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Smoke Signals and Mixed Messages: Medical Marijuana & Drug Policy Signalling Effects

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Smoke Signals and Mixed Messages:

Medical Marijuana & Drug Policy Signalling Effects

by

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Abstract: *Liberal drug policy reform is often criticized for 'sending the wrong message', particularly to youth. Reform opponents argue that liberal policies such as decriminalisation and medical marijuana laws will cause marijuana to be perceived as less risky and lead to an increase in use. We seek to test this claim empirically, exploiting the timing and unique properties of state level medical marijuana laws in the US to isolate policy signalling effects. We use survey-derived state-level estimates of youths' marijuana risk-perceptions and use prevalence, and find evidence of signalling effects on aggregate risk-perceptions of marijuana use that correspond to the introduction of medical marijuana laws. These effects, however, do not conform to what reform opponents predict – medical marijuana provisions appear to send the 'right' message. Further, we find no robust effects on non-medical marijuana use.*

JEL classification: K14, K42, I18, Z19

Keywords: Medical marijuana, drug policy, ballot initiatives, policy signalling

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Several generations of high school students have grown up ignoring and disbelieving everything they've heard from government and police about drugs, including information that was factual and valid, because they discovered for themselves that most of what has been taught to them [about drugs] was simply not true.

Ann Shulgin
Therapist and author
Meeting of the Division of Particles and Fields, 1996[1]

I. INTRODUCTION

The liberalisation of drug policy has been gaining momentum in the United States over the past two decades, particularly at the state level. As countries around the world - including the Netherlands, Switzerland, Portugal, Argentina and the Czech Republic - experiment with alternative policy approaches to hardline prohibition and criminalisation, several US states have also adopted more lenient models to deal with marijuana use and abuse. In the 1970s, eleven states decriminalised marijuana[2], and since 1996, sixteen states have introduced legislation which allows for the medical use of marijuana.

Such drug policy liberalisation is usually accompanied by heated debate, and one argument that is consistently made against reform is that liberal drug policy 'sends the wrong message' about drugs. In particular, opponents argue that changing drug laws to make them more liberal sends a signal to consumers and potential consumers that using drugs is less harmful, so they will consume more (see Eddy, 2010: 32-37). The argument is usually raised with specific regard to youth and children, who are expected to be most affected by the 'wrong message'. Although it appears often in the context of drug policy reform debates, the argument lacks a solid empirical basis – it is

[1] Cited in ProCon (2011d).
[2] Although the term 'decriminalisation' is used to describe several different types of policy (see Pacula, Chriqui and King, 2003; and Pacula et al., 2004), these pieces of legislation all reduced penalties for possession or use of minor amounts of marijuana from (generally) felony offenses to misdemeanors or violations. The eleven states to decriminalise were Oregon (1973); Colorado, Alaska, Ohio (1975); California, Maine, Minnesota (1976); Mississippi, New York, North Carolina (1977); and Nebraska (1978) (see MacCoun and Reuter, 2001). Since then, two other states have introduced policies that are similarly identified as having decriminalised marijuana: Nevada in 2002, and Massachusetts in 2009 (NORML, 2011b).

proffered as a common-sense fact, but has not been the subject of much empirical research and remains to be verified.

A substantial body of literature explores the effects of marijuana decriminalisation policies on consumption decisions and use prevalence, most within the US and Australian contexts[3]. The results from these studies tend to be mixed and sensitive to methodological approach and data used (see Damrongplasit and Hsiao, 2009)[4]. Medical marijuana is discussed widely in the medical and legal disciplines, but these studies tend to focus on the medicinal merits of marijuana, the legal aspects of the provisions, and the political debate surrounding their introduction.

This paper seeks to assess the 'wrong message' claim *a posteriori*, using a series of state level reforms that legalised marijuana for medical purposes in several states in the US. Drug policy can affect use through many different channels: via price and deterrence, for instance. The 'wrong message' argument posits that liberal policies affect behaviour by some other psychological mechanism, which we characterise as a policy signalling effect. Medical marijuana provisions (MMPs) don't change the real price or punishments for non-medical marijuana, so policy signalling effects are easier to identify by any changes in non-medical use. In this sense, MMPs provide a 'natural experiment' with which to isolate drug policy signalling effects.

One frequently observes a lively public and political debate on MMPs that is dominated by arguments about the social effects legal medical use may have. For example, it has been argued that the state MMPs increase illicit drug use; complicate the drug approval process; and undermine federal policy and the war on drugs (through diversion of medical marijuana to the illicit market, by changing enforcement priorities at the state and local levels, and by making it difficult for law

[3] For example Pacula (1998), Thies and Register (1993), DiNardo and Lemieux (2001), Johnston, O'Malley and Bachman (1981), Model (1992, 1993), Saffer and Chaloupka (1995, 1998), Chaloupka, Grossman and Tauras (1999), Chaloupka, Pacula, Farrelly, Johnston and O'Malley (1999), Zhao and Harris (2004) and Damrongplasit, Hsiao and Zhao (2006), Williams, Pacula, Chaloupka and Wechsler (2004).

