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## Marijuana Liberalizations Policies: Why We Can't Learn Much from Policy Still in Motion

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California legalized the use of marijuana for medicinal purposes nearly 17 years ago, representing a major challenge to the federal government's scheduling of marijuana as a Schedule I drug in the 1970 Controlled Substance Act. As many predicted, California was simply the first. As of May 2013, 19 states and the District of Columbia now provide legal protection to patients, and in many cases caregivers, for possession and supply of marijuana for medicinal purposes. In November 2012, Colorado and Washington went even further legalizing the sale and possession of marijuana for recreational purposes. Given the tremendous natural experiment that is taking place, one might expect that much would already be known about the benefits and harms of liberalizing marijuana policies. Unfortunately, however, the tremendous uncertainty regarding what protections actually exist, and for whom, in addition to the enormous heterogeneity in the medical marijuana laws that continue to change over time, has meant that we do not yet know as much as we should.

The questions of whether marijuana is medicine and whether recreational marijuana use is harmless are necessarily intertwined in all of the debates over policy reform, but these are not the focus of this discussion. There is legitimate evidence that active cannabinoids available in the marijuana plant are useful in the treatment of some medical conditions and symptoms (Leung, 2011; Watson, Benson, & Joy, 2000; Institute of Medicine, 1999) and has been for centuries (Eddy, 2010; Grinspoon, 2005). As such, it is not surprising that the American Medical Association (AMA) adopted a resolution in 2009 urging the federal government to review the case for rescheduling marijuana, noting that doing so would facilitate research and development of cannabinoid-based medicine and avoid the patchwork of inadequate state laws that do not focus on establishing clinical guidelines or standards for medically prescribing marijuana (AMA, 2009). There is also evidence in the biomedical and public health literatures of reasonable pathways through which marijuana can harm health or

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impact health outcomes (see Hall & Pacula, 2003; Hall & Degenhardt, 2009; Room et al., 2010; or Caulkins et al., 2012 for extensive reviews). However, the causal linkage between recreational marijuana use and many of these health outcomes has yet to be fully established and continues to be a matter of scientific inquiry due to imprecise information on amounts consumed or potency of the substance used. Nonetheless, state liberalization policies move forward, and scientists are trying to use these natural experiments to assist in the identification of benefits and harms from these policies.

## **THE EFFECTS OF MEDICAL MARIJUANA LAWS: A SUMMARY OF, AND PERSPECTIVE ON, THE LITERATURE**

Researchers have tried to make use of variation in other state marijuana policies, including penalties, decriminalization, and depenalization, to tease out causal relationships regarding the effect of use on outcomes, but these approaches suffer from important limitations when examining U.S. data. First, in many “decriminalized” states, the criminal status of marijuana possession offenses remains in effect (Pacula, Chriqui, & King, 2003; Pacula et al., 2005). Thus, states cannot be uniquely identified as having lower penalties based on the adoption of decriminalization policies. Second, many marijuana possession penalties have not varied much over time, making it difficult to separate true policy effects from unobserved state characteristics correlated with policy adoption (Pacula, Chriqui, & King, 2003; Farrelly et al., 2001). Finally, where policy changes have occurred, they are often so minor that they are unknown to the affected population (MacCoun et al., 2009).

Unlike other marijuana policy changes, medical marijuana laws (MMLs) and the two recent legalization policies have received considerable media attention at the local and national level, in part because many occurred through voter referendum. Thus, MMLs would seem to represent an ideal policy for considering potential causal relationships between marijuana access, use, and harm. Whether the policies impact supply or demand is less relevant than the fact that effects through either mechanism should increase consumption. Thus, to the extent that these policies increase use directly, they will provide a unique source of independent variation necessary for identifying causal relationships between use and harms or benefits.

While numerous studies have examined the association among these policies, marijuana use, and harms, relatively few have used methods that would allow for causal inference. Among those that do, the vast majority of studies employ difference-in-differences (DD) approaches. Importantly, even with similarly rigorous identification techniques, the results have varied tremendously, with some studies concluding that MMLs have no significant impact on marijuana use (Anderson, Hanson, & Rees, 2013; Lynne-Landsman, Livingston, & Wagenaar, 2013; Harper, Strumpf, & Kaufman, 2012) and others finding a positive effect (Chu, 2012; Cerdá et al., 2012; Pacula et al., 2010).

