Medical Marijuana Laws and Teen Marijuana Use

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Abstract

Although policymakers and law enforcement officials argue that medical marijuana laws (MMLs) "send the wrong message" to young people, previous studies have produced no evidence of a causal relationship between MMLs and marijuana use among teens. Using data from the national and state Youth Risk Behavior Surveys, the National Longitudinal Survey of Youth 1997, and the Treatment Episode Data Set, we revisit this relationship. Our results are not consistent with the hypothesis that legalization of medical marijuana leads to increased marijuana use among teenagers.

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These last couple years, the amount of attention that's been given to medical marijuana has been huge. And when I've done focus groups with high school students in states where medical marijuana is legal, they say "Well, if it's called medicine and it's given to patients by caregivers, then that's really the wrong message for us as high school students."

--R. Gil Kerlikowske, Director of the Office of National Drug Control Policy

1. INTRODUCTION

Tobacco and alcohol use by American high school students has been declining since the mid-1990s. Marijuana use followed a similar trend until the mid-2000s, when, according to data from Monitoring the Future, there was a 3 to 4 percentage-point increase in the percentage of high school students who reported having smoked marijuana in the past 30 days accompanied by a similarly-sized decrease in the percentage of 10th and 12th graders who view regular marijuana use as risky (Johnston et al. 2011). Federal officials, including the Director of the Office of National Drug Control Policy (also known as the "Drug Czar"), attributed these developments to the legalization of medical marijuana, noting that the medical marijuana industry has grown dramatically since the mid-2000s (O'Conner 2011).

In 1996, California became the first state to legalize medical marijuana. Since then, more than 20 additional states and the District of Columbia have adopted medical marijuana laws (MMLs). While the therapeutic properties of marijuana are the subject of debate (Gilman 2005; Cohen 2009), the client base of doctors who recommend medical marijuana has expanded to include adolescents with conditions such as autism, insomnia, obsessive compulsive disorder, and attention deficit hyperactivity disorder (Browstein 2009; Ellison 2009; Joseph et al. 2010).[1]

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[1] Advocates of recommending medical marijuana for these conditions maintain that it is safer than alternative medicines such as methylphenidate (also known as "Ritalin"), the stimulant most often prescribed to treat attention deficit hyperactivity disorder (Lucido 2004; Ellison 2009), and zolpidem tartrate (also known as "Ambien"), a medication prescribed to treat insomnia (Chaboya-Hembree 2012). Medical marijuana has also been used to treat adolescents suffering from chronic pain (Belkin 2009).

Minors must have the permission of a parent or legal caregiver in order to use medical marijuana and must be accompanied by a parent or legal caregiver when visiting a dispensary (Ellison 2009). These rules restrict the number of medical marijuana patients under the age of 18.[2] However, policymakers and law enforcement officials contend that legalization encourages young people to underestimate the health risks associated with illicitly using marijuana (O'Connor 2011; Suthers 2012). On the supply side, because it is prohibitively expensive for the government to ensure that all marijuana ostensibly grown for the medicinal market ends up in the hands of registered patients, diversion to the illicit market almost certainly occurs (Anderson et al. 2013). In fact, minors receiving treatment for substance abuse have reported obtaining marijuana directly from adult medical marijuana patients (Thurstone et al. 2011; Salomonsen-Sautel et al. 2012).

Below, we examine the relationship between MMLs and marijuana consumption among high school students using data from the national and state Youth Risky Behavior Surveys (YRBS) for the years 1993-2011. During this period, 16 states, including California, Colorado, Michigan, Oregon, Rhode Island, and Washington, legalized medical marijuana. Our empirical analysis is reduced-form, based on the approach taken by previous researchers interested in the determinants of marijuana use.[3] The results suggest that the legalization of medical marijuana is not accompanied by increases in the use of marijuana among high school students. Specifically, estimates from our preferred specification are small, negative and statistically indistinguishable

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[2] For instance, only 0.2 percent of medical marijuana patients are under the age of 18 in Arizona; in Montana, 0.03 percent of patients are under the age of 18.

[3] For instance, Farrelly et al. (1999) examined the reduced-form relationship between more stringent anti-marijuana policies and marijuana use, while Thies and Register (1993), Saffer and Chaloupka (1999) and Williams (2004) examined the impact of decriminalization. In a similar vein, Pacula (1998), Farrelly et al. (2001), and Williams et al. (2004) examined the impact of alcohol and cigarette policies on marijuana use.

from zero. Using the 95 percent confidence interval around these estimates suggests that the impact of legalizing medical marijuana on the probability of marijuana use in the past 30 days is no larger than 1.5 percentage points.

In addition to analyzing data from the YRBS, we conduct two complementary analyses. The first uses data from the National Longitudinal Survey of Youth 1997 (NLSY97). The behavior of NLSY97 respondents can be observed over time, allowing for the estimation of models that control for unobserved heterogeneity at the individual level. The second uses data from the Treatment Episode Data Set (TEDS), which contains information from drug treatment providers on patients who reported using marijuana before being admitted. These complementary analyses provide further evidence that youth marijuana consumption does not increase with the legalization of medical marijuana.

2. PREVIOUS STUDIES

Several previous studies have examined the relationship between MMLs and marijuana use among teenagers and/or young adults (Wall et al. 2011; Harper et al. 2012; Choo et al. 2014; Pacula et al. 2015).[4] Drawing on data from the National Survey on Drug Use and Health (NSDUH) for the years 2002 through 2007, Wall et al. (2011) found that rates of marijuana use among 12- through 17-year-olds were higher in states that had legalized medical marijuana than in states that had not, but noted that "in the years prior to MML passage, there was already a

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[4] Other studies have examined the relationship between MMLs and marijuana consumption without focusing on minors. Khatapoush and Hallfors (2004) used data on 16- though 25-year-olds living in California and 10 other states. They found no evidence that marijuana consumption went up after California legalized medical marijuana in 1996. Using data for the period 1995–2002 from Denver, Los Angeles, Portland, San Diego and San Jose, Gorman and Huber Jr. (2007) found little evidence that marijuana consumption increased among adult arrestees as a result of the legalization of medical marijuana. Chu (2014) found that legalization was associated with an increase in arrests of young adult males for marijuana possession. Cerdá et al. (2012) examined the cross-sectional relationship between MMLs and marijuana use among adults 18 years of age and above.

higher prevalence of use and lower perceptions of risk" in states that had legalized medical marijuana (p. 714). Drawing on NSDUH data for the years 2002-2009, Harper et al. (2012) found that legalization was associated with a small reduction in the rate of marijuana use among 12- through 17-year-olds.

More recently, Choo et al. (2014) examined state YRBS data from 5 medical marijuana states (Maine, Montana, Rhode Island, and Vermont). Each of these states was paired with a neighboring state that had not adopted a MML and trends in marijuana use over the period 1991-2011 were compared. Choo et al. (2014) found no evidence that legalization leads to an increase in marijuana use among high school students, and concluded that "concerns about 'sending the wrong message' may have been overblown" (p. 163). [5]

Finally, Pacula et al. (2015) used data from the NLSY97 to examine the relationship between MMLs and marijuana consumption. The focus of Pacula et al. (2015) was on young adults, but they restricted their analysis to respondents under the age of 21 in Table 8 (p. 23). With this restriction in place, Pacula et al. (2015) had pre- and post-legalization data from 8 states, two of which only contributed a handful of observations to the NLSY97 (i.e., fewer than 10) in any given year. Among NLSY97 respondents under the age of 21, MMLs were not associated with the probability of marijuana use in the past 30 days; the relationship between MMLs and days of marijuana use in the past month was positive and statistically significant at conventional levels.

Our analysis makes a number of contributions to the literature. First, we draw upon state and national YRBS data from 1993-2011, a period during which 16 states and the District of

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[5] Using state YRBS data from Montana, Rhode Island, Michigan and Delaware, Lynne-Landsman et al. (2013), took a similar approach to estimating the relationship between MMLs and youth consumption. Like Choo et al. (2015), these authors found little evidence that the adoption of a MML increased marijuana use among teenagers.

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Columbia legalized medical marijuana.[6] In contrast, previous studies in this literature have had

much less policy variation to exploit, casting doubt on the generalizability of their results.[7]

Second, no previous study in this literature has examined pre-legalization data from

California, but California is well represented in the national YRBS (a source of data not utilized

by previous researchers). The national YRBS interviewed 2,082 California high school students

in 1993 and 1,161 California high school students in 1995. Because the California medical

marijuana industry is so large, these pre-legalization observations are crucial to obtaining

credible estimates of the effect of MMLs on youth consumption.