[4] Many of these studies use a single binary indicator to capture decriminalisation in parametric estimation, an approach criticised by Pacula et al. (2004), who found that by 1999, judicial practice for marijuana possession charges was broadly consistent across decriminalised and non-decriminalised states in the US.

enforcement to distinguish between legal and illegal use) (Eddy, 2010). Of these three broad arguments, this study explores the first one, which can be classified as the WM argument.

Using survey-derived estimates of state-level marijuana use from the National Survey of Drug Use and Health, we assess whether the introduction of these laws 'sent the wrong message' and lead to the predicted increase in marijuana use. We also directly test whether liberal drug policies cause marijuana to be perceived as less risky. Our broad finding is that while there is some evidence of signalling effects, particularly for school-aged youth, these effects are contrary to what the WM argument predicts. More specifically, we find that the introduction of MMPs corresponds to an increase in the percentage of the population that perceives marijuana as very risky, with negligible effects on marijuana use decisions.

The importance of this research is highlighted by the increasing number of state-level, liberal drug policy reforms occurring in the US – ten states currently have pending medical marijuana laws or ballot initiatives[5] (ProCon, 2011c). Beyond assessing the 'wrong message' argument - which is something of a platitude in drug policy debates and deserving of attention in its own right – this research is unique in assessing how policy affects use by, what we term, a signalling channel. To date, most of the economic analysis of illicit drug policy has focused on more proximate channels such as level of deterrence and the effects of prices and availability. As more states enact liberal drug policies, it is important to understand how they may indirectly affect use, beyond their explicit aims.

To date, only one previous study has sought to empirically test the 'wrong message' argument, also in the context of legalised medical marijuana. This study found no signalling effects, but the generalisability of the results are hampered by the data that were used, and the fact that only California had legal medical marijuana in their sample (Khatapoush and Hallfors, 2004). Our analysis further extends the literature by considering the distinction between policy and public

[5] These states are Alabama, Connecticut, Idaho, Illinois, Massachusetts, New Hampshire, New York, North Carolina, Ohio & Pennsylvania.

discourse as causal drivers of behavioural change. Because we are seeking to assess the 'wrong message' argument as it is employed, we do not develop a theoretical framework to explain how this effect may occur. Rather, we use a framework of causal policy channels to illustrate the argument, and identify empirically-testable components.

II. MEDICAL MARIJUANA PROVISIONS

Marijuana has a long history of medicinal use, and was widely prescribed in the US in the 19th century (Aggarwal et al., 2009). In the early 20th Century, recreational use (and fears of violence resulting from said use) increased, and states and local jurisdictions began implementing laws banning the sale and possession of the drug, either completely, or for non-medical purposes (Pacula, Chriqui, Reichmann and Terry McElrath, 2002). Beginning with the Harrison Narcotics Tax Act of 1914, the next fifty years saw a spate of legislation at the federal level which culminated in the Comprehensive Drug Abuse Prevention and Control Act of 1970 (now known as the Controlled Substance Act (CSA)), which established the federal laws that are currently in force. Importantly, the CSA superseded all previous federal laws, and categorised substances into five schedules, according to their relative potential for abuse and recognised medical usefulness. After some deliberation, it was decided that marijuana be placed in Schedule I - implying that it had no accepted medical uses, and making it illegal for doctors to prescribe it. It was kept in Schedule I at the request of the Assistant Secretary of Health and Scientific Affairs "at least until the completion of certain studies now underway" (U.S.C.C.A.N., 1970 cited in DuVivier, 2005: 279).

