**Assessing the Effects of Medical Marijuana Laws on Marijuana and Alcohol Use:**

**The Devil is in the Details**

by

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Abstract:

This paper sheds light on previous inconsistencies identified in the literature regarding the relationship between medical marijuana laws (MML) and recreational marijuana use by closely examining the importance of policy dimensions (registration requirements, home cultivation, dispensaries) and the timing of when particular policy dimensions get turned on in a state. Using data from our own legal analysis of state MMLs, we evaluate which features are associated with adult and youth recreational use by linking the policy variables to data from the National Longitudinal Survey of Youth (NLSY97), the Youth Risk Behavior Survey (YRBS) and the Treatment Episodes Data System (TEDS). Our analyses control for state and year fixed effects, using state-level policy changes to estimate the effect on changes in our outcome variables. We find that while simple dichotomous indicators are generally negatively associated with use, specific dimensions of MMLs are positively associated with marijuana use in all three datasets. Moreover, these same dimensions are tied to binge drinking and fatal alcohol automobile accidents as well. The findings have important implications for states considering legalization of marijuana, as regulating access to and promotion of retail outlets may be key for reducing the harms associated with these policies.

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## I. Introduction

In November 2012, Colorado and Washington state legalized possession of one ounce or less of marijuana for recreational use by adults (those 21 years or older), and both states are developing guidelines to enable production and sale. At least twelve other states are considering similar policies and arguments for and against these policies are mounting based largely on a thin and conflicting scientific literature of the effects of medical marijuana laws and decriminalization policy on marijuana use and harms. Medical marijuana laws have received particular attention during the legalization debate because of their hypothesized impacts on access to marijuana and perceived harmfulness among key populations, particularly youth (Friese and Grube, 2013; Thurston, Leiberman and Schmiege, 2011). Moreover, many state medical marijuana policies now include provisions for the retail sale of marijuana for medicinal purposes. In parts of some cities like Los Angeles CA and Denver CO, medical marijuana dispensaries are popularly thought to outnumber Starbucks coffee shops (NPR, 2009; The Atlantic Wire 2011). A clear understanding of the impact of medical marijuana laws--particularly aspects relevant for broader legal regulated markets--is imperative for developing coherent public policies pertaining to legalization.

Average levels of marijuana consumption are higher in states with medical marijuana laws (MMLs). In 2004/05, for example, household survey respondents in states with medical marijuana laws were 92% more likely to report using marijuana in the last 12 months than those in non-medical marijuana states (Cerdá et al., 2011). For youth aged 12-17 over the period 2002-2008, prevalence of marijuana use was 25% greater in states with MMLs compared to those states without a MML (Wall et al., 2011). However, just because marijuana use is higher in states that have these laws does not mean that the laws created higher use rates. States with higher prevalence rates may be more likely to pass these initiatives in the first place. Indeed, several studies have shown that there is no statistical relationship (and at times a slight negative relationship) between these laws and recreational use of marijuana when other factors are

accounted for (Harper et al., 2012; Gorman and Huber, 2007). However, other studies examining different years of data and other states show that there remains a positive association between the laws and use for certain populations (Anderson et al., Forthcoming; Cerdá et al 2011).

The purpose of this paper is to carefully examine the impact of medical marijuana laws on marijuana use in the general population and among youth. While a few similar efforts exist (Anderson et al, Forthcoming; Cerdá et al 2011), we are the first to consider how specific medical marijuana provisions regulating cultivation and distribution affect use. We demonstrate the drawbacks of treating medical marijuana laws generically, showing that specific modes of regulation differentially influence consumption, a finding which sheds new light on the inconsistent findings of prior work. More specifically, using a differences-in-differences analysis applied to data from the Youth Behavioral Risk Surveillance System (YRBSS), National Longitudinal Survey of Youth (NLSY), and Treatment Episode Data Set (TEDS), we show that access to dispensaries or home cultivation may increase marijuana consumption, including among youth, even while other forms of medical marijuana legalization appear to reduce consumption. The effects are not consistent across all measures of use in our data sets, suggesting that sampling limitations may also explain some of the disparate past findings regarding the effects of medical marijuana. Our results suggest that the use of a simple dichotomous indicator for legalized medical marijuana in policy research may mask important heterogeneous effects of these laws. Moreover, the measured effects of medical marijuana may be affected by the timing over which policies are being examined, the states being considered in the analysis, and the representativeness of the data drawn from those states.

The remainder of the paper proceeds as follows. In Section II we provide background on medical marijuana laws and these laws' key dimensions. We also summarize the limited research examining the impact of these laws, paying particular attention to past studies' years of analysis and hence their source of legal variation. Section III provides a theoretical framework

for thinking about how medical marijuana laws might influence consumption in the adult population as well as among youth. In Section IV we discuss our data sources, and then present the results from our analyses of the impact of these laws on marijuana use in Section V. Section VI extends our analysis to consider related outcomes, specifically alcohol abuse and fatal automobile accidents. We conclude in Section VII with a summary of our findings and its implications for both medical marijuana policy and legalization proposals.

## II. Background

As of January 1, 2012, 17 states and the District of Columbia had policies recognizing the medicinal value of marijuana and providing a legal defense for patients who used marijuana under the recommendation of a physician. Many early adopting states (those adopting between 1996 and 2000) did so through voter referendum, with such referenda providing little specific guidance about acceptable sources of supply for marijuana. Since then, policies governing medical marijuana, such as the allowance of dispensaries and requirements of patient registration systems, have evolved in fits and starts in response to often competing legislative, administrative, and judicial actions.

Table 1 shows the evolution of certain key dimensions of MML laws across different states through the end of 2011. Specific dimensions considered are whether states require patient registry systems, whether states have allowances for general "pain" rather than just specific medical conditions, whether states legally allow dispensaries, and whether states allow for home cultivation.

Beyond demonstrating which states employ various regulatory approaches, Table 1 also shows that only two early-adopting states (Hawaii and Colorado) have not changed any of these key dimensions relating to access, availability and norms since their policy was initially adopted. Most states, even later adopters, have refined their state policies since initial passage, in

particular with reference to dispensaries. Dispensaries have emerged to a very modest extent in states like Washington and Michigan that do not formally allow dispensaries, and such emergence often precedes a subsequent change in policy. Moreover, in states where dispensaries have been formally protected by state laws (e.g. Colorado and California), the number of dispensaries has exploded, particularly since the 2009 announcement by the U.S. Attorney General that the Justice Department would end raids on distributors who are in compliance with state medical marijuana laws (Ogden, 2012).