To some extent differences in findings can be explained by legitimate differences in the populations examined, as specific age groups and subgroups represent different types of users or margins of use. For example, Harper, Strumpf, and Kaufman (2012) examine data over the period 2003 to 2008 and consider the impact of MMLs 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 and colleagues use a DD 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 use regardless of age group examined (12 to 17 year olds; 18 to 25 year olds, and 26 and over). Anderson, Hanson, and Rees (2013) and Lynne-Landsman, Livingston, and Wagenaar (2013) make use of data from the Youth Risk Behavior Survey (YRBS) and come to the same general conclusion. Chu (2012) and Pacula et al. (2010), however, make use of data on arrestees, who are well-established as having greater involvement with drugs (Taylor et al., 2001; Makkai, Fitzgerald, & Doak, 2000; Taylor & Bennett 1999). Thus, the fact that these studies find a positive association while those examining casual use among the youth or household populations find no effect might simply reflect differential responses in different populations.

Heterogeneity in populations examined is not the only explanation for the differences across studies. Anderson, Hanson, and Rees (2012) and Pacula et al. (2013) offer two more reasons. In their Institute for the Study of Labor (IZA) working paper, Anderson and colleagues (2012) are the first to make the point that differential state representation in various data sets used to evaluate these policies may lead to different outcomes, as the source of identification of policy effects is coming from different states that could conceivably have different experiences. In DD models including state and year fixed effects and state-specific time trends and making use of combined data from the state and national YRBS, they find no statistically significant effect of MMLs on 30-day marijuana prevalence or frequency of use among youth. They replicate these null findings with similarly comprehensive state-level data from the National Longitudinal Survey of Youth 1997 Cohort (NLSY97) and 1992 to 2009 Treatment Episode Data Set (TEDS) data.

In Pacula et al. (2013), we examine the same data sets as Anderson and colleagues, but we find that the use of a single dichotomous indicator to represent MMLs obscures important differences in policies across states and these different dimensions have unique impacts on recreational use. Moreover, we show that these relevant dimensions change over time, and hence the policy is not static over time. When we control for specific dimensions of the MML policies, we find that states restricting broad access to medical marijuana by requiring annual registration of patients have lower marijuana prevalence rates among youth and adult and lower admissions to treatment than states without such requirements. However, states allowing home cultivation and legal dispensaries are both positively associated with recreational use and in particular, heavy use. This important heterogeneity in policies had been overlooked in previous studies, and could easily explain the inconsistency in findings across studies that relied on variation in particular state/years for identification.

## **WHY THE TIMING AND EVOLUTION OF MEDICAL MARIJUANA LAWS MATTERS: PRICES AND POTENCY**

As shown in Table 1, and described in greater detail in Pacula et al (2013), medical marijuana policies continue to evolve in important ways after initial adoption. The issue of

supply mechanism, in particular, has changed a lot even within states over time as more information is gained in terms of court interpretation of the legitimacy of these policies and the federal response to them.

Our research suggests that initial policies that are either silent regarding source of supply (Arizona in 1996, Washington DC in 1998, and Washington state in 1999) or only allow access through home cultivation generate a different policy response than MML policies that allow dispensaries or cooperatives. Why? Part of the answer lies in the differential effects on price.

To better understand this, one has to think about the mechanisms through which MML policies could potentially influence use. Passage of a MML could influence recreational use through one of at least four channels: (1) changes in perceived harms, perceived risks, or disapproval (Bachman et al., 1998, 1981; Khatapoch & Hallfours, 2004); (2) changes in social norms (Jacobson, 2005); (3) changes in ability to access marijuana (Thurstone, Lieberman, & Schmiede, 2011); and (4) changes in the organization of supply that alter costs or methods of production for the black market and, hence, reduce price (Pacula et al., 2010). Any of the first three mechanisms would lead to a shift in the demand for marijuana, but such a shift in demand would mean higher total consumption putting upward pressure on marijuana prices in the market. Indeed, we found evidence of a rise in the average self-reported price per gram of marijuana paid among arrestees using quarterly drug transactions across 40 counties in nearly 30 states using the 2000 to 2003 Arrestee Drug Abuse Monitoring Program (ADAM) (Pacula et al., 2010). So although changing norms might incentivize a casual user to engage in marijuana use, higher prices will deter them from doing so substantially. Thus the rise in total consumption predicted by theory is likely to be driven by the consumption behavior of existing regular users more than the entrance of new users in equilibrium. Such a behavioral response could lead to null findings in studies only considering prevalence rates.