Table 1. States Medical Marijuana Laws, 2010

State	MMP	Date effective	Introduced by	Votes (ballot)	Date Passed	Supply Mech.	Legal Code
Alaska	LMU	4/03/1999	Ballot	58%	3/11/1998	cultivate	Alaska Stat. §§ 17.37.10 - 17.37.80
Arizona	AD	6/12/1996	Ballot	65%	5/11/1996		
California	LMU	6/11/1996	Ballot	56%	5/11/1996	cultivate; dispensaries	California Compassionate Use Act 1996; Cal. Health & Saf. Code, § 11362.5;
Colorado	LMU	1/06/2001	Ballot	54%	7/11/2000	dispensaries	C.O. Const. art. XVIII, §14; Colo. Rev. Stat. § 18-18-406.3; Colo. Rev. Stat. § 25-1.5-106
DC	LMU	26/07/2010	Ballot	69%	1998	dispensaries	
Delaware	LMU	1/07/2011	Senate		13/05/2011	dispensaries	
Hawaii	LMU	28/12/2000	Senate		14/06/2000	cultivate	Haw. Rev. Stat. §§ 329-121 to 329-128
Maine	LMU	22/12/1999	Ballot	61%	2/11/1999	cultivate; dispensaries	Me. Rev. Stat. tit. 22, § 2383-B(5), (6); Me. Rev. Stat. tit. 22, § 2383-B(3)(e)
Maryland	AD	1/10/2003	Senate		1/10/2003		
Michigan	LMU	4/12/2008	Ballot	63%	4/11/2008	cultivate	Michigan Medical Marihuana Act, Mich. Comp. Law §§ 333.26421 - 333.26430
Montana	LMU	2/11/2004	Ballot	62%	2/11/2004	cultivate; dispensaries	Montana Medical Marijuana Act, Mont. Code Ann. §§ 50-46-1 to 50-46-2
Nevada	LMU	1/10/2001	Ballot	65%	7/11/2000	cultivate	Nev. Rev. Stat. §§ 453A.010 - 453A.240
New Jersey	LMU	1/10/2010	Senate		18/01/2010	dispensaries	
New Mexico	LMU	1/07/2007	Senate		2/04/2007	dispensaries	Lynn and Erin Compassionate Use Act, N.M. Stat. Ann. § 30-31C-1
Oregon	LMU	3/12/1998	Ballot	55%	3/11/1998	cultivate	Oregon Medical Marijuana Act, Or. Rev. Stat. § 475.300
Rhode Island	LMU	3/01/2006	Senate		3/01/2006	cultivate; dispensaries	The Edward O. Hawkins and Thomas C. Slater Medical Marijuana Act, R.I. Gen. Laws § 21-28.6
Vermont	LMU	1/07/2004	Senate		26/05/2004	cultivate	Therapeutic Use of Cannabis, Vt. Stat. Ann. tit. 18, §§ 4471- 4474d
Washington	LMU	3/11/1998	Ballot	59%	3/11/1998	cultivate	Wash. Rev. Code §§ 69.51A - 69.51A.901

Note: LMU – legal medical use; AD – affirmative defence; cultivate – patients and/or their caregivers can cultivate medical marijuana; dispensaries – law allows, explicitly or implicitly, the establishment of dispensing collectives

Sources ProCon, 2011a; NORMLa, 2011; Eddy, 2010

In modern times, medicinal marijuana has been the subject of extensive research and numerous clinical trials in the context of a variety of illnesses, notably multiple sclerosis, Tourettes syndrome, epilepsy, glaucoma, spinal cord injuries, Parkinson disease; and for symptoms including cachexia (wasting syndrome), pain, muscle spasticity and nausea (Ben Amar, 2006). Several prominent medical bodies in the US have expressed support for the rescheduling of marijuana to enable prescription by physicians, including the American Medical Association, and the American College of Physicians (ASA, 2010). There are currently two cannabinoid pharmaceuticals available on the market: dronabinol and nabilone (Aggarwal et al., 2009). The federal government also permits the use of the Cannabis Sativa plant strain of marijuana in the context of a limited number of Therapeutic Research Programs (beyond the federally-illegal use under state MMPs). In the medical debate over marijuana's efficacy as a medicine, some key issues are the risks associated with smoking the plant; the justification of prescribing it in plant-based form, given pharmaceutical alternatives; the much-debated addictiveness of marijuana; and other potential side effects (Aggarwal et al., 2009; Ben Amar, 2006).

In 1996 a petition to put medical marijuana[6] on California's November ballots was successful, and Proposition 215 was passed with 55.6 percent support (Eddy, 2010). On the same day that Proposition 215 was approved by California voters, Arizona voters approved a measure that established an affirmative defence of medical necessity against charges of marijuana use. Alaska, the District of Columbia, Oregon and Washington approved ballot measures legalising the medical use of marijuana in 1998, with Maine, Colorado, Nevada, Montana and Michigan following suit over the next ten years (Eddy, 2010). Over the same period, Hawaii, Vermont, Rhode Island,

[6] MMPs broadly legalise the possession and use of the substance for patients suffering from certain conditions, though with variation from state to state (see Pacula et al., 2002, for a detailed discussion of medical marijuana laws and the dimensions along which they vary from state to state).

and New Mexico legalised medical marijuana by senate introduced bills, while Maryland established an affirmative defence provision akin to Arizona's. Most recently, New Jersey legalised medical use in 2010, as did Delaware in 2011. Eleven other states have medical marijuana legislation or ballot initiatives pending (ProCon, 2011c)[7]. *Table 1* provides an overview of states with currently effective MMPs.

An important point about the state provisions is that they are in conflict with federal law – that is, marijuana is still illegal at the federal level, and it is still illegal for doctors to prescribe it. The conflict arises because states legalise marijuana use and cultivation (and sometimes distribution) for certain patients, while the federal CSA has marijuana placed in schedule I, where it is not recognised as having legitimate medicinal uses and is illegal for physicians to prescribe. More specifically, the Supremacy Clause of the U.S. Constitution states that federal law pre-empts conflicting state laws (DuVivier, 2005). Medical users of marijuana are only afforded protection in state courts, and can still be subject to federal prosecution. Several federal cases against MMPs and/or patients have seen the federal government apply the law according to this pre-emption clause[8]. This issue has been raised in court - notably in *United States v. Lopez*[9], *United States v. Morrison*[10], and *Gonzalez v. Raich*[11] – with the outcome of the latter affirming Congress's power to supersede state MMP laws. This conflict between state and federal law has important implications for

[7] It is worth noting that medical marijuana tends to enjoy strong popular support – 23 national public opinion polls going back to 1995 all show respondents favouring medical marijuana, with support ranging from 60-85 percent (Eddy, 2010: 24).

