales, but these estimates are not statistically significant.

We use MML as an instrument for the estimates of the relationship between beer consumption and traffic fatalities presented in Table 15.[36] A 10 percent increase in per capita beer sales is associated with a 17 percent increase in total fatalities. In comparison, using alcohol excise taxes as instruments, Young and Bielinska-Kwapisz (2006) found that a 10 percent increase in per capita alcohol consumption led to an 11 percent increase in traffic fatalities. The difference between these estimates could reflect who, in effect, is being treated. Our analysis of the BRFSS data suggests that the relationship between legalization and alcohol consumption is strongest among young adults (a group prone to heavy drinking and responsible for a disproportionate share of traffic fatalities), while there is evidence that light and moderate drinkers are more responsive to increases in the price of alcohol than are heavy drinkers (Manning, Blumberg, and Moulton 1995). A 10 percent increase in per capita beer sales is associated with a 24 percent increase in fatalities involving alcohol and a 32 percent increase in fa-

[35] These results help explain why the California Beer and Beverage Distributors donated $10,000 to Public Safety First, a committee organized to oppose a California initiative legalizing marijuana (Grim 2010).

[36] This empirical strategy is based on the assumption that legalization is related to traffic fatalities exclusively through beer consumption. Because the first-stage *F*-statistic for the null hypothesis that legalization is unrelated to beer consumption is less than 10, the standard proposed by Staiger and Stock (1997), the second-stage estimates should be interpreted cautiously.

Table 14

Medical Marijuana Laws and Per Capita Alcohol Sales

	ln(Beer Sales)	ln(Wine Sales)	ln(Spirits Sales)
MML	−.049*	−.008	.002
	(.022)	(.013)	(.011)
N	1,071	867	867
R^2	.981	.990	.990
F-test on instrument	4.8	.36	.03

Note. The dependent variable is equal to the natural log of per capita sales in state *s* and year *t* (measured in gallons) and is based on data from *Brewers Almanac* (Beer Institute 1990–2010). Beer sales data are for the period 1990–2010. Wine and spirits sales data are for the period 1994–2010. Controls include the state unemployment rate, per capita income, the state beer tax, and indicators for marijuana decriminalization, .08 BAC laws, administrative license revocation, and zero-tolerance laws. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications.

* Statistically significant at the 5% level.

Table 15

Per Capita Beer Sales and Traffic Fatalities

	Fatalities Total	Fatalities (BAC > 0)	Fatalities (BAC > .10)
ln(Beer Sales)	1.68**	2.40**	3.16**
	(.484)	(.764)	(.841)
R^2	.976	.900	.897

Note. The dependent variable is equal to the natural log of traffic fatalities per 100,000 people. The natural log of per capita beer sales is instrumented with the medical marijuana law (MML) indicator. Controls include the state unemployment rate, per capita income, the state beer tax, and indicators for marijuana decriminalization, .08 BAC laws, administrative license revocation, and zero-tolerance laws. Regressions are weighted using state populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.

** Statistically significant at the 1% level.

talities resulting from accidents in which at least one driver had a BAC greater than or equal to .10.

6. Conclusion

To date, 19 states and the District of Columbia have legalized medical marijuana. Others are likely to follow. A recent Gallup poll found that 70 percent of Americans are in favor of "making marijuana legally available for doctors to prescribe in order to reduce pain and suffering" (Mendes 2010).

Despite intense public interest, medical marijuana laws have received little attention from researchers. In fact, next to nothing is known about their impact on outcomes of interest to policy makers, social scientists, advocates, and opponents.

The current study draws on data from a variety of sources to explore the effects of legalizing medical marijuana. Using information collected from back issues of *High Times*, a monthly magazine that advocates for the legalization of marijuana, we find that MMLs lead to a substantial decrease in the price of high-quality marijuana. Using data from FARS for the period 1990–2010, we find that traffic fatalities fall by 8–11 percent the first full year after legalization. Although registry data from Arizona and Montana suggest that more than half of medical marijuana patients are over the age of 40, the estimated relationship between legalization and traffic fatalities is strongest among young adults.

Why does legalizing medical marijuana reduce traffic fatalities? Alcohol consumption appears to play a key role. The legalization of medical marijuana is associated with a 7.2 percent decrease in traffic fatalities in which there was no reported alcohol involvement, but this estimate is not statistically significant at conventional levels. In comparison, the legalization of medical marijuana is associated with a 13.2 percent decrease in fatalities in which at least one driver involved had a positive BAC level.