Dispensaries, on the other hand, can actually influence the cost structure of supplying marijuana by creating a legitimate need for growers to produce sizable amounts. Caulkins (2010) and Kilmer et al. (2010) explain how economies of scale even at the low end of the production scale generate lower unit costs and, hence, lower prices. A shift in the supply curve, as well as the demand curve, could mean lower prices in equilibrium.

There is indeed evidence from two studies that MMLs, and more specifically legally protected dispensaries, have generated lower prices over time. Anderson, Hansen, and Rees (2013) provide the most direct evidence, showing that states adopting MMLs experienced statistically lower prices for high potency marijuana over the period 1990 to 2011. Importantly, their models show that the negative impact of the MML policy is greater four and five years post implementation of the law than in the immediate year, but they still show a generally negative and significant impact on prices within the first year of adoption. Sevigny and colleagues examine the potency of marijuana seized through local, state, and federal law enforcement activities over the same time period (1990 to 2010) (Sevigny, Pacula, & Heaton, 2013). They decompose MMLs into specific dimensions in their DD models, which include state and year effects. Although the simple dichotomous indicator of

any MML has no statistically significant impact on reported potency within the state, they find that states with legally protected dispensaries do experience statistically higher potency over time than states that do not have MML laws or do not legally protect dispensaries. Interestingly, there is no statistically significant impact on potency of either states tolerating unauthorized dispensaries (e.g., Washington state and Michigan) or those that allow for home cultivation. The findings from this study when combined with findings from Anderson, Hanson, and Rees (2013) suggest that dispensaries are what drive potency-adjusted marijuana prices down, not the MML laws themselves.

So, MMLs that only shift demand generate higher prices and may not lead to greater use among new users, but MMLs that include dispensaries will also shift supply and lead to declines in the price of marijuana as well, which will increase use among new and established users (Pacula & Lundberg, in press). Analyses that treat all MMLs the same or look for one time effects of policy adoption are missing important dynamics. The importance of policy dynamics can be seen in Figure 1, where we show the trend in potency of marijuana (measured in terms of the ratio of the main psychoactive ingredient tetrahydrocannabinol [THC], to the naturally occurring and counter psychoactive compound cannabidiol [CBD]) in California over time (Burgdorf et al., 2011). The simple adoption of the MML does not have a sustained impact on the median THC/CBD ratio until after dispensaries were legally protected (the regulation passed in Oct. 2003, but did not go into effect until January 2004). At that point, the median potency of marijuana clearly climbed through 2007. Analogously, we see in Figure 1 that while there was a small increase in the rate of non-fatal marijuana involved hospital admissions prior to 2004, the rate substantially increased as the median THC to CBD ratio rose. The positive correlation between non-fatal hospital admissions involving marijuana and median THC/CBD needs to be more carefully explored, but demonstrates the point that there may be differential effects of MML policies when supply shifts as well as demand because of changes in potency adjusted price and different user groups responsiveness to this.

## **UNEXPECTED OUTCOMES OF MARIJUANA LIBERALIZATION POLICIES: REDUCTION IN HARMS FROM ALCOHOL?**

In RAND's assessment of the impact of legalizing marijuana in California under Proposition 19, Kilmer et al. (2010) acknowledge a key limitation in assessing the net impact to society is the uncertainty regarding the relationship between marijuana and alcohol consumption. Although there are small recognized health costs associated with using marijuana and treating dependence, these costs are dwarfed in comparison to the criminal justice savings associated with legalizing and regulating the substance. Even if consumption were assumed to rise by 100 percent, the savings of liberalizing policies would dwarf the known health costs associated with using marijuana. However, all potential savings associated with marijuana legalization could be entirely erased, and tremendous losses incurred, if alcohol and marijuana turn out to be economic complements, particularly for young adults.