[8] DuVivier (2005) raises the argument that pre-emption is determined by a strictly intrinsic interpretation of the law (especially with regards to the CSA), and that an extrinsic interpretation would be less likely to find conflict and more able to reconcile state and federal laws.

[9] 514 U.S. 549 (1995).

[10] 529 U.S. 598 (2000).

[11] 545 U.S. 1 (2005).

the effect of MMPs; for example, under the Bush administration, federal bodies were instructed to pursue cases against state-sanctioned marijuana crimes[12] (Fields, 2009).

To date, only one study has considered the merits of the WM argument explicitly, while an Institute of Medicine (IOM) report has discussed the evidence. The IOM report, 'Marijuana & Medicine', discuss the WM argument by analogy to early 20th-century fears that medical use of opiates and cocaine would turn patients into addicts – they note that there is no evidence that medical use of these substances lead to an increased perception of the safety or acceptability of illicit use (1999: 102). The study also discusses the signalling issue by analogy to decriminalisation, the Netherland's de facto legalisation, and the effect of California's MMP – they find no evidence to support the WM argument, and conclude that until a non-smoked rapid onset cannabinoid drug delivery system is available, smoked marijuana is an appropriate treatment in certain situations (IOM, 1999: 102-104, 178-179). Khatapoush and Hallfors (2004) conduct the only study that explicitly examines the merits of the WM argument. They use survey data on past month use of marijuana, risk-perceptions , subjective availability, and approval of marijuana use for California, comparing outcomes to a set of ten control states without MMPs. The data they use comes from a random digit dialling telephone survey conducted as part of a study of the Robert Wood Johnson Foundation's Fighting Back initiative, for three waves: 1995, 1997 and 1999. They found that harm perceptions decreased in California, although they also decreased in control states, but no other changes in California after its introduction of legal medical use. They further consider the WM argument in terms of the 'gateway theory', finding that California's MMP did not lead to greater other drug use. Khatapoush and Hallfors (2004) find that the policy didn't send a 'message'

[12] The Obama administration has pledged not to devote resources to pursuing those compliant with state MMPs (Fields, 2009).

that dramatically changed marijuana attitudes or use, and note the relative unimportance of the medical marijuana issue in determining illicit marijuana use compared to other factors.

We believe that our study has several advantages over that conducted by Khatapoush and Hallfors (2004). The sampling and methodology of the survey from which our estimates are derived (National Survey on Drug Use and Health (NSDUH)) covers a larger sample that is representative of all US states; the authors themselves note that the telephone survey method employed in their study is arguably likely to result in more measurement error due to misreporting than the methods of NSDUH (which is conducted in person using conventional interviewing techniques and on supervised but unmonitored computer terminals for sensitive questions). We additionally use data for a longer time frame of ten years, where the earlier study looked at just three non-consecutive years. Finally, and perhaps most importantly, in the study by Khatapoush and Hallfors (2004), California is the only state that has legal medical use. California is the most populous state in the USA, and unique in its history of cultural drug use, being the epicentre for the 1960s counterculture movement, for example. Beyond this, California has by far the highest number of medical users, owing to a statutory caveat that allows medical use for "any other illness for which marijuana provides relief", beyond those listed in the legislation. The generalisability of these results to other states is questionable, as the authors themselves note. Our study has therefore the benefit of a longer timeframe over which a total of fifteen states introduced MMPs at different points in time.

III. THEORETICAL FRAMEWORK

In the present study, we do not develop a theoretical model to explain how drug policy signalling effects may occur - rather, given the ubiquity of the 'wrong message' (WM) argument, we test it *a posteriori* using a framework of drug policy channels to help illustrate how we isolate signalling effects. The economic analysis of illicit drugs policy is usually conducted within a rational choice framework. This framework is useful for identifying behavioural responses through the usual rational choice channels but doesn't have the necessary tools for analysing the indirect policy signals that are the focus of this study. In a seminal paper[13], MacCoun (1993) develops an alternative framework to rational choice models with which to analyse illicit drug policy. We use this framework to help illustrate how policy signalling could occur and to develop hypotheses that allow us to isolate and verify these signalling effects. The rational choice framework emphasizes that drug policy affects consumption through the channels of restricted availability, increased prices and deterrence effects (induced by risk of punishment). MaCoun (1993) extends this by recognising that there might be additional psychological channels, namely a 'symbolic threshold'[14], the forbidden fruit effect, stigmatisation[15], and informal social control factors[16]. Of most importance for the present analysis is the 'forbidden fruit effect' – this is a catchall term to

[13] Further developed in a subsequent book, see MacCoun and Reuter (2001).