Marijuana dispensaries, as well as the competition and commercialization that can emerge with them, can impact recreational use of marijuana through a number of avenues: increased consumer access, normalizing the behavior and lowering perceptions of risk, and – if competition emerges – possible price reductions. However, previous analyses of the effects of MML laws do not consider their specific provisions, and therefore by default treat all laws as if they have the same impact on recreational use. It is perhaps unsurprising that various studies have found substantially different effects of medical marijuana laws on use given that laws have been measured based only on whether a broad policy is adopted. The fact that the literature ignores important changes over time in elements of state law that likely impact access has contributed to the lack of consistent results.

Many early studies of medical marijuana laws find no significant impact of marijuana use on consumption, but none of the early laws had formal allowances for dispensaries or systematically regulated supply. For example, Khatapoush and Halfors (2004) use a pre-post design for the period 1995-1999 to assess the impact of California's medical marijuana law adopted in 1996. Using data from over 15,000 telephone surveys of young adults in 41 communities, they assess whether California's law affected perceived availability and harmfulness, approval of marijuana, or past-month recreational use among Californians as compared to residents of ten other non-MML states. The only significant difference in outcomes is in perceived harm, which fell more in California over time than in other states. While California

had higher use rates of marijuana than other states, the average difference in trends did not change. They conclude that California's medical marijuana law had no significant impact on recreational marijuana use among young adults.

Gorman and Huber (2007) use data from a slightly longer time period (1995-2003), but restrict their analysis to data in just four early adopting states (California, Colorado, Oregon, and Washington) and look for structural breaks in state-specific quarterly counts of arrestees and marijuana-involved emergency department (ED) episodes following medical marijuana adoption. The authors find that initial passage of medical marijuana laws did not measurably change either indicator of marijuana use. However, they note that they have a very short post-reform time period for Colorado, which was the only state formally allowing dispensaries included in the study.

Harper, Strumpf and Kaufman (2012) examine a later period of policy change, looking over the period 2003-2008 at MML adoption's impact on adolescent self-reported marijuana use and perceived harmfulness using aggregated National Survey on Drug Use and Health (NSDUH) state data. First replicating and then improving upon an earlier descriptive study by Wall et al., (2011), Harper et al. (2012) use a difference-in-differences approach with year and state fixed effects to control for time-stable unobserved heterogeneity at the state level. They find that state MMLs have no statistically significant effect on perceived harmfulness among 12-17 year olds over the time period 2002-2008. When they expanded their sample with an extra year of data and more carefully looked at impacts of these laws across various age groups (12-17 year olds; 18-25 year olds, and 26+), they found no statistically significant impact of the state MML policy on any age group.

The importance of considering differences in responses to these policies by age was also underscored in a study by Anderson and Rees (2011), which identified impacts of the MML policies using NSDUH aggregated data during a period when just three states adopted new policies: Rhode Island (RI), Vermont (VT) and Montana (MT). This work shows similar results of

no statistically significant effect on minors (aged 12-17), but positive effects of the policies on older young adults. They find the law in Montana and Rhode Island increased use for those 18 years and older.

Anderson, Hansen, and Rees (2012) use a similar difference-in-differences approach to Harper et al. (2012), but employ a much longer panel of data from the 1993-2009 Youth Risk Behavior Survey (YRBS). In general, models making use of both the state and national YRBS data (which represents respondents between the ages of 12- 17) show no statistically significant effect of the MML policy on thirty day prevalence of use. In fact, in some specifications, the authors find the policies are negative and statistically significant. However, because YRBS participation varies across years, the authors only have eight MML states with pre- and post-policy adoption data in each of the national and state samples. The Anderson et al. (2012) paper is unique in its efforts to replicate findings in a variety of other data sets and in considering different margins of use. Additional analyses are conducted making use of individual longitudinal data from the National Longitudinal Survey of Youth 1997 (NLSY97) and the 1992-2009 Treatment Admissions Data Set (TEDS) were consistent with the YRBS analysis.

Chu (2012) uses data from 1988-2008 and a differences-in-differences analysis to consider the effect of MML on two other proxies for use—marijuana arrests and marijuana rehabilitation treatments. In contrast to other studies, Chu finds evidence a strong effect of legalization on both outcomes, with increases in admissions observed among juveniles as well as adults. While Chu's use of administrative data arguably alleviates some concerns related to self-reporting, a drawback of this analysis is that it confounds any direct impact of MML on use with concomitant responses of law enforcement or health care providers to legal change.

All these prior studies treat MMLs as a homogenous set of laws. This paper, in contrast, recognizes that not all medical marijuana policies are homogenous and that important policy

dimensions are not static.[1] We use variation in the timing of the core elements of MML policy shown in Table 1 to assess whether particular forms of regulation are more relevant for use. We also consider whether a more nuanced analysis of the attributes of these laws can explain the apparent inconsistent findings to date regarding the effects of these laws on use. Moreover, like Anderson et al. (forthcoming), we consider multiple measures of use, allowing us to consider both overall prevalence and patterns of use for different subpopulations of interest. Considering different margins of use is potentially valuable in light of national data showing relatively little change in thirty-day prevalence rates of marijuana use during the 2000s, but large increases in near-daily use, particularly among juveniles (SAMHSA, 2012).

## III. Theoretical Framework

To the extent that medical marijuana laws influence either (a) the perceived harmfulness of marijuana or (b) social availability of marijuana through home cultivation or dispensaries, they can indirectly influence demand by shifting a taste parameter of the utility function or changing the full price an individual faces for using marijuana. If we let *M* represent marijuana consumption, *O* represent a vector of other substance use (e.g. alcohol), and *C* represent a general composite consumption good, we can write the individual's maximization problem as follows[2]:

(1) $Max_{\{C, M, O\}}\ U(C) + bV(M, O)$

subject to:

[1] Other studies *have* been published evaluating the impact of these laws on particular populations employing less rigorous sample designs or methods (Thurstone, 2011; Cerda et al 2012; Friese and Grube, 2013). In general, they too have found conflicting results. Given the methods are less rigorous than those discussed here, we simply note that these studies contribute to the general point of conflicting evidence in the literature.

[2] The current static analysis ignores the influence of habit formation on demand for marijuana and other illicit substances. There is some empirical evidence that marijuana is habit forming (e.g. Pacula, 1998); however, research suggests that about 1 in 10 users who ever use the drug will actually become dependent, a relatively small fraction of the user group (Hall et al, 2001). Hence this additional level of complexity is omitted from the current model.

