



## Policy analysis

## The effects of medical marijuana laws on potency

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## ABSTRACT

**Background:** Marijuana potency has risen dramatically over the past two decades. In the United States, it is unclear whether state medical marijuana policies have contributed to this increase.

**Methods:** Employing a differences-in-differences model within a mediation framework, we analyzed data on  $n=39,157$  marijuana samples seized by law enforcement in 51 U.S. jurisdictions between 1990 and 2010, producing estimates of the direct and indirect effects of state medical marijuana laws on potency, as measured by  $\Delta^9$ -tetrahydrocannabinol content.

**Results:** We found evidence that potency increased by a half percentage point on average after legalization of medical marijuana, although this result was not significant. When we examined specific medical marijuana supply provisions, results suggest that legal allowances for retail dispensaries had the strongest influence, significantly increasing potency by about one percentage point on average. Our mediation analyses examining the mechanisms through which medical marijuana laws influence potency found no evidence of direct regulatory impact. Rather, the results suggest that the impact of these laws occurs predominantly through a compositional shift in the share of the market captured by high-potency sinsemilla.

**Conclusion:** Our findings have important implications for policymakers and those in the scientific community trying to understand the extent to which greater availability of higher potency marijuana increases the risk of negative public health outcomes, such as drugged driving and drug-induced psychoses. Future work should reconsider the impact of medical marijuana laws on health outcomes in light of dramatic and ongoing shifts in both marijuana potency and the medical marijuana policy environment.

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## Introduction

Marijuana (cannabis) is the most widely used illicit substance in the United States, with about 17.4 million past-month users in 2010. Recent trends reveal an increase in marijuana prevalence, especially among younger populations. Between 1990 and 2010, rates of past-month marijuana use increased about 68% for youth aged 12–17, 46% for young adults aged 18–25, and 12% for adults aged 26–34 (Substance Abuse and Mental Health Services Administration, 2011). Over the same time period, average concentrations of  $\Delta^9$ -tetrahydrocannabinol (THC)—the main psychoactive component of marijuana—nearly tripled from 3.4% to 9.6% (EISOHLY, 2008, 2012). This epidemiology has important public health implications, as mounting evidence links higher potency marijuana to an array of adverse outcomes, especially among novice users (Hall & Degenhardt, 2006, 2009; McLaren, Swift, Dillon, & Allsop, 2008). In particular, research supports claims of dose-dependency between THC levels and risk of acute anxiety

(Crippa et al., 2009), psychosis (Di Forti et al., 2009), cognitive impairment (Ramaekers et al., 2006), and vehicular accidents (Li et al., 2012; Ramaekers, Berghaus, van Laar, & Drummer, 2004).

Although there has been some recent attention in the academic literature to the question of whether permissive state medical marijuana laws (MMLs) have contributed to the recent rise in recreational use of marijuana, with results from published studies appearing quite mixed (e.g., Friese & Grube, 2013; Harper, Strumpf, & Kaufman, 2012), virtually no attention has been given to the possible impact these state laws might have on consumption through their effects on the average potency of the marijuana consumed. Indeed, it is entirely possible that a rise in the average potency of marijuana could be associated with a decline in total quantity of marijuana consumed, as users consuming higher potency marijuana require less marijuana to reach the same level of intoxication (van Laar, Frijns, Trautmann, & Lombi, 2013; Reinerman, 2009).

In light of the public health concerns associated with rising rates of high-potency marijuana use, particularly among youth, and the possible mediating effect this rise would have on total marijuana consumed, an obvious first question to ask is whether medical marijuana laws have contributed to rising potency trends over the past two decades. Although no state law directly regulates the THC

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content of medical marijuana, there is some evidence to suggest that the typical potency of medical marijuana is higher than that of recreational marijuana sold in black markets (Burgdorf, Kilmer, & Pacula, 2011). It may be the case that the general allowance for growing high-grade marijuana for medical purposes—including specific rules governing retail outlets or dispensaries, home cultivation, and patient caregivers—has contributed to the upward trend in potency observed in recreational markets.

The focal relationship we examine in this study, therefore, concerns the effect of state medical marijuana laws on cannabis potency. Specifically, we investigate state-level variations in potency for the years 1990–2010 using data from the University of Mississippi's Potency Monitoring Program (PMP), a federally-funded surveillance program that forensically analyzes marijuana samples seized by federal, state, and local law enforcement agencies (see Mehmedic et al., 2010). Recognizing that alternative state policies and programs may also affect potency, we explore the competing effects of rival explanatory factors, including marijuana decriminalization and law enforcement efforts. In the next section, we further explicate these policies and possible mechanisms of action.

### State marijuana policies, markets, and potency

Marijuana is not a uniform product, varying considerably by strain (indica, sativa, hybrid), cultivation technique (hemp, sinsemilla, hydroponic), and manner of processing (herb, resin, oil). The resulting cannabis phenotypes contribute to wide variations in potency across both time and place (Burgdorf et al., 2011; Slade, Mehmedic, Chandra, & Elsohly, 2012). Although direct empirical evidence is limited, insider and journalistic accounts suggest that MMLs—and the medical marijuana industry built up around them—have greatly enhanced the development and diffusion of high-potency cannabis cultivars and sophisticated technologies of production (Downs, 2012; Geluardi, 2010; Rendon, 2013; West, 2011). As Rendon (2013, p. 147) explains about developments in the earliest adopting medical marijuana state, “the legalization of marijuana for medical use in California has changed everything about the market for pot and is pushing changes for growers, breeders, and the plant itself.”