[14] This refers to moral aspects that complement, but are distinct from, notions of risk and reward. In essence, individuals who exhibit an 'approval-seeking mentality' may comply with the law just because it is the law, being less influenced by the instrumental effects of punishment or reward (MacCoun, 1993: 503-504). The law thus acts as a symbolic threshold that keeps some individuals from using drugs.

[15] Stigmatisation is characterised in terms of the labelling theory of psychology and sociology: the stigma associated with the legal penalties for violating a law can actually increase the likelihood of re-offending, rather than reducing or deterring it (MacCoun, 1993: 505). This effect is argued to be due to the alienation of offending individuals, and the implicit promotion of contact with other deviants.

[16] This refers to how injunctive and descriptive norms (i.e. rules; and the visible evidence of others having followed them) can play a part in an individual's decision to break or follow a rule - in the case of drugs, these vary depending on reference group (family, peers, co-workers, friends), and in many contexts may be in conflict. This element introduces confounding factors that may affect the decision to use drugs: reference group (and level of bonding, motivation to follow the descriptive norm) and social context.

describe an increase in consumption indirectly resulting from restrictions that are placed on consumption. The forbidden fruit effect refers to the popular intuition that making something illegal increases its attractiveness to certain people. MacCoun (1993) discusses three psychological mechanisms by which this effect may occur: reactance theory (restricting freedom of choice increases attractiveness of the restricted choice); the principle of scarcity (artificial scarcity increases attractiveness through the learned association of scarcity and quality); and risk-seeking behaviour (some individuals may be more attracted to use drugs, because of the risk associated with taking them). The forbidden fruit effect is a policy signalling effect, comparable to the 'wrong message' argument – by making marijuana illegal, policy indirectly signals to some individuals that marijuana is desirable. We generalise MacCoun's (1993) 'forbidden fruit' transmission channel to be a policy signalling channel, capable of sending different unintentional and indirect 'messages' to different individuals that may ultimately affect their drug consumption decision. *Figure 1* illustrates how the seven channels affect consumption.

We use this framework to isolate policy signalling effects and to break the WM argument into testable components. State MMPs act here as a 'natural experiment' in which a policy change occurs but doesn't alter the rational choice mechanisms for our group of interest. An empirical analysis of illicit drug policy is inherently plagued by problems of identification: identifying use is troublesome, insofar as drug consumption is an illegal activity and users have a strong incentive to hide and misreport consumption; further, given the multiple channels through which any given policy and regime influences drug consumption, it is difficult to isolate behavioural changes that are uniquely attributable to a policy of interest. While we face the usual data problems with regards to measures of drug use, several

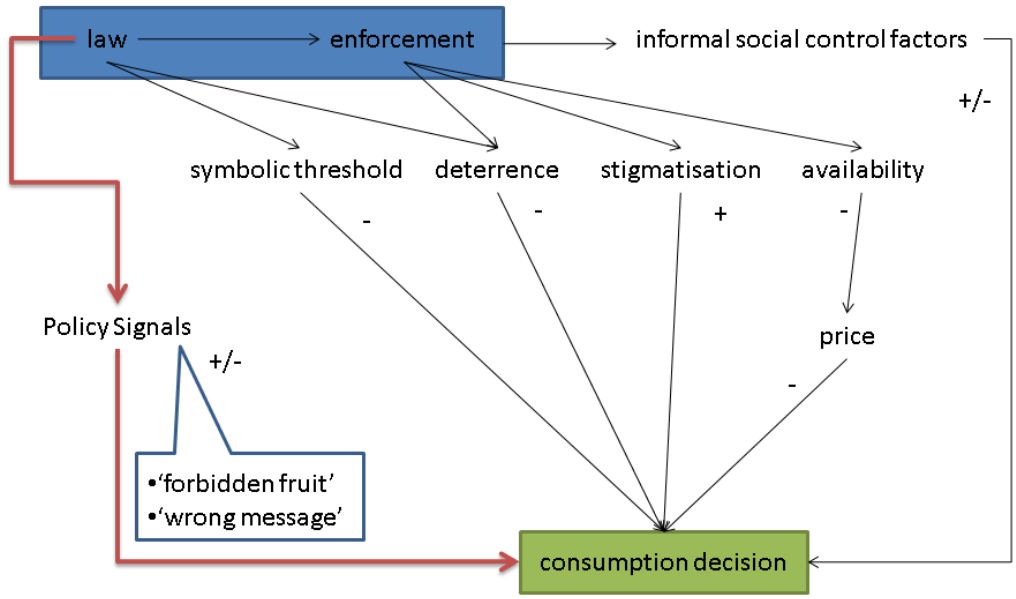
characteristics of MMPs simplify the isolation of signalling effects (when compared to marijuana decriminalisation policies, for instance). The introduction of a MMP significantly alters several of these channels for medical users, and will lead to an increase in the medical-using subpopulation – which by default was zero prior to the legislation, as all users were considered to be illegitimate users. The symbolic threshold and deterrence effects (see *Figure 1*) are no longer an issue for them, and given that MMPs allow them to grow their own marijuana or set up a supply mechanism, they are not affected by the availability and price on the black market. Ultimately, a MMP identifies and separates medical users from illicit users. If we assume that the number of formerly-illicit, but now legitimate medical users is sufficiently small, then the departure of medical users from the black market should have no serious impact on the aggregate demand in the black market. Further, since MMPs do not alter the status or penalties for non-medical marijuana use, the majority of the channels for non-medical users remain unaffected by the legislation. Thus, any changes in non-medical use that occur after the introduction of a MMP can be mainly attributed to signalling effects and informal social control factors.