(2) $Y = C + P_M M + P_O O$

(3) $b = f(H_i, A_i, \gamma_i, Z, \varepsilon)$ *for* $i = M, O$.

Following other models of substance use, utility is presumed to be separable in the consumption of drugs and all other goods. Hence, $U$ and $V$ in equation (1) are subutility functions, where $U' > 0$, $U'' < 0$, $V_i > 0$ and $V_{ii} < 0$ for $i = M, O$.[3] The vector $b$ represents individual-level factors that influence the marginal utility of consuming marijuana and other substances, as is indicated by equation (3). The marginal utility of consuming marijuana and other substances is a function of the individual's perceptions regarding the harm of using specific substances ($H_i$), the social availability of the drug ($A_i$), the legal risks associated with consuming each drug ($\gamma_i$), individual observable characteristics, such as age or marital status ($Z$), and unobservable factors that influence an individual's "tastes" for drugs ($\varepsilon$), such as thrill-seeking behavior. It is assumed that the individual error term, $\varepsilon$, is *i.i.d.* with a mean of zero.

Equation (2) specifies the individual's budget constraint, with $Y$ representing the individual's income and $P_M$ and $P_O$ representing the monetary price of marijuana and other substances consumed, respectively. Because marijuana is generally illegal to use and is believed to impose negative health consequences to the individual (Hall, 2009; Hall and Degenhardt, 2009), the monetary price of purchasing marijuana does not represent its full cost to the user. Additional costs include the health risks ($H_M$) and legal risks ($\gamma_M$) of consuming the substance. However, these additional costs are not typically paid for through market transactions and therefore represent nonpecuniary aspects of the full price.[4] They cannot

[3] An implicit restriction imposed by the use of separable utility functions is that marijuana or other substance use is not allowed to increase the marginal utility of consuming other goods, such as leisure time. This is likely to be a rigid assumption that should be explored in future research.

[4] The monetary price of marijuana or any illicit drug reflects only those costs and risks borne by the seller in the black market. The actual monetary price charged will likely differ from consumer to consumer, based on the seller, the ability of the buyer to judge quantity and quality, and the history between the buyer and seller. For more about prices in drug markets see Caulkins (1994, 1995).

therefore be represented through the budget constraint and are instead represented as individual-specific shift parameters to the marginal utility of consuming marijuana. Higher nonpecuniary costs are presumed to lower the marginal utility of consuming marijuana, or $\partial b / \partial H < 0$ and $\partial b / \partial \gamma < 0$.

The influence of medical marijuana laws (*MedMJ*) on perceived harm $(H_M)$ and social availability ($A_M$) can be incorporated into this model by noting that these parameters are themselves a function of several additional factors. The individual's perceptions of the risk of using marijuana on an occasional or regular basis is likely to be a function of the individual's own information set of the health benefits and risks of marijuana, the prevailing social norms regarding the use of marijuana , and other individual personality factors that influence the individual's receptivity to these different information sources. The presence of medical marijuana laws is presumed to reduce perceptions of harm from regular marijuana use by providing a medical justification for its use, thus causing marijuana to be seen more for its positive attributes and less for the negative ones. This implies that $\partial H_M / \partial (MedMJ) < 0$.

The social availability of marijuana to the individual can similarly be written as a function of several other factors, including the individual's exposure to peers and/or family members who use marijuana and the prevailing social norms regarding use of marijuana. To the extent that medical marijuana laws expose youth to more adults and/or peers who use the substance or to the extent that these laws enable home cultivation by friends, family and/or peers, these laws are likely to increase its social availability. This implies that $\partial A_M / \partial (MedMJ) > 0$.

Ideally, we would like to estimate a system of models that enable us to simultaneously evaluate demand equations associated with the maximization problems described in equations (1)-(3) as well as the perceived harm and perceived availability. The problem is that sufficient data do not exist for us to capture all the relevant domains and uniquely identify each of the

mechanisms. Moreover, measures of general access and perceived harm are often not available for an individual's immediate peer group and hence are proxied through aggregated measures at a school or state level. Thus, we estimate here a reduced form of the model given by:

(4) $M = M\{P_M, P_O, Y, H(MedMJ), A(MedMJ), \gamma_M, Z; \varepsilon\}$

The model is first estimated with state aggregated measures of consumption so as to generate models that are consistent with previous studies, and then where our data permits, we also estimate individual level demand equations.

## IV. Data and Empirical Specification

To study the association of medical marijuana laws and its different dimensions on utilization, we employ a variety of data sets. The results from each data set should provide complementary evidence given that each has its strengths and weaknesses.

### 4.1: National Longitudinal Survey of Youth (NLSY97).

The NLYSY97 provides individual-level data on a host of outcomes, including detailed information on marijuana and alcohol use over the past 30 days. In our analysis, we were able to use data from 1997-2009. The NLSY only follows a single cohort consisting of a population between the ages of 12 and 17 in 1997. This cohort is followed for the entire sample. A limitation of this type of data, especially when compared to repeated cross-sections which are resampled, is that the sample is constantly aging. Consequently, our sample is a different age when studying the effects of late-adopting states compared to earlier-adopting states. The primary advantage of the data is the richness of the outcome variables, which includes the number of days in the previous 30 days in which the individual used marijuana.

These data are also not representative at the state-level. However, our analysis will study *changes* in individual-behavior, reducing concerns that this affects the validity or interpretation of our estimates.

4.2. *Youth Risk Behavior Surveillance (YRBS) System*.

The YRBS System surveys high school students on a host of risky behaviors, including alcohol and drug use. The data are repeated cross-sections, available biennially for 1991-2011. State participation is not consistent so it is common for a state to provide data in one wave but not the next. Many states require permission to access their state's YRBS data from the CDC and previous studies have noted difficulties and delays in receiving data from all states (Anderson et al., 2012). These data provide individual-level information. However, aggregated state-year statistics are available from the CDC without state-level permission using their Youth Online application (http://apps.nccd.cdc.gov/youthonline). We use these data for our analysis. The individual-level files do not provide much demographic information that can be used in our regression analysis so little is lost using these aggregated numbers (furthermore, the Youth Online provides the data at detailed demographic levels). Using these data allows us to maximize the number of state-years covered. Our final data include the fraction of high school students in state-year that have used marijuana (alcohol) in the previous 30 days.