Third, with two exceptions (Lynne-Landsman et al. 2013; Pacula et al. 2015), previous

studies in this literature have relied on aggregate (state-level) data, potentially reducing precision

and leading to Type II errors. An important advantage to using the YRBS data is that they are at

the individual (micro) level, allowing us to examine the relationship between MMLs and

marijuana use by age and gender.

Finally, the YRBS data contain information on marijuana use and availability at school.

These outcomes are of special interest given the recent efforts in California and Colorado to

close medical marijuana dispensaries operating near schools.[8]

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[6] Appendix Table 1 provides a list of states that have legalized medical marijuana during the period 1993-2011.
Although the New Jersey medical marijuana law came into effect on October 1, 2010, implementation was delayed
(Brittain 2012). Coding New Jersey as a non-medical marijuana state in 2011 has no appreciable impact on the
results presented below.

[7] Harper et al. (2012) had pre- and post-legalization data from 5 states; Choo et al. (2014) also had pre-and post-
legalization data from 5 states; Lynne-Landsman et al. (2013) had pre-and post-legalization data from 4 states; and,
when their sample was restricted to NLSY respondents under the age of 21, Pacula et al. (2015) had pre- and post-
legalization data from 8 states. It should be noted that Pacula et al. (2015) did not list the states that contributed pre-
and post-legalization data to their analysis of NLSY97 respondents under the age of 21. However, by 2006 these
respondents had turned 21, so Pacula et al. (2015) were unable to exploit post-legalization data from Arizona,
Delaware, Michigan, New Jersey, Rhode Island, and New Mexico. California legalized medical marijuana in 1996,
one year before the NLSY97 began collecting data.

[8] In an effort to combat youth marijuana use, John Walsh, the U.S. Attorney for Colorado, sent letters to medical
marijuana dispensaries located within 1,000 feet of schools asking them to relocate or close. Walsh cited figures

3. THE DATA

The national YRBS is conducted biennially by the Centers for Disease Control and Prevention (CDC) and is a nationally representative sample of U.S. high school students.[9] Federal agencies rely upon the national YRBS to track trends in adolescent behavior including eating and exercise habits, violence, sexuality, and substance use. Previous studies such as Merrill et al. (1999) and Abdel-Ghany and Wang (2003) have used these data to examine determinants of youth marijuana use. The state surveys are coordinated by the CDC and are administered by state education and health agencies. Like the national YRBS, the state YRBS is school-based and contains multiple items designed to elicit information on risky behaviors.

Our analysis draws on both of these data sources in order to ensure that identification is based on as many MML changes as possible. Although intended to be nationally representative, not all 50 states are represented in any given wave of the national YRBS. In fact, between 1993 and 2011, only 6 states contributed data to the national YRBS every year (California, Florida, Georgia, Michigan, New York, and Texas), and 11 states contributed data to the national YRBS before and after the legalization of medical marijuana (Arizona, California, Colorado, Delaware, Hawaii, Maine, Michigan, New Jersey, New Mexico, Oregon, and Washington). Appendix Table 2 shows the number of observations by year and state in the national YRBS. States that

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from the Colorado Department of Education showing that drug-related school suspensions, expulsions, and law enforcement referrals increased dramatically from 2008-2011 (Ingold 2012), and he was quoted as saying that many school districts in Colorado "have seen a dramatic increase in student abuse of marijuana, with resulting student suspensions and discipline" (McCrimmon and Jones 2012). Melinda Haag, the U.S. Attorney for the Northern California district, targeted dispensaries located within 1,000 feet of schools, parks, and playgrounds, arguing that marijuana serves as a gateway drug and that, because "brains are not fully developed until your mid 20s", youth are particularly susceptible to its effects (Brooks 2012).

[9] The national YRBS was first conducted in 1991. However, because the 1991 wave is based on only a handful of schools, we chose to omit it from the analysis.

legalized medical marijuana are denoted with a star superscript and post-legalization observations are italicized.[10]

With a few exceptions, most states conducted their own version of the YRBS sometime between 1993 and 2011, and at least 15 administered the YRBS in any given year during this period.[11] Roughly half of the states have given the CDC permission to release their data, while the remaining require that requests to use their data be made directly. We obtained data from 45 states, 11 of which conducted surveys before and after the legalization of medical marijuana (Alaska, Arizona, Delaware, Maine, Michigan, Montana, Nevada, New Jersey, New Mexico, Rhode Island, and Vermont). Appendix Table 3 shows the number of observations each state contributed to the state YRBS analysis. Again, states that legalized medical marijuana are denoted with a star superscript and post-legalization observations are italicized.

When combined, the national and state YRBS data include the District of Columbia and all 50 states; sixteen of these states contributed data before and after the legalization of medical marijuana.[12] Table 1 provides descriptive statistics for the national and state YRBS samples by

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[10] In the regression analyses, the fraction of the year that the law was in effect was used when a state legalized medical marijuana during a survey year. We experimented with assigning 0 to these years; we also experimented with assigning 1 to these years. The results, which are available upon request, were similar to those reported below.

[11] The following CDC webpage provides a detailed history of the state YRBS: http://www.cdc.gov/healthyyouth/yrbs/history-states.htm.

[12] For instance, California contributed two years of pre-legalization data and 8 years of post-legalization data to the combined analysis; Colorado contributed 3 years of pre-legalization data and 4 years of post-legalization data to the combined analysis; Maine contributed 3 years of pre-legalization data and 7 years of post-legalization data to the combined analysis; Michigan contributed 8 years of pre-legalization data and two years of post-legalization data to the combined analysis; Montana contributed 6 years of pre-legalization data and 4 years of post-legalization data to the combined analysis; New Mexico contributed 5 years of pre-legalization data and 3 years of post-legalization data to the combined analysis; Rhode Island contributed 5 years of pre-legalization data and 3 years of post-legalization data to the combined analysis; Vermont contributed 4 years of pre-legalization data and 3 years of post-legalization data to the combined analysis; and Washington contributed 3 years of pre-legalization data and 4 years of post-legalization data to the combined analysis. Although the District of Columbia legalized medical marijuana in 2010, it has never conducted a state YRBS and contributed observations to the national YRBS in only two years, 1995 and 2011.

whether medical marijuana was legal at the time of the interview. According to the national YRBS data, 22 percent of high school students used marijuana at least once in the past 30 days, and 9 percent used marijuana at least 10 times during the past 30 days (our definition of frequent use). In the state YRBS data, 20 percent of respondents used marijuana in the past 30 days and 8.5 percent were frequent users.

Figure 1 presents trends in marijuana use based on weighted national YRBS data. It shows a steady decline in marijuana use among high school students from the late-1990s through 2007. From 2007 to 2011, the percentage of high school students who used marijuana in the past 30 days increased from 19.7 percent to 22.9 percent. Figure 2 presents trends in marijuana use based on unweighted state YRBS data. Despite the fact that they are designed to be representative at the state level, these data show the same steady decline in marijuana use from the late-1990s through the mid-2000s and a comparable increase after 2007, suggesting that the national and the state YRBS are capturing the same broad changes in tastes and policies.

Figures 3 and 4 present pre- and post-legalization trends in marijuana use based on national and state YRBS data, respectively. We report marijuana use for the three years prior to legalization, the year in which the law changed (year 0), and the three years following legalization. These figures provide simple and direct tests for whether youth marijuana consumption changed with the legalization of medical marijuana. In Figure 3, there appears to be a decrease in marijuana use immediately after legalization, followed by an increase of comparable magnitude. A similar pattern is evident in Figure 4: marijuana use decreases immediately after legalization, increases after one year, and then decreases again by a comparable amount after two years. Although neither figure provides strong evidence of an

increase in marijuana use after legalization, other factors related to, for instance, economic

conditions could be masking the impact of legalization.