While this conclusion may seem hasty, it is justified for several reasons. First, MMPs only change the penalties for marijuana use for a very specific and relatively small subset of the population – people with legitimate medical need[17]. By specifying approved conditions, and putting the onus of verifying medical need on physicians (who have a strong incentive not to over-prescribe, given that prescribing marijuana is already in conflict with federal law), MMPs erect significant barriers that prevent non-medical users from misrepresenting themselves as medical users. Secondly,

[17] The most recent estimate of the number of legitimate medical users in the US places the total at 369,634, with an overwhelming majority coming from California alone – some 253,800 (Yarett, 2010). This gives a national percentage of medical users of just over 0.1 percent. Anthony, Chen and Storr (2005) estimate the number of recent marijuana users in 2003 was approximately 15 million.

MMPs do not significantly alter the supply side of the marijuana market – considering that marijuana consumption has been widespread in the US, going back to at least the 1960s, illicit supply channels are likely to be entrenched in society. With medical users generally growing their own marijuana, and considering the relatively small number of medical users compared with non-medical users, there is unlikely to be any significant shifts in demand in the illicit market resulting from an influx of new users or departure of previous users. Diversion of medical marijuana into the black market is a particularly contentious issue, especially in the context of dispensaries, however several factors operate to mitigate this effect: patients and their caregivers who divert their medical marijuana to the black market face the usual non-medical supply penalties, with the additional consequence of losing their own medicine; dispensaries, in operating openly, face the scrutiny of law enforcement and have strong intrinsic motivations to self-police against illegal resale (ASA, 2010).

Figure 1. How Drug Policy Affects Consumption Decisions



Notes: Policy Transmission Channels adapted from MacCoun (1993). Plus and minus signs indicate direction of effects on consumption

We employ state variation in the institutional process of how laws were introduced to help confirm the veracity of any evidence of signalling effects. The signalling argument assumes that individuals are *aware* of the policy change. This being the case, we can expect that signalling effects should be more evident where the policy change is more apparent. Of the fifteen states that had active MMPs by 2008, ten were introduced via ballot initiative while five were introduced by senate bill. The former required majority popular support, while the latter needed majority only in the senate. Given the general rise in the amount of voter-initiated legislation, there is a growing literature that seeks to track the effects of ballot initiatives on political participation and voter turnout. One consistent finding is that states with more ballot initiatives tend to have higher voter turnout in midterm elections (Tolbert, Grummel and Smith, 2001; Tolbert and Smith, 2005; Donovan, Tolbert & Smith, 2009). We use this finding to motivate a hypothesis about the relative strength of signalling effects of ballot initiated MMPs compared to those initiated by the senate.

Signal Strength Hypothesis: *Signalling effects will be more evident in states that enacted their MMP via ballot initiative.*

While this hypothesis doesn't directly flow from the voter-turnout findings, we argue that the heightened campaigning in ballot states, by both advocates and opponents, is likely to raise the volume of media coverage and information that citizens are exposed to, compared with senate states. Further, the ability to participate in the legislative process in the case of ballot initiatives is likely to place the issue before more people who may otherwise not have concerned themselves with medical marijuana.

We use the timing of MMP policy changes to help distinguish between *signalling* and *public discourse* effects – if policy is the causal driver of behavioural change, we should see ongoing effects while the policy is active; if public discourse is the causal driver, we should only see a temporary effect while the policy change is high on the public agenda. Additionally, we investigate causality by testing for anticipation effects – if policy does cause changes in risk-perception or use, then these changes should not be evident *before* the policy takes effect.

A final issue we consider is how policy signals may have changed as medical marijuana laws gained more legitimacy – following California and Arizona's laws in 1996, more and more states have begun introducing MMPs. Signalling effects may have been different for the early adopters compared with those introducing them later. Namely, states that introduce MMPs after 1999 have a more solid reference point, and the national attention that the issue had received by then implies that more individuals are likely to have a realistic understanding of what such a policy entails. This could change any signalling effect and how it manifests. We therefore investigate this potential issue by looking just at those states that implemented a MMP after 1999.

In order to test it empirically, we must break the WM argument into smaller components. *Table A1* in the Appendix details some comments by MMP opponents that rely on the WM argument in some form. We identify four common elements of WM arguments:

WM1: MMPs cause marijuana to be perceived as safer.