4.3. Treatment Episode Data Set (TEDS).

The TEDS provides demographic and substance abuse characteristics of admissions to alcohol and drug treatment facilities. The data include the substance or substances that the individual is being treated for. The TEDS only includes treatment centers which receive public funding. Assuming that the prevalence of public funding for treatment centers is not systematically related with medical marijuana law adoption, this coverage issue should not bias our results since we will be including state fixed effects in our analysis. Furthermore, the data

note whether an individual is referred by the criminal justice system. We will use this variable to check whether changes in criminal justice policy are affecting our results.

The TEDS provides annual data and our analysis uses 1992-2008. State reporting is relatively consistent in the TEDS. The outcome variable for the TEDS analysis is the number of treatments in which marijuana (alcohol) is the primary substance of abuse. This outcome is different from utilization but is an interesting dimension of marijuana use on its own.

Anderson et al (2012) are careful to note the limitations of the state and national YRBS for evaluating the effects of MMLs, but with this exception authors have been less explicit in their papers in terms of acknowledging the source of identification for their evaluation of MML policy effects in the data they use. We show in Table 2 the states in which we have pre and post policy implementation data for each of the data sets used in our analysis (YRBS, NLSY and TEDS) in addition to the NSDUH, which has been used by other researchers. What can be seen in Table 2 is that use of a particular data set in essence identifies the states from which identification will be obtained, due to the limitations in terms of coverage of each of them.

In the NLSY, there is fairly good inclusion of individuals across many states that adopt a policy within the survey window. However, because the NLSY is a longitudinal survey, the policies are changing when individuals are in general older than 19 years of age – not when they are youth. Moreover, this is well past the average age of initiation of marijuana in the US (SAMHSA, 2011), so behavior is being examined among late initiates or established users. The sensitivity to policy changes for these two groups could arguably be different than that of young adults (18-24) or youth in general. The state YRBS, as noted by Anderson et al (2012), has good coverage for many states that adopt policies and consistently evaluates impact on school age children. However, important early adopting states like California and Washington are missing from the sample. Because of changes in the sampling frame of the NSDUH survey, state aggregate measure so use are only available from 2002 forward. Thus, studies making

use of these policies completely miss the impacts of early adopting states (and if these states are included in the control group, they could completely bias the difference-in-differences approach due to refinements to the early policies that occur after 2002). The TEDS, however, does not suffer from these sorts of problems as data have been systematically collected since before any of the state policies have been adopted. However, the TEDS data capture use behavior on a much different margin than simple prevalence estimates do, so it is entirely possible that findings observed in TEDS would not necessarily hold for general prevalence estimates.

Keeping in mind these caveats, we show in Table 3 the mean values of each of our measures of marijuana and alcohol use in our primary data sets. Consistent with what has been reported elsewhere, we find higher rates of marijuana use among individuals living in states that have adopted MMLs than in states that do not have these policies. This is broadly true across all data sets. However, we do not find the same consistent story across data sets in terms of alcohol use (perhaps indicative of the age of the samples included in each of the data sets). We see that for the NLSY and TEDS data (the data sets including people of older ages), alcohol use is also higher in states that have adopted MML policies on average. In the YRBS, which only includes 12-17 year olds in every way, alcohol use rates are generally lower in states that have MML policies. The fact that there are important differences in simple descriptive statistics for each of these data sets suggests that controlling for unobservable state factors will be important for the analysis.

### *4.4 Empirical specifications*

For all data sets, we use state-level changes in medical marijuana policy to identify the relationship between that policy and marijuana utilization. We implement this by including state and year fixed effects in all regressions to perform a difference-in-differences analysis.

For the NLSY, we have data at the individual level and thus we estimate logistic regression models of self-reported marijuana use as a function of medical marijuana policies, beer and cigarette taxes, state fixed effects, year fixed effects and a variety of individual factors including gender, race/ethnicity, age, and educational attainment.

In the YRBS, we use state aggregated prevalence rates and study the relationship between the fraction of students using marijuana in the past 30 days and MML. We model this relationship through the use of a Poisson regression, which provides consistent evidence when the expected value of the outcome variable is modeled correctly (Silva and Tenreyro (2006)). We estimate

$$y_{st} = \exp(\alpha_s + \gamma_t + X'_{st}\delta + \beta \times MML_{st})\epsilon_{st} \quad (5)$$

The TEDS analysis uses the same specification. The outcome variable is the number of admissions in the state-year.

Controls that are included in these models include dimensions of medical marijuana laws, a vector of state time-varying factors (including age distribution within the state, proportion that are male, proportion that are criminal justice referral for the state, the median income within the state, beer taxes, cigarette taxes and the state unemployment rate), state fixed effects and year dummy variables. All standard errors in our analysis are adjusted for clustering at the state-level.

## V. Results

Coefficient estimates from logistic models of thirty day prevalence and near daily use of marijuana in the YRBS and NLSY are presented in Table 4. The top part of the table provides results for the entire sample, while the bottom portion of the table provides results for those

under the age of 21 in the NLSY (for greater comparability to the YRBS). In columns (1), (3) and (6) we estimate models that simply include the MML policy variable as a single dichotomous indicator, consistent with how it has been evaluated in previous studies. We see that regardless of whether we use the NLSY or YRBS or if we look at simple past month prevalence or heavy use of marijuana, we find no statistically significant association between the dichotomous policy MML variable and these measures of use. This is true for the full sample in the NLSY as well as the restricted sample (age <=21).

In columns (2), (4) and (6) we estimate similar models as in (1), (3) and (5) using the same data set, but we also include measures of the relevant policy elements capturing aspects of when these elements changed over time even post adoption of a MML law. Now, we begin to see some interesting and important differences from prior estimates in the literature. First, column (2) shows that the inclusion of the additional policy elements causes the medical marijuana main variable to become negative and significant – suggesting that youth 12-17 years of age are less likely to report use in states that have a medical marijuana law. However, we also now see that states that allow medical marijuana dispensaries and home cultivation offset the positive benefits of a MML law because youth living in these states are more likely to report use in the past month.