Unfortunately, the evidence on this relationship remains mixed, particularly if looking specifically at the behavior of Americans. Early studies that relied on variation in state beer taxes, marijuana decriminalization policies, or increases in the minimum legal drinking age

suggested that alcohol and marijuana are economic substitutes (Chaloupka & Laixuthai, 1997; Saffer & Chaloupka, 1999; DiNardo & Lemieux, 2001). Subsequent studies that incorporate measures of the monetary price of marijuana and look at demand for both substances simultaneously suggest that the two goods are economic complements (Pacula, 1998; Williams et al., 2004). Behavioral economic laboratory studies also generally find complementarity among people who use harder substances (e.g., Petry, 2001), but occasionally one comes across a study showing evidence of substitutability (e.g., Kadden et al., 2009). Recent attempts to tease out the relationship have taken advantage of improved identification strategies, relying on discontinuities in the cost of accessing alcohol that exist when individuals turn 21 and can legally drink. Even these studies generate inconclusive results. Yörük and Yörük (2011, 2013) find evidence of complementarity while Crost and Guerrero (2012) and Crost and Rees (2013) find evidence of substitutability. Perhaps some of the inconsistency can be explained by differential responses among polydrug users versus single substance users at the age discontinuity, but even if such an interpretation is true, it does not help us translate these effects into knowledge about the market demand curve, which is what is most relevant for policy purposes.

MMLs have also been used to examine this relationship (Anderson, Hansen, and Rees, 2012, 2013; Pacula et al., 2013), but analyses making use of the simple dichotomous indicator suffer the same limitations as discussed previously. The laws are not homogenous, nor are they static, and hence interpretation of findings over any given time period will not necessarily reflect a true overall treatment effect. In our analyses, we considered the differential impacts of particular policy dimensions and again found important nuances (Pacula et al., 2013). Strict registration requirements were negatively associated with self-reported alcohol use and alcohol-related traffic fatalities for both adults and youth, while dispensaries were found to be positively associated with both. These results are consistent with findings for marijuana, suggesting alcohol and marijuana may be complements. However, it is not clear to what extent these effects reflect the true equilibrium impact of the policy or each of these dimensions. Far more work paying closer attention to differential mechanisms is needed before conclusions can be drawn.

## SO WHAT CAN WE EXPECT FROM MARIJUANA LEGALIZATION?

Despite the insufficient consideration of heterogeneity and changes in MML policies over time, we believe that a few salient insights can be gleaned from the current scientific literature and weighed in one's consideration of the desirability of liberalization policies for marijuana. First, we conclude from the current literature that the rescheduling of marijuana and provision of it through typical highly regulated medical channels would not lead to widespread increases in its use or harms. Second, legalization would generate savings in terms of reduced criminal justice costs and improve social welfare by eliminating criminal sanctions for minor marijuana offenses (Kilmer et al., 2010; Gieringer, 2009). These savings will far exceed the probable regulatory cost of implementing even a highly regulated marijuana market, although one should not expect all criminal justice costs to disappear unless drugged driving laws and underage use offenses are not actively enforced.



Third, marijuana use will rise under legalization, in large part because legally sanctioned production and competition will drive down prices. It is hard to know, based on the current literature, the extent to which greater marijuana use will lead to greater harms. It will likely depend on a number of factors, including who ends up responding the most to price. If it is the casual adult user who enters the market and consumes in relatively small amounts, then the expected harms are very small. If it is new young users, more involved heavy users, or users of other substances, then the harms could be greater. The literature examining differential elasticities across the population of users is very thin for marijuana (Pacula & Lundberg, in press).