WM2: MMPs cause marijuana use to increase.

WM3: MMPs cause more people to start using non-medical marijuana.

WM4: Youth are particularly susceptible to the 'wrong message' of MMPs.

We test each of these elements using survey-derived estimates of marijuana risk-perceptions and use prevalence.

Though often discussed and argued in the political context, to date there has been very little research into whether such effects do, in fact, exist. However there has been some research on other types of drug-related messages and their effects on use, namely on prevention campaign outcomes (e.g., Caulkins et al., 1999; Hornik et al., 2008; Anderson, 2010) and on the advertising of legal drugs like alcohol and tobacco (e.g., Saffer and Dave, 2006; Saffer and Chaloupka, 2000; Wakefield, et al., 2006). With regard to prevention campaigns, the general finding is that they tend to be ineffectual at curtailing drug use, and sometimes even correspond to increases in drug use metrics (Caulkins et al., 1999; Hornik et al., 2008; Anderson, 2010). Likewise, the advertising of alcohol and tobacco products tends to have no effect, or a small positive effect on consumption amongst adults (Saffer and Dave, 2006; Saffer and Chaloupka, 2000; Wakefield, et al., 2006). Some indirect evidence of possible signalling effects has been noted in the Swiss heroin substitution and prescription context. Nordt and Stohler (2006) identify a consistent drop in the size of the problematic heroin user population after the introduction of the heroin substitution program in Zurich, of about 4 percent a year. They argue that a potential reason for this decline could be that by 'medicalising' opiate dependence – that is, characterising it as an illness – the policy inadvertently made heroin less attractive to young people. This argument is sometimes echoed by MMP advocates in rebutting the WM argument. The Marijuana Policy Project released a report outlining arguments for MMP advocates to use in debates, and included the following rebuttal to the WM argument: "It is absurd to think that children will want to be as 'cool' as a dying

cancer patient. If anything, the use of marijuana by seriously ill patients might de-glamorize it for children. The message is 'marijuana is for sick people'" (Mirken, 2008: 6) Given that the interpretation of a policy message ultimately falls on individuals, it is possible and likely that different individuals will receive conflicting messages from the same policy. If there are policy signalling effects and they are visible in behavioural metrics at the state level, our interest, then, is in what the dominating signalling effect is.

Moreover, in most cases, the argument identifies the change in policy as the source of behavioural change, but it is possible that the discourse surrounding the policy change has a greater impact on drug consumption decisions then the policy itself does. Khatapoush and Hallfors (2004: 764) stress that the "very fact there was a debate highlighted the tension between possible medical benefit while reminding the public that marijuana is illegal, to say nothing of the message sent by actions of federal agencies, such as raids on distribution centers..." Indeed, if medical use is legalised but no non-medical users are informed, it seems unlikely that there will be any signalling effect. While our analysis considers the WM argument on its own terms – that is, that the policy sends a behaviour-modifying signal – we also consider the possibility of discourse effects in robustness specifications.

IV. DATA

The empirical component of this study is based on estimates of state-level marijuana use metrics derived from the National Survey on Drug Use and Health (NSDUH). The NSDUH estimates are representative of the overall percentage of the non-institutionalised population using various substances. We combine this data with

state-level control variables that might also drive drug use, and policy variables that capture the implementation of MMPs.

1. MMP Policy Variables

We created several policy variables to capture whether a state has a medical marijuana law. To test the signal strength hypothesis, we create two, non-overlapping dichotomous policy variables that reflect the different institutional processes by which MMPs are introduced: $BALLOT_{st}$ and $SENATE_{st}$. $BALLOT_{st}$ is set equal to one if a state has a ballot-initiated MMP (including affirmative defence provisions) in place in a given year. Similarly, $SENATE_{st}$ is set equal to one if a state has a senate-enacted MMP (including affirmative defence provisions) in place in a given year.

To investigate timing aspects of policy changes, we also create a more detailed series of institution-differentiating policy variables. $BPOLp2_{st}$ equals one if a state enacts legislation in year *t+2*, $BPOLp1_{st}$ equals one if it enacts legislation in year *t+1*, $BPOL_{st}$ equals one if it enacted the legislation in year *t*; $BPOLm1_{st}$ equals one if it enacted the legislation in year *t-1*; $BPOLm2_{st}$ equals one if it enacted the legislation two or more years ago (i.e. in periods *t-2, t-3, t-4*, etc.). States with senate introduced legislation have five analogous indicators: $SPOLp2_{st}$, $SPOLp1_{st}$, $SPOL_{st}$, $SPOLm1_{st}$, and $SPOLm2_{st}$.We match our policy variables to NSDUH data for the 1999-2008 period. *Table A2* in the Appendix provides descriptive statistics for the policy variables.