Interestingly, when we examine the effects of these policy elements in the NLSY (column 4), we see some different results depending on the age of the sample considered. For the full NLSY sample, we get no statistically significant effect of the dichotomous MML law (different from the YRBS) and even more surprising, when we restrict the sample to those < 21, we the dichotomous MML law becomes positive and significant. One can get a sense of what is driving these differential results in the NLSY vis-à-vis the YRBS when one considers the impact of different policy elements. In the NLSY data, we see that requiring patient registration reduces reported use for both the full sample and even those < 21, and once again medical marijuana dispensaries increase prevalence for both the full sample and the younger group. The fact that

different policy dimensions come in significant (registries versus home cultivation) in the NLSY data versus the YRBS data is likely due to the different state policies providing identification between the two samples. As was seen in Table 2, the NLSY sample includes information from several additional states (Washington, Oregon and New Jersey) but Alaska is only included in the YRBS analysis. So, the "inconsistency" in results is most likely driven by inconsistency in the dimensions captured by the group of states being used for identification. Importantly, marijuana dispensaries are consistently positively associated with use in both data sets. This is despite very different influences of the single dichotomous indicator of MML laws overall.

In column (6) we find that none of the policy elements influence heavy use in the past month in the full NLSY sample. In other words, none of the MML policy dimensions influence heavy use for the entire adult sample of the NLSY. Interestingly, however for those < 21, we see that registries again are associated with less heavy use of marijuana and now home cultivation (which was shown to positively affect marijuana use in the YRBS youth) is positively associated with heavy marijuana use among those < 21 in the NLSY.

Although the findings are difficult to understand as a whole, there are a few important takeaways. First, we can replicate previous results from the literature in terms of null finding of the single dichotomous indicator for MML laws. Second, when we begin to consider specific elements of the laws that might influence behavior we see that several of those elements do, in fact, change behavior in addition to modifying the result for the single dichotomous MML indicator in some data sets. Thus, these previously ignored policy dimensions represent an important omitted variable in earlier studies. Third, the specific dimensions of the policies important for influencing demand are highly sensitive to the specific states being used for identifying the relationship, as the dimensions are heterogeneous across states. In general, the one consistent finding we have is for marijuana dispensaries having a positive impact on past month use in both the NLSY and YRBS. Importantly, however, the findings with respect to

heavy use of marijuana in the NLSY suggest that dispensaries are only important for impacting the number of current users, not the number of heavy users.

To more carefully assess the implication of these policies on heavy use, we show in Table 5 estimates for similarly specified difference-in-difference models using as our outcome measure primary marijuana treatment admissions from the TEDS data. Because so many marijuana treatment admissions are generated by law enforcement activities, we differentially evaluate the impact of policies on all treatment admissions and those that did not come through the criminal justice system (non-CJ). In the top portion of the table, we look at the effects of the policies on all age groups and in the bottom portion of the table we again restrict the samples to only include those < 21. Consistent with evidence presented by Anderson et al (2012), we find fewer primary marijuana treatment admissions in MML states than in non-MML states, and our results are statistically significant. The difference in significance between our results and those of Anderson et al is likely to be due to the increased power coming from the pooling of all individuals < 21. But the main takeaway is that simply having a MML policy does not lead to greater marijuana treatment admissions.

Again, however, our results also show that the story does not end there. When we look at all treatment admissions (including CJ referrals), we find that states that allow for home cultivation experience higher rates of primary marijuana treatment admissions than those that do not. Moreover, dispensaries are also shown to have a positive effect, although results do not approach statistical significance for either the full sample or for youth < 21. Importantly, that result changes considerably when we focus in on the Non-CJ referrals to treatment. Here, as before, we see the negative effect of a simple MML law, but that negative impact is more than offset by the positive impact home cultivation and dispensaries have on treatment admissions. These results, particularly with respect to home cultivation, suggest the earlier finding in Table 4 pertaining to heavy use in the NLSY sample of youth may in fact be a real effect, as we do not have the problem of “selective states” being evaluated in the TEDS. All states are included with

pre and post policy data. Thus the reliability of these results regarding the importance of specific policy dimensions is presumed to be higher. Moreover, we also see a negative impact of state laws that require patient registries coming in for the older sample as well. This was a result that emerged in the NLSY analysis only (not the YRBS results), being particularly strong for youth and even heavy users.

## VI. Discussion & Extensions

The evidence above on the effects of medical marijuana on marijuana use shows that the specific dimensions of the laws matter and that some of the aspects influence demand differentially. Thus findings for a single law indicator, which will capture the net effect of those policies being evaluated in the sample for the time frame considered, can cause one to miss some important underlying dimensions of the policy that may or may not offset the main effect of a law. What this means is that, depending on the time period and state laws being examined in a given sample, one can see very different effects of the policies overall. This explains at least some of the inconsistency in findings from the literature. But it also raises an important next question of what does this mean for marijuana-involved public health outcomes?

We attempt to answer this question next, at least as it pertains to a particularly important public health outcome: alcohol use. There is tremendous concern regarding the potential impact of marijuana legalization policies in Washington State and Colorado on alcohol consumption, particularly among high risk users. The economics literature regarding the relationship between alcohol and marijuana remains uncertain. Early studies examining the relationship between alcohol and marijuana relying on information on state beer taxes and marijuana decriminalization policy suggest that alcohol and marijuana are economic substitutes (Chaloupka and Laixuthai, 1997; Chaloupka and Saffer, 1999; DiNardo & Lemieux, 2001). Subsequent studies that incorporate measures of the monetary price of marijuana suggest that

the two goods are economic complements (Pacula, 1998; Farrelly et al., 1999; Williams et al., 2004). However, two recent studies making use of the regression discontinuity in drinking at age 21 generate completely opposite findings (Yoruk & Yoruk, 2011; Crost & Rees, Forthcoming). Thus, the question of the unintended impact of liberalizing marijuana policies on alcohol related harm remains a critical unresolved question.

Two studies to date have looked specifically at the question of the impact of medical marijuana laws on drinking and in particular alcohol-related fatalities (Anderson & Rees, 2011; Anderson et al., Forthcoming). Both studies show that alcohol use and alcohol related automobile fatalities are negatively associated with these policies, suggesting that the laws have the positive effect of reducing alcohol related harm. However, both studies rely on a single dichotomous indicator of medical marijuana laws. Thus, it is important to reassess these findings in light of our results above.

We begin by assessing the impact of these policies in the survey data we previously examined for marijuana. Table 6 shows the results of identical models of self-reported alcohol use in the past 30 days from both the YRBS and NLSY data. We also include in the final two columns information from the TEDS treatment data, showing the impact of these policies on per capita rates of treatment admissions where alcohol is the primary substance of abuse. Unlike the case for marijuana, alcohol treatment admissions are not as significantly influenced by criminal justice treatment referrals. Nonetheless, for completeness we examine if there are differential effects in these two populations. Again, we report results for the full population of each survey/data set in the top, and compare those results to analyses for those < 21 in the bottom portion of the table.