4. STATISTICAL METHODS

In an effort to control for economic conditions and other policies (as well as any changes

in the composition of YRBS respondents), we turn to a standard regression framework that

exploits both temporal and geographic variation in MMLs. Specifically, we estimate the

following equation:

(1) $\qquad$ *Marijuana Use$_{ist}$* $= \beta_0 + \beta_1 MML_{st} + \textbf{X1}_{ist}\beta_2 + \textbf{X2}_{st}\beta_3 + v_s + w_t + \Theta_s \cdot t + \varepsilon_{ist},$

where i indexes individuals, s indexes states, and t indexes years. The vectors v_s and w_t represent

state and year fixed effects, respectively, and state-specific linear time trends are represented by

$\Theta_s \cdot t$. Although state-specific linear trends are a standard method of controlling for unobserved

factors at the state level that evolve smoothly over time such as preferences and tastes, no

previous study in this literature has included them. The variable MML_{st} is an indicator for

whether medical marijuana was legal in state s and year t. The coefficient of interest, β_1,

represents the effect of medical marijuana legislation.[13]

The dependent variable, *Marijuana Use$_{ist}$*, is equal to 1 if respondent i reported using

marijuana in the past 30 days, and equal to 0 otherwise. The vector $\textbf{X1}_{ist}$ includes individual-

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[13] Anderson et al. (2013) used a similar empirical strategy to examine the effects of MMLs on the price of
marijuana, traffic fatalities, and alcohol consumption. As a test of exogeneity, these authors regressed changes in
MMLs on state-level policies. Neither alcohol- nor drug-related policies predicted the legalization of medical
marijuana. Likewise, MMLs were unrelated to per capita police expenditures, although it is possible that police
redirected their effort towards keeping marijuana out of the hands of youth after legalization.

level controls for age, sex, race, and grade, while the vector $X2_{st}$ includes state-level controls for whether marijuana use and possession was decriminalized, the presence of a BAC 0.08 law, the state beer tax, income per capita, and the unemployment rate. Previous research has shown that marijuana use is sensitive to decriminalization (Saffer and Chaloupka 1999), alcohol policies (Pacula 1998; DiNardo and Lemieux 2001), and economic conditions (Hammer 1992). All regressions are estimated as linear probability models and standard errors are corrected for clustering at the state level (Bertrand et al. 2004). In addition to examining marijuana use in the past 30 days, we examine frequent marijuana use, marijuana use at school, and whether the respondent was offered or bought marijuana on school property. Descriptive statistics for these outcomes are presented in Table 1.

5. RESULTS

Tables 2 through 5 present unweighted OLS estimates of the relationship between MMLs and the outcomes discussed above. Separate estimates for the national and state YRBS are presented along with estimates based on the combined data.

Using the national YRBS and a "bare bones" specification without covariates or state-specific linear time trends, legalization of medical marijuana is associated with a 5.6 percentage point decrease in the probability of marijuana use within the past 30 days, and a 3.5 percentage point decrease in the probability of frequent use (Table 2). We can reject the hypothesis that the relationship between MMLs and these outcomes is positive at conventional levels. The same specification yields smaller and insignificant (but still negative) estimates of β_1 using the state YRBS data. When the national and state YRBS data are combined, we find that the legalization of medical marijuana is associated with a 1.7 percentage point decrease in the probability of

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marijuana use within the past 30 days, and a (statistically insignificant) 0.8 percentage point decrease in the probability of frequent use. One explanation for these negative estimates is provided by Anderson and Rees (2014, p. 227). These authors noted that MMLs allow suppliers to sell to adults with some assurance of not being prosecuted, while selling marijuana to a minor is still a risky proposition even with legalization.[14]

A similar pattern of results emerges when the covariates are included on the right-hand side of the estimating equation. In the national YRBS, legalization is associated with significant reductions in the probability of marijuana use; in the state YRBS, the estimates of β_1 are negative, but not significant; when the state and national YRBS data are combined, legalization of medical marijuana is associated with a 1.7 percentage point decrease in the probability of marijuana use within the past 30 days, and a (statistically insignificant) 0.9 percentage point decrease in the probability of frequent use. Ninety-five percent confidence intervals around estimates of β_1 produced using the combined YRBS data suggest that the impact of legalization on the probability of marijuana use in the past 30 days is no larger than -0.1 percentage points and the impact of legalization on the probability of frequent marijuana use in the past 30 days is no larger than 0.1 percentage points.

When state-specific linear trends are included on the right-hand side (our preferred specification), the estimates of β_1 are uniformly negative, but never statistically distinguishable from zero.[15] Ninety-five percent confidence intervals around estimates of β_1 produced using the

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[14] See also Hansen et al. (2013), who examined the effect of taxes on the informal (i.e., "social") market for cigarettes. These authors found that an increase in taxes reduced smoking even among teenagers who relied on the informal market as opposed to commercial outlets.

[15] Appendix Table 4 presents weighted estimates from the national YRBS. Again, there is little evidence that legalization of medical marijuana leads to increased marijuana use among high school students. Appendix Table 4 also presents weighted estimates based on state YRBS data and combined YRBS data. The weights were constructed using information on age, population, sex, and race at the state level obtained from the National Cancer Institute's Surveillance Epidemiology and End Results Program (http://seer.cancer.gov/popdata/). Distinguishing

combined YRBS data suggest that the impact of legalization on the probability of marijuana use in the past 30 days is no larger than 1.5 percentage points and the impact of legalization on the probability of frequent marijuana use in the past 30 days is no larger than 0.8 percentage points. In comparison, based on nationally representative data from Monitoring the Future, marijuana use among 12th graders increased by 4.3 percentage points from 2006 to 2011; marijuana use among 10th graders increased by 3.4 percentage points over this same period.[16] Based on national YRBS data, marijuana use among high school students increased by 3.4 percentage points from 2007 to 2011.

In Table 3, we explore whether the relationship between MMLs and marijuana use depends on gender. These estimates are from our preferred specification that includes the full set of covariates and state-specific linear time trends. With one exception, they are negative and statistically indistinguishable from zero. The hypothesis that β_1 for male respondents is equal to β_1 for female respondents is never rejected.

Table 4 compares estimates of β_1 for YRBS respondents who were under the age of 17 when they were interviewed with estimates for respondents who were 17 years of age or older.[17]

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the treatment effect from state-specific trends becomes especially difficult when states contribute only one or two years of pre-treatment data (Wolfers 2006). In Appendix Table 5, we attempt to address this issue. The top panel of Appendix Table 5 presents estimates of the relationship between MMLs and youth consumption when medical marijuana states that contributed only one year of pre-treatment data are dropped from the analysis. These estimates are similar to those in Table 2. In the bottom panel, we drop medical marijuana states that contributed only one or two years of pre-treatment data. In the national YRBS, legalization is associated with a significant increase in the probability of marijuana use in the past 30 days when state-specific linear trends are included on the right-hand side. However, in the state and combined YRBS, the estimates of β_1 are similar to those in Table 2. Finally, we experimented with controlling for state-specific quadratic trends. While omitted for the sake of brevity, these results were also similar to those reported in Table 2.

[16] Estimates of marijuana use in the past 30 days for 8th, 10th, and 12th graders are available from Johnston et al. (2011) and are based on data from Monitoring the Future. Monitoring the Future has interviewed nationally representative samples of 8th, 10th, and 12th graders since 1991. However, state identifiers are generally not made available to researchers. Our efforts to obtain these data were politely rebuffed.

[17] The YRBS data include information on all high school students, some of whom are as old as 19.

In the national YRBS data, the relationship between legalization and marijuana use is negative and significant among respondents under the age of 17, but insignificant among respondents 17 years of age and older. The relationship between legalization and frequent use is negative (but statistically insignificant) among both younger and older respondents. The remaining estimates of β_1 in Table 4 are small and statistically insignificant.[18]

Table 5 reports estimates of the effect of legalization on the use of marijuana on school property in the past 30 days and estimates of the effect of legalization on the probability a student reported having been offered, sold, or given an illegal drug at school in the past year. These estimates are of particular interest given the recent attempts to close dispensaries operating near schools (Brooks 2012; McCrimmon and Jones 2012). The estimated relationship between MMLs and the use of marijuana on school property is consistently negative, but insignificant in the combined sample. Legalization is associated with a 2.0 percentage point decrease in the probability of having been offered, sold, or given an illegal drug at school in the past year in the combined sample.

5.1 Analysis of the National Longitudinal Survey of Youth 1997

In this complementary analysis, we examine the relationship between MMLs and the use of marijuana by youth in the NLSY97. The NLSY97, which is conducted annually, is a nationally representative sample of individuals who were 12 through 16 years of age as of December 31st, 1996. The primary data source of Pacula et al. (2015), the NLSY97 contains detailed information on educational attainment, family background, and socio-economic status,

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[18] Although the results are not reported, we estimated equation (1) for respondents 18 years of age and older. There was no evidence that the legalization of medical marijuana was associated with an increase in marijuana use among this age group.

and its respondents are asked a host questions with regard to marijuana use including, "On how many days have you used marijuana in the last 30 days?"[19] Because our focus is on teenagers, we limit the analysis to respondents ages 12 through 19 at the time of the survey.