Given the relatively small size of legitimate medical marijuana markets (Bowles, 2012; General Accountability Office, 2002), one possible concern regarding our hypothesized policy effect is that any potential impact will be swamped by trends in the much larger recreational market. However, if there is substantial technology and product transfer between medical and recreational marijuana markets, as we suspect, the influence of these policies will be more broadly detectable. Indeed, the available evidence suggests that the two markets are quite interrelated, especially where oversight is lax, and that substantial quantities of medical marijuana are being overproduced and diverted into recreational markets (Finlaw & Brohl, 2013; Rendon, 2013; Wirfs-Brock, Seaton, & Sutherland, 2010). A recent investigation by the Rocky Mountain High Intensity Drug Trafficking Area program, for instance, documented dozens of cases of diversion of Colorado medical marijuana by dispensaries, registered patients, and licensed caregivers (Investigative Support Center, 2012). Indicative of such leakage, recent research with in-treatment adolescents in Denver found that one-half to three-quarters had previously used diverted medical marijuana for nonmedical reasons (Salomonsen-Sautel, Sakai, Thurstone, Corley, & Hopfer, 2012; Thurstone, Lieberman, & Schmiede, 2011).

Decriminalization policies and law enforcement efforts can potentially influence potency as well, so we also assess the competing effects of these rival factors. We hypothesize that the effects of these various policies may operate, at least partly, through

state-level contextual features such as product composition and overall size of the marijuana market. In other words, we surmise these policies help shape state markets, which in turn influence the quality and type of marijuana supplied to and demanded by users in these markets. We examine these various policies and propositions in more detail in the following sections.

### Medical marijuana laws

As of mid-2013, twenty states (including the District of Columbia) have adopted laws affording qualifying patients the right to possess and use marijuana for medical purposes without the threat of state prosecution and punishment.<sup>1</sup> Researchers have only recently begun to investigate the policy impacts of these laws. Most of these studies have focused on marijuana use, especially among youth, and in general they find no association between these policies and youth use (Anderson, Hansen, & Rees, 2012; Cerdá, Wall, Keyes, Galea, & Hasin, 2012; Friese & Grube, 2013; Gorman, Huber, & Charles, 2007; Harper et al., 2012; Khatapoush & Hallfors, 2004; Lynne-Landsman, Livingston, & Wagenaar, 2013; Wall et al., 2011). Studies considering adults have found very modest correlations (Anderson, Hansen, & Rees, 2013). Other studies have examined a range of alternative outcomes, finding that MMLs are not significantly related to emergency department visits (Gorman et al., 2007) and positively related to marijuana prices (Pacula, Kilmer, Grossman, & Chaloupka, 2010), with mixed results on treatment service utilization (Anderson et al., 2012), and even apparent benefits with respect to alcohol-related traffic fatalities (Anderson et al., 2013). However, to date, all of these studies have grouped medical marijuana laws as homogenous policies, ignoring the extent to which particular aspects of state laws (e.g., allowance of dispensaries) have influenced these results (Pacula, Powell, Heaton, & Sevigny, 2013).

Presently, thirteen states have implemented, or are in the process of establishing, state-licensed medical marijuana dispensary systems. Marijuana supplied under a state-sanctioned distribution regime is likely to be relatively more potent and of consistently higher quality than either home-grown or black market marijuana due to greater quality control, efficiency gains in production and reduced enforcement risks. In the Netherlands, for instance, marijuana sold through coffee shops and pharmacies for recreational and medical use, respectively, is more potent on average than marijuana available in the illicit markets of neighboring countries (Hazekamp, 2006; King, Carpentier, & Griffiths, 2004; Pijlman, Rigter, Hoek, Goldschmidt, & Niesink, 2005). In Switzerland, Killias, Isenring, Gilliéron, and Vuille (2011) report that the mean THC content of recreational marijuana dropped from 15.7% (range: 7.9–28.4%) to 12.0% (range: 3.7–17.6%) between 2004 and 2009 after the government shut down previously tolerated retail cannabis shops.

Personal home cultivation currently offers another supply option in fifteen medical marijuana states. These policies might promote the production of less potent marijuana if the majority of patients, especially those who are seriously ill, lack the necessary amenities, resources, or skills to cultivate and maintain their own supply of medical-grade marijuana (Chapkis & Webb, 2008; Feldman & Mandel, 1998). There is evidence to suggest that some

<sup>1</sup> We include Maryland in this group, a state that provides only an affirmative defense for possession of medical marijuana but does not permit home cultivation or regulate other sources of supply. We also distinguish current medical marijuana laws from the more circumscribed (and often unfunded) state therapeutic research programs enacted in the 1970s and 1980s that allowed investigational access to marijuana strictly within a clinical research setting.

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