When we simply include the single dichotomous indicator of a MML law in analyses using each of these data sets, we generally find either no statistically significant relationship between the policy and alcohol use, or in the case of alcohol admissions among youth, a negative and statistically significant effect of the policy. As this is generally consistent with

results for marijuana, it provides suggestive evidence that the two goods are economic complements as alcohol admissions go down in response to the same policy as marijuana admissions. It is important not to read too much into that result just yet.

When additional policy measures are included into each of the runs using the different data sets, we again get some perhaps disturbing differences in findings across studies. It is important to keep in mind, however, that identification of state policy effects is being assessed off of different state policies across these data sets. Only the TEDS data comprehensively assesses the effects of changes in all the states, but only heavy use consumption is reflected in these data. There are two consistent findings when looking across the top panel of Table 6. First, when policy elements of the MML laws are also included, the simple dichotomous indicator of having a MML policy becomes negative and statistically significant at a very high level. Second, home cultivation generally comes in positively associated with drinking prevalence rates (in the NLSY) and alcohol treatment admissions (for the full data and the non-CJ sample). Marijuana patient registries, which were shown to be negatively related with marijuana use in Tables 4 and 5, are generally associated with more alcohol use in the YRBS and TEDS. The sign on this variable is negative and significant in the NLSY, but this result is not sustained in the TEDS results for the full sample so is discounted here.

When we look at alcohol use among youth in the bottom portion of the table, the results are generally similar to that for adults. The mere existence of a MML policy is negatively associated with drinking prevalence and alcohol treatment admissions, but home cultivation is positively associated with both as well. Moreover, we now see a much more consistent positive effect of dispensaries on alcohol use (in NLSY) and treatment admissions (TEDS), consistent with findings with respect to marijuana. In other words, having greater access to marijuana either through home cultivation or pot dispensaries is generally associated with increased alcohol use and dependence among youth.

None of these outcomes are exactly the same as that previously examined by Anderson et al (Forthcoming), however. In particular, it may be the case that those individuals who are willing to drive drunk differ in certain unobservable ways than those who become dependent more broadly on alcohol. Thus, for the sake of completeness, we also attempt to replicate Anderson et al (Forthcoming) using the same estimation strategy in the 1990-2009 Fatal Accident Reporting System (FARS). 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, as known to police, emergency medical services, emergency departments and death certificates. Similar to Anderson and his colleagues, we estimate the rate of alcohol-involved fatal accidents for various groups (total fatalities, youth age 15-19 traffic fatalities and percent of alcohol involved fatalities) as a function of medical marijuana laws, a vector of state time-varying factors influencing driving practices (average vehicle miles traveled, seat belt laws, graduated drivers licenses, administrative license revocations), state time varying alcohol policies (blood alcohol content, or BAC, laws and the beer tax), state specific fixed effects and year dummy variables.[5]

Results for similar models to Anderson et al (forthcoming) are presented in Table 7. As there are a few differences in the recognition of medical marijuana laws on the books between our analysis and theirs (in particular the policies in Arizona and DC), we first construct a dichotomous indicator of MML policy that is consistent with the definition they use and replicate their results closely. Our results are broadly consistent although slightly smaller in magnitude to their estimates excluding a state linear time trend (which we exclude due to our need to uniquely capture variation within state in policy elements). We next show that we indeed get very similar results when we instead use our own dichotomous measure of MML policies. In the third column, we then introduce the other policy elements and examine what it does to the main

[5] Unlike Anderson et al, we use the same Poisson specification given by equation (5), as it is deemed to be a more appropriate model fit.

MML finding. We find that MML policies remain negatively associated with total fatal accident rates in the total population, but that this negative relationship is partially offset in states that also allow dispensaries. This is because the presence of dispensaries leads to greater alcohol involved fatalities (consistent with heavier alcohol use, as shown in the TEDS data). Moreover, the result becomes even stronger when we restrict the data to those less than 21. These results provide an important example of where policy recommendations could go awry if policy analyses ignore important nuances of the laws.

## VII. Conclusions

Medical marijuana laws are not homogenous. There are important nuances to these policies that have differential effects on marijuana consumption and its related public health harms. Contrary to many expectations, we do find that in general MML policies reduce marijuana consumption. However, consistent with expectations we find that states that allow dispensaries and/or allow home cultivation can completely offset any positive effect of MML laws on marijuana consumption. Similarly, these policies also appear to offset the positive influence of MML laws on alcohol consumption. Marijuana dependence appears to be higher in states with more lenient access to medical marijuana. Measures of supply, in particular home cultivation and state acceptance of dispensaries, are associated with higher levels of dependence. Importantly, they are also associated with higher admissions to treatment for alcohol abuse.

The results in this paper provide some additional insight to the inconsistent findings in the literature related to MML policies in general. Consistent with evidence shown by Anderson et al (2012), our analyses show that results of policy effects will be highly sensitive to the specific states in which identification is being drawn from. We add more insight into that discussion, however, by demonstrating why this is the case. MML policies are not homogenous and they do change and get refined over time in important ways. Ignoring the important heterogeneity in laws and key elements related to access that change over time can lead one to

misinterpret the true effect of a given policy. Indeed a more careful consideration is warranted that considers the particular states being evaluated and the dimensions of the medical marijuana laws represented by those states. The offsetting effects of particular policy dimensions on marijuana and alcohol use, dependence, and alcohol involved fatalities suggests that these policies might influence use through a variety of different mechanisms, some that may be more important than others for a given population. Further work is needed to assess whether these findings hold for other marijuana related harms, as it is clear that the effects are not consistent across different levels of use and different age groups.

Finally, the results should caution policy makers not to infer anything about the relationship between alcohol and marijuana from analyses of medical marijuana policies, particularly when these policies are examined as simple dichotomous indicators. Indeed a more careful consideration is warranted that considers the particular states being evaluated and the dimensions of the medical marijuana laws represented by those states. The offsetting effects of particular policy dimensions on marijuana and alcohol use, dependence, and alcohol involved fatalities suggests that these policies might influence use through a variety of different mechanisms, some that may be more important than others for a given population. Further work is needed to assess whether these findings hold for other marijuana related harms, as it is clear that the effects are not consistent across different levels of use and different age groups.