There are two primary benefits to using the NLSY97 data. First, unlike the YRBS, the NLSY97 includes high school dropouts. This is important because high school dropouts are more likely to use marijuana than their counterparts who stay in school (Bray et al. 2000). Second, because the NLSY97 data follow adolescents over time, it is possible to control for unobserved heterogeneity at the individual level.

However, there are two significant drawbacks to using NLSY97 data. First, California legalized medical marijuana before data collection began and several other states legalized medical marijuana when most of the NLSY97 respondents were in their twenties and thirties.[20] Second, two of the states that legalized medical marijuana in the late 1990s and early 2000s contributed only a handful of observations (i.e., fewer than 10) to the NLSY97 in any given year.

Table 6 presents descriptive statistics from the NLSY97 and Table 7 presents regression results. Specifically, we report estimates from the following equation:

(2) $\quad Marijuana\ Use_{ist} = \beta_0 + \beta_1 MML_{st} + \textbf{X1}_{ist}\beta_2 + \textbf{X2}_{st}\beta_3 + \lambda_i + w_t + \Theta_s \cdot t + \varepsilon_{ist},$

where i indexes individuals, s indexes states, and t indexes years. Year fixed effects are represented by w_t, and state-specific linear time trends, omitted by Pacula et al. (2015), are

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[19] Based on the answers to this question, we are able to construct measures of marijuana use that correspond to the marijuana use measures in the YRBS data. Economists who have used these data to study determinants of marijuana use include Aughinbaugh and Gittleman (2004) and Cowen (2011).

[20] For instance, New Mexico legalized medical marijuana in 2007, when the average age of NLSY97 respondents was 25; Michigan legalized medical marijuana in 2008; and Arizona legalized medical marijuana in 2011.

represented by $\Theta_s \cdot t$. The variable MML_{st} is defined as above and β_1 represents the effect of medical marijuana legislation on marijuana use in the past 30 days. In addition, we examine the relationship between MMLs and frequent marijuana use defined as having used marijuana on at least 10 of the past 30 days. The vectors $X1_{ist}$ and $X2_{st}$ are composed of the individual- and state-level controls, respectively.[21]

Because NLSY97 respondents are observed in multiple years, we are able to include individual fixed effects, λ_i, on the right-hand side of the estimating equation. In addition to absorbing time-invariant heterogeneity at the individual level, these effects account for factors at the state level that may be correlated with marijuana use and the legalization of medical marijuana, although it is important to note that identification comes from changes in the law and from movement between states with different MMLs. All regressions are estimated as linear probability models and standard errors are corrected for clustering at the state level (Bertrand et al. 2004).

Each cell in Table 7 represents the results from a separate regression. Estimates in column (1) are based on a specification that includes only individual and year fixed effects; estimates in column (2) are based on a specification that also includes the covariates listed in Table 6; and estimates in column (3) are based on a specification that adds state-specific linear time trends. Consistent with the results of Pacula et al. (2015), there is little evidence to support the hypothesis that MMLs encourage marijuana use by teenagers. Although 5 of the 6 coefficient estimates are positive, none are statistically significant at conventional levels. If the largest estimates are taken at face value, the legalization of medical marijuana is associated with

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[21] The state-level controls are identical to those used in the YRBS analysis. The individual-levels controls include indicators for education status, which are not available in the YRBS.

a 0.7 percentage point increase in the probability of marijuana use in the past 30 days, and a 1.3

percentage point increase in the probability of frequent use.[22]

5.2 Analysis of the Treatment Episode Data Set

Pacula et al. (2015) used data from the Treatment Episode Data Set (TEDS) for the

period 1993-2011 to examine the relationship between MMLs and marijuana-related admissions

to publicly-funded drug treatment facilities.[23] They found that legalization was associated with a

significant reduction in admissions of individuals under the age of 21 who reported marijuana as

their primary substance of abuse.

In Table 8, we re-examine the TEDS data, focusing on a broader measure of marijuana

use than that used by Pacula et al. (2105): admissions of individuals who reported marijuana as

their primary, secondary, or tertiary substance of abuse. Specifically, we estimate the following

equation using TEDS data for the period 1992-2009:

(2) $\qquad \ln(Admission\ Rate_{st}) = \beta_0 + \beta_1 MML_{st} + X_{st}\beta_2 + v_s + w_t + \Theta_s \cdot t + \varepsilon_{st},$

where $Admission\ Rate_{st}$ is the sex-specific admission rate in state s and year t. Because TEDS

does not provide the exact age or date of birth, we consider sex-specific admission rates for two

age groups: 15- through 17-year-olds and 18- through 20-year-olds. The variable MML_{st}

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[22] Appendix Table 6 presents estimates that incorporate the sample weights provided by the NLSY97. Following Mellor (2011), we used the average of the sample weights for each individual for the years in which he or she participated in the NLSY97. These results are similar to those reported in Table 7.

[23] Other economists who have used these data include Anderson (2010), Corman et al. (2010), Cunningham and Finlay (2011), and Nonnemaker et al. (2011). The TEDS data contain information on admissions to facilities that provide substance abuse treatment and are required to report to a state substance abuse agency because they receive public funds, are licensed to provide substance abuse treatment, or "are administratively tracked for other reasons" (Substance Abuse and Mental Health Services Administration 2012, p. 94).

indicates whether a MML was in effect in state s and year t, the vector X_{st} is composed of the controls described in Appendix Table 7, and v_s and w_t are state and year fixed effects. State-specific linear trends, which Pacula et al. (2015) omitted, are represented by $\Theta_s \cdot t$.[24]

Table 8 presents the estimates from (3).[25] Each cell represents the results of a separate regression. Estimates in column (1) are based on specifications that only include state and year fixed effects. The estimates in column (2) are based on specifications that add the covariates, and the estimates in column (3) are based on specifications that include state-specific linear time trends. Consistent with the results of Pacula et al. (2015), there is no evidence to support the hypothesis that MMLs increase marijuana use among 15- through 17-year-olds. In fact, the estimates of β_1, although statistically insignificant, are uniformly negative. Likewise, there is no evidence that medical marijuana laws are associated with increased marijuana use among 18- through 20-year-olds.

6. CONCLUSION

From the mid-2000s though 2011, marijuana use among U.S. teenagers increased by 3 to 4 percentage-points (Johnston et al. 2011). Policymakers and law enforcement officials attributed this increase to the adoption of medical marijuana laws (MMLs), arguing that these laws "send the wrong message" and lead young people to underestimate the health risks associated with marijuana use (O'Connor 2011; Roan 2011; Suthers 2012). In contrast, advocates of legalization have argued teenagers find it more difficult to obtain marijuana as drug dealers are replaced by caregivers and dispensaries (Ferner 2012; Sullum 2013).

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[24] Descriptive statistics for the TEDS data are presented in Appendix Table 7.

[25] The slight difference in sample size between estimates for 15- through 17-year-olds and 18- through 20-year-olds is due to missing values.

In order to examine the relationship between MMLs and youth consumption, we draw on data from the national and state Youth Risk Behavior Surveys (YRBS) for the years 1993-2011. These data cover a period when 16 states, including California, Colorado, Montana, Oregon and Washington, legalized medical marijuana, and allow us to estimate the effect of legalization on outcomes such as marijuana use in the past month, frequent marijuana use, and the use of marijuana on school property.

Our results are not consistent with the hypothesis that the legalization of medical marijuana caused an increase in the use of marijuana among high school students. In fact, estimates from our preferred specification are small, consistently negative, and are never statistically distinguishable from zero. Using the 95 percent confidence interval around these estimates suggests that the impact of legalizing medical marijuana on the probability of marijuana use in the past 30 days is no larger than 1.5 percentage points, and the impact of legalization on the probability of frequent marijuana use in the past 30 days is no larger than 0.8 percentage points. In comparison, based on nationally representative data from Monitoring the Future, marijuana use in the past 30 days among 12th graders increased by 4.3 percentage points from 2006 to 2011 (Johnston et al. 2011); based on national YRBS data, marijuana use among high school students increased by 3.4 percentage points from 2007 to 2011.