There remains a very important open-ended question regarding whether reforming marijuana laws will lead to more or less use of alcohol and other intoxicating substances. The uncertainty of the literature with respect to alcohol in particular is surprising given the attention this question has received. Ultimately, the mixed results may be a function of poor identification strategies or the result of differential relationships occurring in different populations of users. At this point, we do not believe it is possible to clearly say definitively which it is. But alcohol is not the only relevant substance to consider. Important questions exist surrounding the possible substitution of marijuana for prescription or nonprescription opioids used to manage chronic pain. Reports from patients suggest that medical marijuana has indeed reduced their need and use of these substances (Nunberg et al., 2011), but more careful research systematically testing this claim is needed.

It is important to bear in mind that policymakers can take steps to mitigate some of the potential health harms of liberalization policies if public health advocates become engaged. Regulations could be shaped that set limits on the maximum potency or THC/CBD that can be available in the market and requiring regular random testing of samples from producers and growers to ensure compliance. Similarly, rules regarding proper labeling or limited product forms might also be considered. Rules can be put in place to limit opportunities to use marijuana and alcohol together and reduce the commercialization of marijuana. Such ideas that represent attempts to mitigate legitimate public health concerns appear to be missing from current state policy debates, but are desperately needed.

Thus, we believe much remains unanswered about the potential effects of marijuana liberalization policies because the most relevant questions have yet to be fully considered and addressed. Existing policy experiments have not been used to answer what we see as the most important questions, namely are public health harms from marijuana use a function of the person consuming it (age, polysubstance user, or other identifying factor)? Amount consumed? Activities engaged in while under the influence? Method of consumption? Potency? Or duration of use? How responsive is problematic use to changes in price? To answer these questions definitively, researchers need a bit more time and a lot better data.

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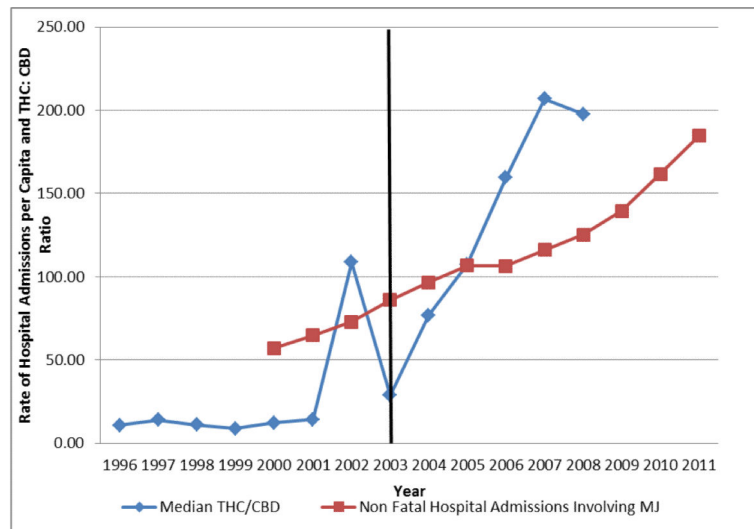
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**Figure 1.** Trends in Median THC/CBD Ratios (Potency) of Marijuana Seized in California and Marijuana-Involved Non-Fatal Hospitalizations.

**Table 1**

Summary of state medical marijuana laws as of January 1, 2012.

State	Year Initial MML Passed	Year Home Cultivation Allowed?	Year Dispensaries Legally Allowed?
Alaska	1998	1998	NA
Arizona	1996	2010	2010
California	1996	1996	2003
Colorado	2000	2000	2000
Delaware	2011	NA	2011
District of Columbia	1998	NA	2010
Hawaii	2000	2000	NA
Maine	1999	1999	2009
Maryland	2003	NA	NA
Michigan	2008	2008	NA*
Montana	2004	2004	NA as of 2011 <sup>++</sup>
Nevada	2001	2001	NA
New Jersey	2009	NA	2009
New Mexico	2007	2007	2007
Oregon	1998	1998	NA*
Rhode Island	2007	2007	2009
Vermont	2004	2004	2011
Washington	1998	2011	NA*

*Note:* NA means that cultivation or dispensaries are not legally allowed per state law. In some states, indicated with an asterisk (\*) dispensaries can be found in certain cities or regions, but state law does not legally protect them, so they operate at their own risk. In Montana, initial state law was ambiguous as to the legal protection of cooperatives and dispensaries, but a subsequent law in 2011 made it clear they were not legally protected.