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Table 1: Summary of State Medical Marijuana Laws as of Jan 1 2012

| State | Year of Legislation/ Referendum/ Court Decision | Patient Registry Required? | Allowed for "Pain" ? | Home Cultivation ? | Dispensaries Allowed? |
|---|---|---|---|---|---|
| Alaska | 1998<br>1999<br>2007 | No<br>Yes | Yes | Yes | No |
| Arizona | 1996<br>2010 | No<br>Yes | Yes | No<br>Yes | No<br>Yes |
| California | 1996<br>2003 | No | Yes | Yes | No<br>Yes |
| Colorado | 2000<br>2010<br>2011 | Yes | Yes | Yes | Yes |
| Delaware | 2011 | Yes | Yes | No | Yes |
| District of Columbia | 1998<br>2010 | No<br>Yes | No | No | No<br>Yes |
| Hawaii | 2000 | Yes | Yes | Yes | No |
| Maine | 1999<br>2002<br>2009<br>2010<br>2011 | No<br>No<br>Yes | Yes | Yes | No<br>No<br>Yes |
| Maryland | 2003<br>2011 | No | No<br>Yes | No | No |
| Michigan | 2008 | No | Yes | Yes | No |
| Montana | 2004<br>2011 | No<br>Yes | Yes | Yes | Ambiguous<br>No |
| Nevada | 2001<br>2003<br>2005 | Yes | Yes | Yes | No |
| New Jersey | 2009 | Yes | Yes | Yes | Yes |
| New Mexico | 2007 | Yes | No | No | Yes |
| Oregon | 1998<br>1999<br>2005<br>2007 | No<br>No<br>No<br>Yes | Yes | Yes | No |
| Rhode Island | 2007<br>2009 | Yes | Yes | Yes | No<br>Yes |
| Vermont | 2004<br>2007<br>2011 | Yes | No<br>Yes | Yes | No<br>No<br>Yes |
| Washington | 1998<br>2007<br>2010<br>2011 | No | Yes | No<br>No<br>No<br>Yes | No |

Note: For each state, the first year listed represents year of initial legalization. Other years listed indicate years with additional legal changes. In some cases, new laws did not alter any of the four policy dimensions listed in the table.

Table 2: Data Sets with Pre- and Post- Implementation Information on Medical Marijuana Policies Assessable as of May 2012

| State | Year | NLSY | YRBS | NSDUH State Aggregates | TEDS |
|---|---|---|---|---|---|
| Alaska | 1996 | | X | | X |
| Arizona | 2010 | | | | |
| California | 1996 | | | | X |
| Colorado | 2000 | X | X | | X |
| Delaware | 2011 | | | | |
| District of Columbia | 2010 | | | | |
| Hawaii | 2000 | X* | X | | X |
| Maine | 1999 | X | X | | X |
| Maryland | 2003 | X* | X | X | X |
| Michigan | 2008 | X* | X | X | |
| Montana | 2004 | X* | X | X | X |
| Nevada | 2001 | X | X | | X |
| New Jersey | 2009 | X* | | X | X |
| New Mexico | 2007 | X* | X | X | X |
| Oregon | 1998 | X | | | X |
| Rhode Island | 2007 | X* | X | X | X |
| Vermont | 2004 | X* | X | X | X |
| Washington | 1998 | X | | | X |

Notes: Asterisk for specific states in the NLSY indicates that cohort is passed age of primary initiation of marijuana by the time the state law passed.

Table 3: Sample Means of Measures of Marijuana and Alcohol Use for Each of Our Main Data Sets

| | No MML | | MML | |
|---|---|---|---|---|
| **YRBS (1993-2009)** | Mean | SE | Mean | SE |
| Percentage Using Marijuana in Last 30 Days | 20.88 | 5.74 | 22.67 | 3.14 |
| Percentage Using Alcohol in Last 30 Days | 45.34 | 7.02 | 39.75 | 4.60 |
| N | 238 | | 29 | |
| **NLSY (1997-2008)** | Mean | SE | Mean | SE |
| Percentage Using Marijuana in Last 30 Days | 14.89 | 35.60 | 16.75 | 37.34 |
| Percentage Using Marijuana in At Least 16 of Last 30 Days | 5.12 | 22.03 | 5.62 | 23.02 |
| Percentage Using Marijuana in At Least 21 of Last 30 Days | 4.07 | 19.76 | 4.53 | 20.79 |
| Percentage Using Alcohol in Last 30 Days | 52.68 | 49.93 | 59.64 | 49.06 |
| Percentage Using Alcohol in At Least 16 of Last 30 Days | 4.51 | 20.76 | 5.63 | 23.05 |
| Percentage Using Alcohol in At Least 21 of Last 30 Days | 2.22 | 14.75 | 2.78 | 16.45 |
| N | 78641 | | 18072 | |
| **TEDS (1992-2008)** | Mean | SE | Mean | SE |
| Marijuana Treatments per 1,000 | 0.89 | 0.53 | 1.24 | 0.53 |
| Alcohol Treatments per 1,000 | 3.57 | 2.53 | 4.68 | 3.25 |
| N | 744 | | 84 | |

Table 4: Impact of Medical Marijuana Laws on Recent and Heavy Marijuana Use in YRBS and NLSY Data Sets

| | YRBS | | NLSY | | NLSY | |
|---|---|---|---|---|---|---|
| Data Set | (1) | (2) | (3) | (4) | (5) | (6) |
| Outcome | Used in the Past Month | | Used in the Past Month | | Heavy Use in Past Month | |
| MML | -0.016 | -0.701** | -0.014 | 0.005 | 0.004 | -0.022 |
| | (0.030) | (0.342) | (0.010) | (0.028) | (0.011) | (0.022) |
| MML, Registry | | 0.036 | | -0.041** | | -0.026 |
| | | (0.045) | | (0.016) | | (0.021) |
| MML, Dispensaries | | 0.745** | | 0.033*** | | 0.003 |
| | | (0.331) | | (0.009) | | (0.006) |
| MML, Home | | 0.640** | | -0.01 | | 0.046 |
| | | (0.320) | | (0.031) | | (0.029) |
| State FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 267 | 267 | 96,624 | 96,624 | 96,624 | 96,624 |
| | | | | | | |
| | | | NLSY, <=21 | | NLSY, <=21 | |
| Outcome | | | Used in the Past Month | | Heavy Use in Past Month | |
| MML | | | 0.004 | 0.030*** | 0.011 | 0.003 |
| | | | (0.010) | (0.008) | (0.008) | (0.005) |
| MML, Registry | | | | -0.033** | | -0.026** |
| | | | | (0.017) | | (0.014) |
| MML, Dispensaries | | | | 0.040*** | | -0.003 |
| | | | | (0.008) | | (0.010) |
| MML, Home | | | | -0.027 | | 0.031*** |
| | | | | (0.017) | | (0.007) |
| State FEs | | | Yes | Yes | Yes | Yes |
| Year FEs | | | Yes | Yes | Yes | Yes |
| State covariates | | | Yes | Yes | Yes | Yes |
| N | | | 53,935 | 53,935 | 53,935 | 53,935 |

Significance Levels: * 10%, ** 5%, *** 1%. Standard errors in parentheses adjusted for clustering at the state level. Controls included but not shown: ln(population), unemployment rate, age distribution, BAC limit, beer tax. NLSY analysis also includes age fixed effects.