In addition to the YRBS analysis, we examine data from the National Longitudinal Survey of Youth 1997 (NLSY97) and the Treatment Episode Data Set (TEDS). The NLSY97 allows us to follow survey respondents over time, while the TEDS data allow us to examine marijuana use among a high-risk population. Consistent with the results of (Pacula et al. 2014), we find little evidence that marijuana use is related to the legalization of medical marijuana in either of these data sources.

Although our estimates do not lend support to the often-voiced argument that legalization leads to increased consumption of marijuana among teenagers, it is important to note that our study has at least one limitation: the YRBS data run through 2011 and the TEDS data only run through 2009. In the past few years several states have seen dramatic changes to the market for medical marijuana. For instance, the number of providers in Montana plummeted after Drug Enforcement Agency raids and the passage of SB 423 (the "Montana Marijuana Act"). As future waves of the YRBS are released, researchers will be in a position to update our estimates and explore whether these changes have affected the behavior of teenagers.

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Figure 1. Past 30 Day Marijuana Use
National YRBS 1993-2011
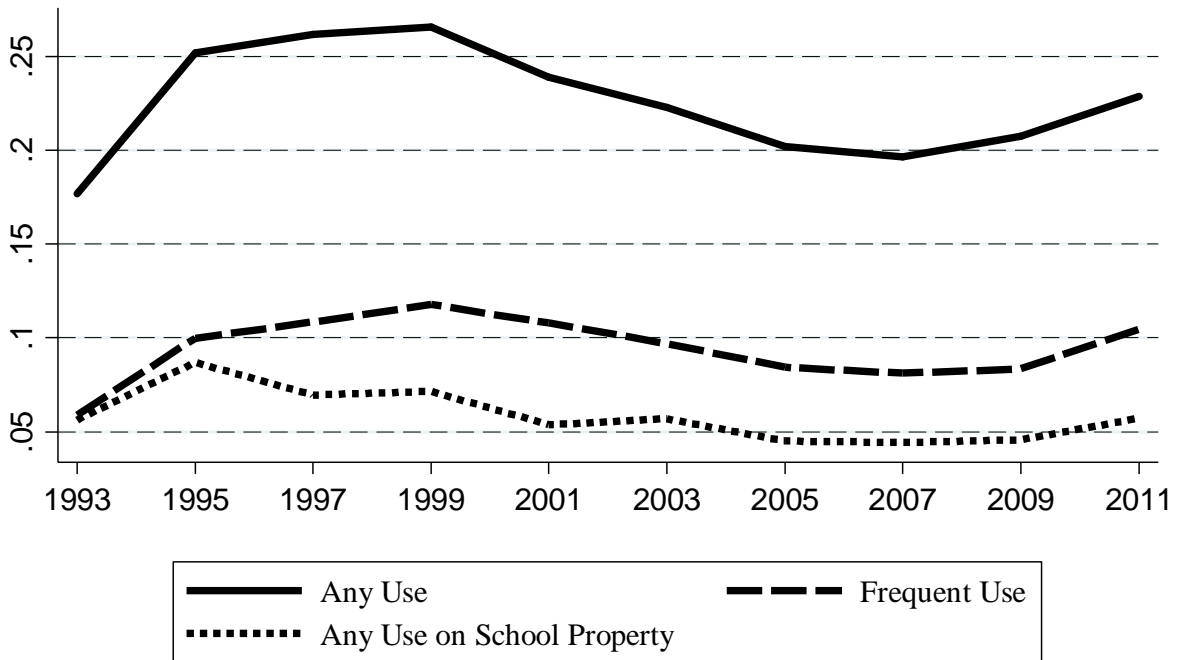
Notes: Based on weighted data from the national YRBS. Appendix Table 1 presents information on which states passed a MML between 1993 and 2011

Figure 2. Past 30 Day Marijuana Use
State YRBS 1993-2011
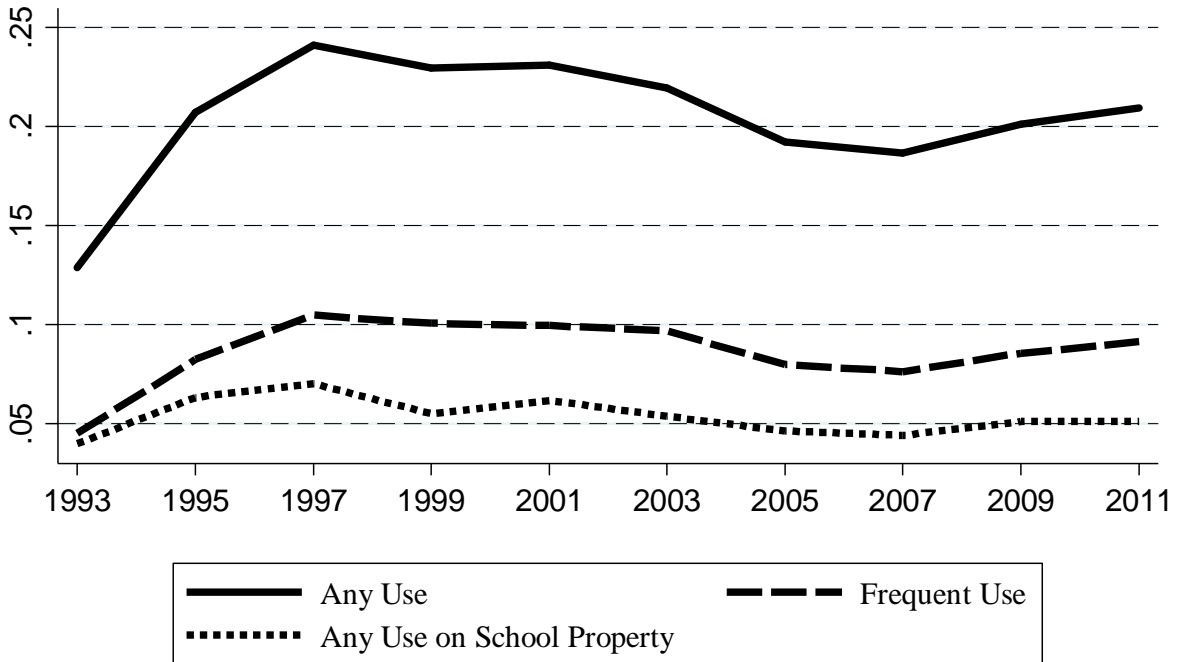
Any Use — Frequent Use — Any Use on School Property

Notes: Based on unweighted data from the state YRBS. Appendix Table 1 presents information on which states passed a MML between 1993 and 2011

Figure 3. Past 30 Day Marijuana Use
National YRBS 1993-2011
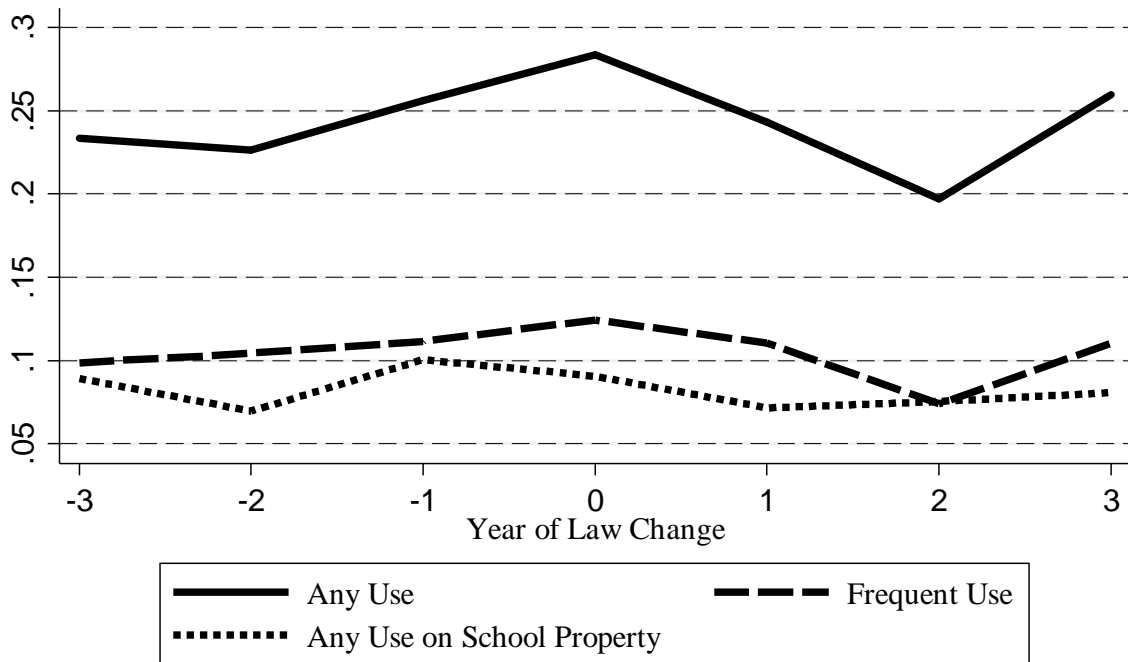
Notes: Based on unweighted data from the national YRBS. Appendix Table 1 presents information on which states passed a MML between 1993 and 2011