The negative relationship between the legalization of medical marijuana and traffic fatalities involving alcohol lends support to the hypothesis that marijuana and alcohol are substitutes. In order to explore this hypothesis further, we examine the relationship between medical marijuana laws and alcohol consumption. We find that the legalization of medical marijuana is associated with reduced alcohol consumption, especially among young adults. Evidence from simulator and driving-course studies provides a potential explanation for why substituting marijuana for alcohol could lead to fewer traffic fatalities. These studies show that alcohol consumption leads to an increased risk of collision (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009). Even at low doses, drivers under the influence of alcohol tend to underestimate the degree to which they are impaired (MacDonald et al. 2008; Marczinski, Harrison, and Filmore 2008; Robbe and O'Hanlon 1993; Sewell, Poling, and Sofuoglu 2009), drive at faster speeds, and take more risks (Burian, Liguori, and Robinson 2002; Ronen et al. 2008; Sewell, Poling, and Sofuoglu 2009). In contrast, simulator and driving-course studies provide only limited evidence that driving under the influence of marijuana leads to an increased risk of collision, perhaps as a result of compensatory driver behavior (Kelly, Darke, and Ross 2004; Sewell, Poling, and Sofuoglu 2009).

However, because other mechanisms cannot be ruled out, the negative relationship between medical marijuana laws and alcohol-related traffic fatalities does not necessarily imply that driving under the influence of marijuana is safer than driving under the influence of alcohol. For instance, it is possible that legalizing medical marijuana reduces traffic fatalities through its effect on substance use in public. Alcohol is often consumed in restaurants and bars, while many states prohibit the use of medical marijuana in public.[37] Even where it is

[37] For instance, according to state laws, in Colorado "the medical use of marijuana in plain view of, or in a place open to, the general public" (Colo. Const. art. XVIII, sec. 14, para. 5[a][II]) is prohibited; in Connecticut, the smoking of marijuana is prohibited in "any public place" (Conn. Pub. Act No. 12-55, sec. 2[b][2] [2012]); in Oregon, engaging "in the medical use of marijuana in a public place" (Or. Laws 475.316, sec. 1[b] [2011]) is prohibited; and in Washington, it is a

not explicitly prohibited, anecdotal evidence suggests that public use of medical marijuana can be controversial (see, for instance, Whitnell 2008; Adams 2010; Moore 2010; Ricker 2010). If marijuana consumption typically takes place at home, then designating a driver for the trip back from a restaurant or bar becomes unnecessary, and legalization could reduce traffic fatalities even if driving under the influence of marijuana is every bit as dangerous as driving under the influence of alcohol.

Appendix

Table A1
Available Registry Information by State, 2011

	Registered Patients	Chronic Pain (%)	Male (%)	Average Age	18–40 Years of Age (%)
Alaska	380[a]				
Arizona	11,133	86	75		42
California	1,250,000[b]				
Colorado	128,698	94	69	40	
Hawaii	8,000[c]				
Maine	796				
Michigan	105,458				
Montana	30,036	86		41	48
New Mexico	3,981	24			
Oregon	49,220	65			
Rhode Island	3,073	20			
Vermont	349[d]				
Washington	100,000[b]				

Source. Unless otherwise indicated, the information was obtained from official state registry data from NORML, Medical Marijuana (http://norml.org/index.cfm7Group_ID = 3391).
[a] Based on a communication between NORML and the Alaska Bureau of Vital Statistics.
[b] Estimated by NORML.
[c] Estimated by the Drug Policy Forum of Hawaii.
[d] Based on a communication between NORML and the Vermont Criminal Information Center.

misdemeanor "to use or display medical cannabis in a manner or place which is open to the view of the general public" (Wash. Rev. Code 69.51A.060.1 [2011]). Although Montana law prohibits the use of medical marijuana in parks, schools, public beaches, and correctional facilities, it does not explicitly prohibit its use in other public places (S.B. 423, 62d Leg., sec. 11[1][b][8] [Mont. 2011]).

Table A2
Summary of Medical Marijuana Laws by State

State	Summary
Alaska	Caregivers are limited to one patient (unless a relative of more than one patient); home cultivation is allowed, but dispensaries are prohibited
California	Caregivers can have multiple patients; home cultivation and collectives and/or cooperatives are allowed
Colorado	Caregivers can have multiple patients; home cultivation and dispensaries are allowed
District of Columbia	Caregivers are limited to one patient; home cultivation is prohibited; the district has five licensed dispensaries and 10 cultivation facilities
Hawaii	Caregivers are limited to one patient; home cultivation is allowed, but dispensaries are prohibited
Maine	Caregivers can have multiple patients but are prohibited from cultivating collectively; home cultivation and a limited number of licensed, nonprofit dispensaries are allowed
Michigan	Caregivers can have multiple patients; home cultivation is allowed
Montana	Caregivers can have multiple patients; home cultivation is allowed
Nevada	Caregivers can have multiple patients; home cultivation is allowed; dispensaries are prohibited
New Jersey	Caregivers are limited to one patient; home cultivation is prohibited; the state has 10 licensed nonprofit dispensaries and/or cultivation centers
New Mexico	Caregivers can have multiple patients but are prohibited from cultivating; home cultivation is allowed with a license; the state has a limited number of licensed, nonprofit producers
Oregon	Caregivers can have multiple patients; home cultivation for multiple patients is allowed; dispensaries are prohibited, but collectives and/or cooperatives are allowed
Rhode Island	Caregivers can have multiple patients; home cultivation and up to three licensed, nonprofit compassion centers are allowed
Vermont	Caregivers are limited to one patient; home cultivation is allowed; the state has four licensed, nonprofit dispensaries
Washington	Caregivers are limited to one patient; home cultivation and collective cultivation by patients are allowed