Table 5: Impact of Medical Marijuana Laws (MML) on Treatment Admissions, Marijuana as the Primary Substance of Abuse/Dependence (TEDS, 1992-2008)

| | All | | Non-CJ | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| MML | -0.099 | -0.295*** | -0.165** | -0.485*** |
| | (0.062) | (0.076) | (0.069) | (0.082) |
| MML, Registry | | -0.166 | | -0.212** |
| | | (0.108) | | (0.112) |
| MML, Dispensaries | | 0.112 | | 0.223*** |
| | | (0.070) | | (0.069) |
| MML, Home | | 0.287*** | | 0.439*** |
| | | (0.074) | | (0.073) |
| State FEs | Yes | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes |
| N | 828 | 828 | 828 | 828 |
| **Under 21** | | | | |
| | (1) | (2) | (3) | (4) |
| MML | -0.142** | -0.348*** | -0.143** | -0.441*** |
| | (0.067) | (0.072) | (0.076) | (0.085) |
| MML, Registry | | -0.207 | | -0.213 |
| | | (0.128) | | (0.131) |
| MML, Dispensaries | | 0.086 | | 0.377*** |
| | | (0.087) | | (0.082) |
| MML, Home | | 0.324*** | | 0.408*** |
| | | (0.054) | | (0.080) |
| State FEs | Yes | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes |
| N | 828 | 828 | 828 | 828 |

Significance Levels: * 10%, ** 5%, *** 1%. Standard errors in parentheses adjusted for clustering at the state level. Controls included but not shown: ln(population), unemployment rate, age distribution, BAC limit, beer tax.

Table 5: Impact of Medical Marijuana Laws (MML) on Alcohol Use in the YRBS, NLSY and Alcohol Treatment Admissions in the TEDS

| | Full Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Data Set | YRBS | | NLSY | | TEDS | | TEDS | |
| Outcome | Use in the Past 30 Days | | Use in the Past 30 Days | | Number of Treatments | | Number of Non-CJ Treatments | |
| MML | -0.038 | -0.186 | -0.019 | -0.039*** | 0.079 | -0.406*** | 0.015 | -0.712*** |
| | (0.023) | (0.169) | (0.011) | (0.014) | (0.096) | (0.065) | (0.139) | (0.089) |
| MML, Registry | | 0.066* | | -0.058*** | | 0.228*** | | 0.304** |
| | | (0.037) | | (0.018) | | (0.073) | | (0.148) |
| MML, Dispensaries | | 0.112 | | 0.038*** | | 0.086 | | 0.113 |
| | | (0.164) | | (0.009) | | (0.062) | | (0.110) |
| MML, Home | | 0.089 | | 0.048** | | 0.412*** | | 0.641*** |
| | | (0.161) | | (0.021) | | (0.073) | | (0.108) |
| State FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 267 | 267 | 96,172 | 96,172 | 828 | 828 | 828 | 828 |
| | 21 and Under Samples | | | | | | | |
| Data Set | YRBS | | NLSY | | TEDS | | TEDS | |
| Outcome | Use in the Past 30 Days | | Use in the Past 30 Days | | Number of Treatments | | Number of Non-CJ Treatments | |
| MML | -0.038 | -0.186 | -0.008 | -0.026** | 0.14 | -0.111 | -0.143** | -0.441*** |
| | (0.023) | (0.169) | (0.013) | (0.014) | (0.087) | (0.078) | (0.076) | (0.085) |
| MML, Registry | | 0.066* | | -0.066*** | | 0.035 | | -0.213 |
| | | (0.037) | | (0.025) | | (0.147) | | (0.131) |
| MML, Dispensaries | | 0.112 | | 0.035*** | | 0.207** | | 0.377*** |
| | | (0.164) | | (0.011) | | (0.100) | | (0.082) |
| MML, Home | | 0.089 | | 0.056** | | 0.241** | | 0.408*** |
| | | (0.161) | | (0.026) | | (0.146) | | (0.080) |
| State FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year FEs | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 267 | 267 | 53,851 | 53,851 | 828 | 828 | 828 | 828 |

Significance Levels: * 10%, ** 5%, *** 1%. Standard errors in parentheses adjusted for clustering at the state level. Controls included but not shown: ln(population), unemployment rate, age distribution, BAC limit, beer tax. NLSY analysis also includes age fixed effects.

Table 7: Impact of Medical Marijuana Laws on Alcohol Related Fatalities in FARS

| Fatal Accident Rate | | | | | | |
|---|---|---|---|---|---|---|
| | All | | | 21 and Under | | |
| MML (AHR) | -0.076*** | | | -0.136*** | | |
| | (0.028) | | | (0.038) | | |
| MML (new) | | -0.067*** | -0.102** | | -0.114*** | -0.146*** |
| | | (0.026) | (0.042) | | (0.037) | (0.023) |
| MML, Registry | | | 0.006 | | | -0.013 |
| | | | (0.051) | | | (0.075) |
| MML, Dispensaries | | | 0.083* | | | 0.093* |
| | | | (0.042) | | | (0.053) |
| MML, Home | | | 0.030 | | | 0.032 |
| | | | (0.055) | | | (0.053) |
| Year FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| State FEs | Yes | Yes | Yes | Yes | Yes | Yes |
| State covariates | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 1021 | 1021 | 1021 | 1021 | 1021 | 1021 |

Significance Levels: * 10%, ** 5%, *** 1%. Standard errors in parentheses adjusted for clustering at the state level. Controls included but not shown: ln(population), unemployment rate, age distribution, BAC limit, beer tax, decriminalization, graduated driver's license, adminstrative license revocation, seatbelt laws, VMT.