Figure 4. Past 30 Day Marijuana Use
State YRBS 1993-2011
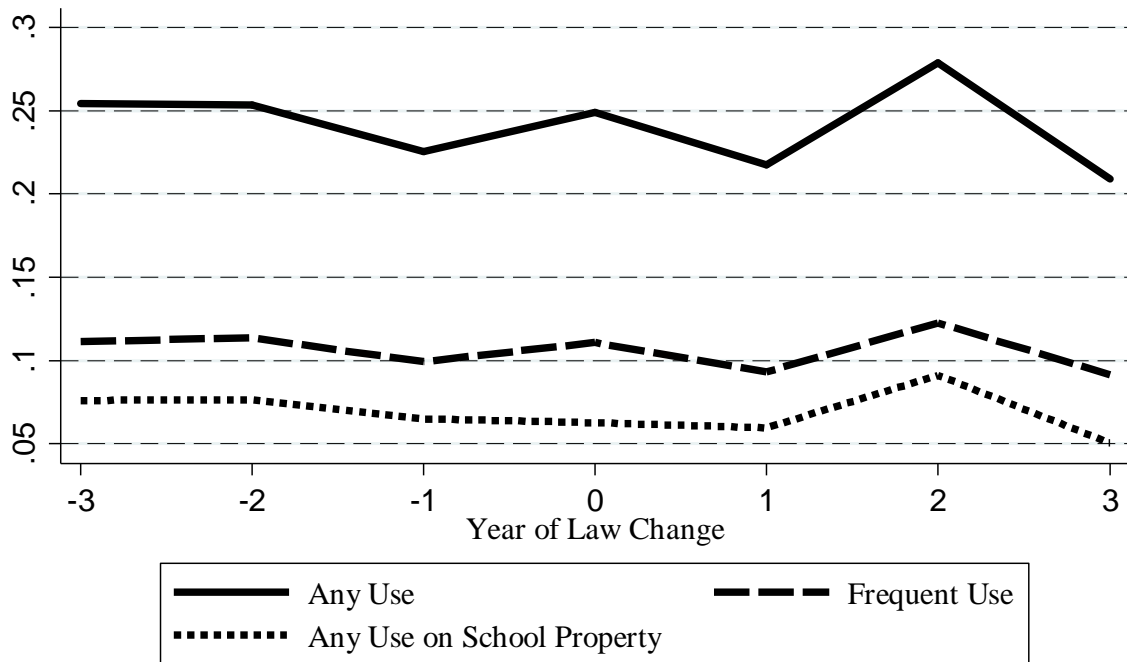
Notes: Based on unweighted data from the state YRBS. Appendix Table 1 presents information on which states passed a MML between 1993 and 2011

Table 1. Descriptive Statistics: YRBS 1993-2011

	National YRBS		State YRBS		
	MML = 1	MML = 0	MML = 1	MML = 0	Description
Dependent Variables					
Marijuana Use in Past 30 Days	.234	.220	.223	.198	= 1 if respondent has used marijuana in the past 30 days, = 0 otherwise
Frequent Marijuana Use in Past 30 Days	.094	.092	.098	.083	= 1 if respondent has used marijuana at least 10 times in the past 30 days, = 0 otherwise
Marijuana Use at School in Past 30 Days	.072	.061	.061	.050	= 1 if respondent has used marijuana at school in the past 30 days, = 0 otherwise
Offered, Sold, or Given Drug on School Property	.318	.263	.248	.255	= 1 if respondent has been offered, sold, or given an illegal drug at school in the past year, = 0 otherwise
Independent Variables					
Age	16.0	16.2	15.8	16.0	Age of respondent
Male	.485	.490	.489	.484	= 1 if respondent is male, = 0 if respondent is female
Grade 9	.249	.240	.267	.287	= 1 if respondent is in 9th grade, = 0 otherwise
Grade 10	.238	.246	.258	.271	= 1 if respondent is in 10th grade, = 0 otherwise
Grade 11	.253	.256	.237	.240	= 1 if respondent is in 11th grade, = 0 otherwise
Grade 12	.259	.256	.202	.195	= 1 if respondent is in 12th grade, = 0 otherwise
Black	.079	.261	.040	.156	= 1 if respondent is black, = 0 otherwise
White	.324	.435	.702	.640	= 1 if respondent is white, = 0 otherwise
Other Race	.597	.304	.259	.204	= 1 if respondent is not white or black, = 0 otherwise
Decriminalization	.812	.195	.321	.227	= 1 if state has decriminalized marijuana, = 0 otherwise
BAC 0.08 Law	.963	.589	.978	.683	= 1 if state has a BAC 0.08 law, = 0 otherwise
Beer Tax	.182	.285	.229	.258	State real beer tax (2000 dollars)
Real State Income	10.4	10.2	10.3	10.3	Natural logarithm of state real income per capita
Unemployment Rate	7.61	5.96	6.74	5.78	State unemployment rate
N	23,688	118,439	121,307	599,261	

Notes: Means are based on unweighted data from the national and state YRBS (1993-2011).

Table 2. Medical Marijuana Laws and Youth Consumption, 1993-2011

	National YRBS			State YRBS			Combined National and State		
Panel A: Marijuana Use in Past 30 Days									
MML	-.056***	-.047***	-.029	-.010	-.010	-.005	-.017*	-.017**	-.007
	(.019)	(.014)	(.026)	(.007)	(.007)	(.005)	(.009)	(.008)	(.011)
N	142,127	142,127	142,127	720,568	720,568	720,568	862,695	862,695	862,695
Panel B: Frequent Marijuana Use in Past 30 Days									
MML	-.035**	-.030***	-.016	-.004	-.004	-.001	-.008	-.009	-.004
	(.015)	(.011)	(.018)	(.004)	(.004)	(.004)	(.006)	(.005)	(.006)
N	142,127	142,127	142,127	720,568	720,568	720,568	862,695	862,695	862,695
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
State-specific trends	No	No	Yes	No	No	Yes	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 3. Medical Marijuana Laws and Youth Consumption by Gender

	National YRBS		State YRBS		Combined National and State	

Panel A: Marijuana Use in Past 30 Days

	Male	Female	Male	Female	Male	Female
MML	-.029	-.028	.001	-.011	-.004	-.010
	(.026)	(.027)	(.008)	(.008)	(.012)	(.012)
N	69,575	72,552	349,184	371,384	418,759	443,936

Panel B: Frequent Marijuana Use in Past 30 Days

	Male	Female	Male	Female	Male	Female
MML	-.014	-.016	.0005	-.003	-.002	-.005
	(.020)	(.016)	(.005)	(.003)	(.008)	(.006)
N	69,575	72,552	349,184	371,384	418,759	443,936
State FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trends	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 4. Medical Marijuana Laws and Youth Consumption by Age Group

	National YRBS		State YRBS		Combined National and State	

Panel A: Marijuana Use in Past 30 Days

	Age < 17	Age ≥ 17	Age < 17	Age ≥ 17	Age < 17	Age ≥ 17
MML	-.046**	-.005	-.010	-.005	-.009	-.009
	(.023)	(.036)	(.006)	(.008)	(.010)	(.015)
N	81,524	60,603	468,569	251,999	550,093	312,602

Panel B: Frequent Marijuana Use in Past 30 Days

	Age < 17	Age ≥ 17	Age < 17	Age ≥ 17	Age < 17	Age ≥ 17
MML	-.018	-.013	-.003	-.008	-.004	-.011
	(.016)	(.021)	(.003)	(.006)	(.006)	(.008)
N	81,524	60,603	468,569	251,999	550,093	312,602
State FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trends	Yes	Yes	Yes	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 5. Medical Marijuana Laws and Access to Marijuana at School