Sources. The descriptions are based on information from Marijuana Policy Project (2011) and Jacobson et al. (2011).

Table A3
Descriptive Statistics for *High Times* Analysis, 1990–2011

Variable	Mean	Description
Dependent:		
Price high-quality marijuana	313.25 (88.13)	Median per-ounce price of high-quality marijuana (2000 $)
Price low-quality marijuana	128.70 (64.24)	Median per-ounce price of low-quality marijuana (2000 dollars)
Independent:		
MML[a]	.135 (.338)	Equals one if a state had a medical marijuana law in a given year and zero otherwise
Mean age	36.08 (1.78)	Mean age of the state population
Unemployment	5.70 (1.92)	State unemployment rate
Income	10.25 (.173)	Natural logarithm of state real income per capita (2000 $)
Decriminalized[a]	.250 (.433)	Equals one if a state had a marijuana decriminalization law in a given year and zero otherwise
Beer tax	.259 (.230)	Real beer tax (2000 $)

Note. Price data are based on information from 8,271 purchases recorded in the "Trans High Market Quotations" section of *High Times*. Of these, 7,029 were classified as high-quality and 1,242 were classified as low-quality. Standard deviations are in parentheses.

[a] Takes on fractional values for the years in which laws changed.

Table A4
Medical Marijuana Laws and Male Traffic Fatalities by Age

	Fatalities, 15–19	Fatalities, 20–29	Fatalities, 30–39	Fatalities, 40–49	Fatalities, 50–59	Fatalities, 60+
MML	−.071	−.189*	−.158+	−.095	−.040	−.087+
	(.067)	(.080)	(.089)	(.074)	(.059)	(.046)
R^2	.884	.924	.920	.909	.842	.892

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using the relevant state-by-age populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.

+ Statistically significant at the 10% level.

* Statistically significant at the 5% level.

Table A5
Medical Marijuana Laws and Female Traffic Fatalities by Age

	Fatalities, 15–19	Fatalities, 20–29	Fatalities, 30–39	Fatalities, 40–49	Fatalities, 50–59	Fatalities, 60+
MML	.037	−.159**	−.221+	−.076	−.040	.019
	(.123)	(.058)	(.127)	(.080)	(.079)	(.059)
R^2	.789	.861	.833	.824	.703	.838

Note. The dependent variable is equal to the natural log of fatalities per 100,000 people. Regressions are weighted using the relevant state-by-age populations. Standard errors, corrected for clustering at the state level, are in parentheses. Year fixed effects, state fixed effects, state covariates, and state-specific trends are included in all specifications. $N = 1{,}071$.

+ Statistically significant at the 10% level.

** Statistically significant at the 1% level.

Table A6

Alcohol Consumption in the Past 30 Days by Age: Variable Means

	All	18–19	20–29	30–39	40–49	50–59	60+
Drank > 0	.489	.367	.589	.571	.560	.508	.379
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
15+ Drinks	.188	.147	.237	.200	.210	.196	.154
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
30+ Drinks	.106	.091	.129	.100	.110	.111	.097
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
60+ Drinks	.044	.047	.056	.038	.045	.048	.041
	[3,884,082]	[54,296]	[378,058]	[614,541]	[739,094]	[760,147]	[1,337,946]
Binge drank	.118	.192	.258	.180	.147	.102	.040
	[3,928,524]	[55,426]	[383,970]	[621,722]	[746,974]	[767,567]	[1,352,865]
2+ Binges	.073	.131	.163	.105	.090	.065	.026
	[3,928,524]	[55,426]	[383,970]	[621,722]	[746,974]	[767,567]	[1,352,865]
Number of drinks	20.26	26.91	22.71	18.32	19.74	20.39	20.61
	(35.28)	(51.03)	(40.56)	(33.05)	(35.16)	34.87	(33.80)
	[1,900,760]	[19,944]	[222,500]	[350,855]	[414,093]	[386,371]	[506,997]

Note. The data are based on information collected from the Behavioral Risk Factor Surveillance System (BRFSS) for the period 1993–2010. Standard deviations are in parentheses, and sample sizes are in brackets.

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