	National YRBS	State YRBS	Combined National and State
Panel A: Marijuana Use at School in Past 30 Days			
MML	-.014	-.005**	-.005
	(.017)	(.002)	(.006)
N	142,156	655,479	797,635
Panel B: Offered, Sold, or Given an Illegal Drug on School Property in Past Year			
MML	-.023	-.021**	-.020**
	(.017)	(.009)	(.008)
N	143,406	703,522	846,928
State FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
Covariates	Yes	Yes	Yes
State-specific trends	Yes	Yes	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 6. Descriptive Statistics: NLSY97

	MML = 1	MML = 0	Description
Dependent Variables			
Marijuana Use in Past 30 Days	.161	.145	= 1 if respondent has used marijuana in the past 30 days, = 0 otherwise
Frequent Marijuana Use in Past 30 Days	.061	.058	= 1 if respondent has used marijuana at least 10 times in the past 30 days, = 0 otherwise
Independent Variables			
Age	16.8	16.6	Age of respondent
No High School Degree	.728	.771	= 1 if respondent has no high school degree, = 0 otherwise
GED/High School Degree	.271	.228	= 1 if respondent has a GED or a high school degree, = 0 otherwise
Over High School Degree	.001	.000	= 1 if respondent has more than a high school degree, = 0 otherwise
Decriminalization	.909	.225	= 1 if state has decriminalized marijuana, = 0 otherwise
BAC 0.08 Law	.920	.326	= 1 if state has a BAC 0.08 law, = 0 otherwise
Beer Tax	.208	.261	State real beer tax (2000 dollars)
Real State Income	10.4	10.3	Natural logarithm of state real income per capita
Unemployment Rate	5.74	4.45	State unemployment rate

Notes: Means are based on unweighted data from the National Longitudinal Survey of Youth 1997.

Table 7. Medical Marijuana Laws and Youth Consumption: Evidence from the NLSY97

Panel A: Marijuana Use in Past 30 Days

MML	.001	.007	-.004
	(.016)	(.018)	(.022)
N	40,986	40,986	40,986

Panel B: Frequent Marijuana Use in Past 30 Days

MML	.011	.013	.008
	(.010)	(.011)	(.014)
N	40,986	40,986	40,986
Individual FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
Covariates	No	Yes	Yes
State-specific trends	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the National Longitudinal Survey of Youth 1997; the covariates are listed in Table 6. Standard errors, corrected for clustering at the state level, are in parentheses.

Table 8. Medical Marijuana Laws and Marijuana Use Among Individuals Admitted to a Drug Treatment Facility

	Admission Rate, Ages 15-17	Admission Rate, Ages 15-17	Admission Rate, Ages 15-17
MML	-.027	-.034	-.067
	(.120)	(.113)	(.115)
N	1,737	1,737	1,737
R^2	.608	.852	.909

	Admission Rate, Ages 18-20	Admission Rate, Ages 18-20	Admission Rate, Ages 18-20
MML	-.045	-.026	-.061
	(.068)	(.068)	(.051)
N	1,756	1,756	1,756
R^2	.493	.873	.899
State FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
Covariates	No	Yes	Yes
State-specific trends	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the Treatment Episode Data Set (1992-2009). The dependent variable is equal to the natural log of the sex-specific admission rate for individuals reporting marijuana as their primary, secondary, or tertiary substance of abuse; the covariates are listed in Appendix Table 7. Regressions are weighted using the relevant state age- and gender-specific populations. Standard errors, corrected for clustering at the state level, are in parentheses.

Appendix Table 1. Medical Marijuana Laws, 1993-2011

	Effective date
Alaska	March 4, 1999
Arizona	April 14, 2011
California	November 6, 1996
Colorado	June 1, 2001
Delaware	May 13, 2011
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: Connecticut, Illinois, Maryland, Massachusetts and New Hampshire
legalized medical marijuana after 2011.

Appendix Table 2. Number of Observations by State-Year: National YRBS

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	Total
AL	783	97	784	55	307	635	…	476	1,036	313	4486
AZ*	429	…	1,085	130	399	341	280	603	353	*1,098*	4718
AR	393	284	362	…	…	272	…	412	297	…	2020
CA*	2,091	1,170	*1,948*	*2,445*	*2,157*	*1,698*	*1,531*	*2,077*	*2,754*	*1,812*	19,683
CO*	257	99	267	…	*643*	…	…	…	*190*	242	1698
CT	…	…	218	…	…	…	231	…	…	…	449
DE*	…	212	…	…	…	361	…	…	…	*226*	799
DC*	…	504	…	…	…	…	…	…	…	*298*	802
FL	516	533	668	852	1,048	1,397	533	735	222	1,374	7878
GA	896	435	341	804	480	409	1,804	344	1,303	128	6944
HI*	…	…	…	303	…	…	…	…	*229*	…	532
ID	…	…	…	…	155	…	238	…	…	260	653
IL	703	238	…	225	431	313	475	580	1,463	975	5403
IN	…	…	…	…	178	411	169	395	…	268	1421
IA	…	241	778	…	…	…	237	245	…	…	1501
KS	170	…	203	…	…	313	276	…	197	295	1454
KY	…	…	…	…	…	…	528	357	…	212	1097
LA	…	279	573	611	…	681	156	…	423	…	2723
ME*	247	151	236	*197*	*203*	*197*	…	…	…	…	1231
MD	144	…	809	…	…	260	…	…	…	…	1213
MA	357	271	1,616	…	251	211	256	710	…	283	3955
MI*	144	1,084	499	514	337	392	287	297	*315*	622	4491
MN	320	…	…	…	…	…	95	…	186	…	601
MS	353	478	327	628	339	…	…	348	…	93	2566
MO	181	544	…	551	461	261	102	345	85	343	2873
MT*	…	…	…	…	206	…	…	…	…	…	206
NE	396	…	…	…	…	…	…	…	…	…	396
NV*	…	…	…	…	*234*	…	…	…	*380*	199	813
NJ*	…	…	727	234	218	298	310	673	474	*113*	3047
NM*	657	…	278	…	153	100	…	*219*	*598*	…	2005
NY	1,225	510	356	710	300	898	457	900	1,165	626	7147
NC	296	114	332	508	664	…	631	560	…	1,087	4192
OH	524	548	543	556	223	290	271	…	…	…	2955

Appendix Table 2. Number of Observations by State-Year: National YRBS (continued)

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	Total
OK	…	…	223	…	394	…	232	278	…	…	1127
OR*	188	…	…	…	*184*	…	*268*	…	*243*	…	883
PA	357	659	271	481	…	316	411	211	1,046	423	4175
RI*	…	…	…	74	…	…	…	…	…	…	74
SC	391	…	517	783	…	877	284	…	…	…	2852
SD	…	…	…	…	…	296	…	…	…	…	296
TN	512	346	571	263	593	…	392	162	…	286	3125
TX	2,723	1,648	941	2,686	2,016	2,583	1,709	1,444	1,318	1,737	18805
UT	…	…	…	…	…	178	271	195	…	…	644
VT*	…	…	…	…	…	249	…	…	…	…	249
VA	…	64	…	727	…	242	345	426	96	201	2101
WA*	374	82	104	…	*52*	…	*101*	…	*246*	*166*	1125
WV	301	…	…	…	262	…	228	245	460	254	1750
WI	…	…	289	526	236	177	240	178	676	647	2969

Notes: States that legalized medical marijuana are denoted with a star superscript and post-legalization observations are italicized.

Appendix Table 3. Number of Observations by State-Year: State YRBS

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	Total
AL	4,292	3,821	3,642	2,013	1,502	1,041	1,050	...	1,392	1,317	20,070
AK*	...	1,576	...	...	...	1,413	...	1,235	1,198	1,238	6,660
AZ*	...	...	...	...	...	...	1,859	1,622	1,458	1,892	6,831
AR	...	2,217	1,942	1,429	1,657	...	1,449	1,520	1,560	1,277	13,051
CO*	...	...	...	...	...	...	1,456	...	1,445	1,392	4,293
CT	...	...	1,696	...	...	...	2,107	1,944	2,272	1,945	9,964
DE*	...	...	...	2,297	2,820	2,929	2,589	2,328	2,204	2,129	17,296
FL	...	...	...	...	4,070	3,923	4,370	...	5,264	5,796	23,423
GA	...	...	...	...	...	2,007	1,672	2,297	1,754	1,798	9,528
ID	3,907	...	...	...	1,668	1,680	1,402	1,355	2,081	1,637	13,730
IL	3,938	3,003			...	...	...	2,280	2,863	3,355	15,439
IN	...	...	...	...	...	1,615	1,498	2,219	1,456	2,727	9,515
IA	...	...	1,509	...	...	...	1,340	1,413	...	1,506	5,768
KS	...	...	...	...	...	...	1,619	1,666	1,975	1,798	7,058
KY	...	...	1,556	...	...	1,539	3,166	3,345	1,671	1,619	12,896
LA	...	...	5,349	...	...	...	...	1,247	944	1,066	8,606
ME*	...	1,373	1,793	...	1,287	1,610	1,296	1,252	8,048	8,625	25,284
MD	...	...	...	...	...	...	1,367	1,447	1,535	2,480	6,829
MA	...	...	...	...	...	3,471	3,268	2,951	2,568	2,579	14,837
MI*	...	...	4,265	2,553	3,454	3,318	3,153	3,349	3,216	3,999	27,307
MS	1,431	1,251	1,461	1,569	1,772	1,454	...	1,517	1,729	1,767	13,951
MO	...	4,775	1,442	1,589	1,621	1,525	1,846	1,495	1,577	...	15,870
MT*	2,458	2,474	2,493	2,858	2,554	2,610	2,936	3,776	1,752	3,937	27,848
NE	3,149	...	...	...	...	2,855	3,645	...	...	2,605	12,254
NV*	1,985	1,492	1,437	1,657	1,404	1,914	1,488	1,700	1,974	...	15,051
NH	2,639	2,114	...	...	...	1,304	1,246	1,560	1,440	1,348	11,651
NJ*	...	...	...	...	2,004	...	1,469	...	1,703	1,596	6,772
NM*	...	...	...	...	...	...	5,270	2,507	4,765	5,543	18,085
NY	...	...	3,645	3,287	...	8,931	9,146	12,361	13,487	12,176	63,033
NC	2,685	1,912	...	...	2,474	2,471	3,766	3,304	5,418	2,145	24,175
ND	...	1,586	...	1,777	1,558	1,631	1,700	1,702	1,768	1,849	13,571
OH	2,408	...	2,166	2,009	...	1,170	1,354	2,386	...	1,335	12,828
OK	...	...	...	...	...	1,348	1,669	2,543	1,372	1,127	8,059
PA	...	...	...	...	...	...	...	...	2,013	...	2,013

Appendix Table 3. Number of Observations by State-Year: State YRBS (continued)

	1993	1995	1997	1999	2001	2003	2005	2007	2009	2011	Total
RI*	...	...	1,462	...	1,340	1,746	2,284	*2,065*	*3,040*	*3,739*	15,676
SC	4,641	5,304	5,341	4,441	...	...	1,234	1,181	1,038	1,359	14,594
SD	1,325	1,169	1,571	1,632	1,559	1,762	1,539	1,543	2,091	1,488	13,185
TN	3,257	...	...	...	...	1,900	1,512	1,996	2,153	2,553	10,114
TX	...	...	...	...	6,852	...	4,030	3,090	3,406	3,924	21,302
UT	4,372	3,193	1,353	1,455	1,023	1,401	1,486	1,868	1,514	1,622	11,722
VT*	...	...	...	...	8,959	7,870	*9,055*	*7,290*	*9,908*	*8,187*	51,269
VA	...	...	...	...	...	...	...	...	...	1,369	1,369
WV	2,772	2,042	1,789	1,452	...	1,716	1,332	1,337	1,549	2,087	11,262
WI	3,201	...	1,292	1,300	2,056	2,073	2,248	2,028	2,373	2,925	16,295
WY	...	1,663	1,993	1,608	2,693	1,507	2,371	2,051	2,726	2,346	17,295

Notes: States that legalized medical marijuana are denoted with a star superscript and post-legalization observations are italicized.

Appendix Table 4. Weighted YRBS Analysis

	National YRBS			State YRBS			Combined National and State		
Panel A: Marijuana Use in Past 30 Days									
MML	-.019	-.016	-.004	-.011**	-.013***	-.003	-.035*	-.035**	-.021
	(.015)	(.013)	(.018)	(.004)	(.005)	(.003)	(.018)	(.013)	(.020)
N	142,127	142,127	142,127	720,568	720,568	720,568	862,695	862,695	862,695
Panel B: Frequent Marijuana Use in Past 30 Days									
MML	-.006	-.005	.014	-.003	-.006	.003	-.024	-.025**	-.015
	(.015)	(.013)	(.015)	(.003)	(.004)	(.003)	(.015)	(.012)	(.015)
N	142,127	142,127	142,127	720,568	720,568	720,568	862,695	862,695	862,695
State FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
State-specific trends	No	No	Yes	No	No	Yes	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. The national YRBS regressions are weighted using the sample weights provided by the CDC. Weights for the state and combined YRBS samples were constructed using population estimates from the National Cancer Institute's Surveillance Epidemiology and End Results Program. Standard errors, corrected for clustering at the state level, are in parentheses.

Appendix Table 5. Sensitivity of Results to Sample Selection

	National YRBS		State YRBS		Combined National and State	
Panel A: Marijuana Use in Past 30 Days *(states with only one year of pre-MML data dropped)*						
MML	-.045***	-.031	-.014*	-.008	-.017*	-.005
	(.014)	(.026)	(.008)	(.005)	(.009)	(.011)
N	138,568	138,568	698,190	698,190	853,818	853,818
MML states contributing data	AZ, CA, CO, DE, ME, MI, NJ, NM, WA		AZ, DE, ME, MI, MT, NV, NJ, RI, VT		AZ, CA, CO, DE, ME, MI, MT, NV, NJ, NM, RI, VT, WA	
Panel B: Marijuana Use in Past 30 Days *(states with one or two years of pre-MML data dropped)*						
MML	-.018	.066***	-.011	-.012*	-.013	.007
	(.019)	(.018)	(.011)	(.006)	(.009)	(.006)
N	118,086	118,086	621,637	621,637	782,617	782,617
MML states contributing data	AZ, CO, ME, MI, NJ, NM, WA		AZ, DE, MI, MT, NV, NJ, RI		AZ, CO, DE, ME, MI, MT, NV, NJ, NM, RI, WA	
State FEs	Yes	Yes	Yes	Yes	Yes	Yes
Year Fes	Yes	Yes	Yes	Yes	Yes	Yes
Covariates	Yes	Yes	Yes	Yes	Yes	Yes
State-specific trends	No	Yes	No	Yes	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the YRBS (1993-2011); the covariates are listed in Table 1. Standard errors, corrected for clustering at the state level, are in parentheses.

Appendix Table 6. Weighted NLSY97 Analysis

Panel A: Marijuana Use in Past 30 Days

MML	-.003	.003	-.010
	(.013)	(.014)	(.022)
N	40,986	40,986	40,986

Panel B: Frequent Marijuana Use in Past 30 Days

MML	.011	.015	.009
	(.011)	(.011)	(.016)
N	40,986	40,986	40,986
Individual FEs	Yes	Yes	Yes
Year FEs	Yes	Yes	Yes
Covariates	No	Yes	Yes
State-specific trends	No	No	Yes

* Statistically significant at 10% level; ** at 5% level; *** at 1% level.

Notes: Each cell represents a separate OLS estimate based on data from the National Longitudinal Survey of Youth 1997; the covariates are listed in Table 6. Regressions are weighted using the sample weights provided by the NLSY97. Standard errors, corrected for clustering at the state level, are in parentheses.

Appendix Table 7. Descriptive Statistics: Treatment Episode Data Set

	MML = 1	MML = 0	Description
Dependent Variables			
Admission Rate, Ages 15-17	1,326	779	Admissions of 15- through 17-year-olds who reported marijuana as their primary, secondary, or tertiary substance of abuse per 100,000 population
Admission Rate, Ages 18-20	817	657	Admissions of 18- through 20-year-olds who reported marijuana as their primary, secondary, or tertiary substance of abuse per 100,000 population
Independent Variables			
Male Rate	.500	.504	= 1 if admissions rate is for males, = 0 otherwise
Decriminalization	.587	.181	= 1 if state has decriminalized marijuana, = 0 otherwise
BAC 0.08 Law	.903	.513	= 1 if state has a BAC 0.08 law, = 0 otherwise
Beer Tax	.258	.256	State real beer tax (2000 dollars)
Real State Income	10.3	10.2	Natural logarithm of state real income per capita
Unemployment Rate	5.72	5.12	State unemployment rate

Notes: Means are based on unweighted data from the Treatment Episode Data Set (1992-2009).