2. The National Survey of Drug Use and Health (NSDUH)

The NSDUH is an annual national survey on substance abuse that began in 1979 as the National Household Survey on Drug Abuse. The survey records information on the use of commonly abused substances such as alcohol, marijuana, and cocaine, as well as treatment history, the treatment gap, mental health, and detailed personal and demographic information. The survey is conducted by the Research Triangle Institute research team under contract of the Substance Abuse and Mental Health Services Administration (SAMHSA) at the Office of Applied Statistics. Since 1999, the survey has employed a 51-state design with an independent, multistage area probability sample for each state and DC. In 2002, the survey was renamed to NSDUH, and since then participants receive $US30 remuneration – this lead to an increase in participation rates, and places limitations on comparisons between data collected before and after 2002. Detailed data-collection and survey methodology reports are available from SAMHSA (see SAMHSA, 2010; NSDUH, 2010, Caviness et al., 2009).

The survey methodology includes oversampling youths and young adults to improve precision of substance abuse estimates, and so that each state's sample is approximately equally distributed between 12-17 year olds, 18-25 year olds, and those 26 years or older. Surveys are conducted in person at the respondent's address, using spoken question and answer format and supervised but unmonitored question and answers on a computer terminal for sensitive questions (Caviness et al., 2009). The use of computer terminals for sensitive questions, specifically those related to respondents drug-use, are an important advantage of NSDUH over other surveys that helps to mitigate measurement error due to misreporting.

Because the survey doesn't include the institutionalised population, we face a possible sample selection bias – a substantial proportion of individuals incarcerated in prisons and jails are drug offenders (Caulkins and Chandler, 2006). As such, our analysis using NSDUH data may, in fact, be missing one of the most at-risk and relevant sub-populations. Given that almost all states divert first & second-time petty marijuana possession offenders away from incarceration, the relevant individuals that our analysis misses are those that are more heavily involved in the use and/or supply of illicit drugs. Considering that the signalling effects are expected to be strongest for marginal marijuana users, this exclusion is not such a significant issue and may, in fact, be ideal. Nonetheless, we attempt to control for this problem by including drug arrest control variables.

Another important issue when employing survey data, one that is particularly relevant in the context of substance abuse, is measurement error due to respondents under-reporting their actual use. NSDUH began in 1979 and has undergone significant methodological scrutiny to address this issue - while misreporting is inevitably a problem, NSDUH data and derived estimates are among the most reliable data on US drug use.

3. Marijuana Metrics Estimates

Since the 51-state sampling redesign in 1999, SAMHSA has published estimated state prevalence rates for a variety of measures derived from the survey. We use estimates of marijuana risk perceptions, past month use, and average annual first use rates for our analysis. Currently, estimates are available from 1999 to 2008. A survey-weighted

hierarchical Bayes methodology is employed to derive the annual estimates using small area estimation modelling (see NSDUH, 2010 for details)[18].

4. Dependent and Control Variables[19]

In regards to our dependent variables we are interested in the variables that relate specifically to marijuana:

- Percentage of the population perceiving great risk of smoking marijuana once a month (*risk*). The variable is derived from survey responses to the question, 'how much do people risk harming themselves physically and in other ways when they smoke marijuana once a month?' (SAMHSA, 2010). Respondents can select four different levels of risk, from no risk through to great risk. The variable represents the estimated percentage of individuals who would answer this question with the highest available level of risk – 'great risk'.
- Percentage of the population that used marijuana at least once in the past month (*pastmonth*). The variable derived from responses to a series of questions on the use and frequency of use in the 30 days up to and including the day of the survey. The questions are structured so as to be internally consistent, and ask respondents to verify their answers where any inconsistency arises.
- Annual rate of first-use of marijuana (*firstuse*) – the percentage of the population who used marijuana for the first time in the past 12 months. The

[18] While a micro-level analysis of the survey data would be an ideal follow-up to investigate the behavioural dynamics of any policy signalling effects, the public-use micro-level NSDUH data files do not include geographic identifiers for confidentiality purposes. As such, we cannot identify the state for each observation and match them to state-level marijuana laws.

[19] *Table A3* in the Appendix presents descriptive statistics for our three variables of interest, for the age-subpopulations we consider. Given the methodological change in 2002, we present descriptive statistics for both the entire sample period, and also for the limited 2002-2008 period.

variable is derived from a series of question on marijuana use, and the year and month of first use[20].

The NSDUH state estimates for these measures include estimates for: the entire 12 years and older population; the 12-17 year old population; the 18-25 year old population; and the 26 years and older population - this gives us 12 marijuana metric variables that are used as dependent variables in regressions. We strongly focus on the potential MMP signalling effects for school-aged youth from 12 to 17 years, but consider the other populations as well. It is interesting to note that the age category 18-25 perceive a great risk of using marijuana, while youths have higher past month consumption and first use rates than the whole population. Young adults have the lowest, as well as the highest past month consumption rates by substantial margins, with comparable first use rates to youth. When pre-methodology change years are omitted, we observe no substantial change in averages for each variable.

We also match the NSDUH estimates to several additional state-level variables which are likely to affect marijuana consumption and influence the impact of any signalling effects. A potentially important determinant of aggregate marijuana use is state expenditure on substance abuse prevention and treatment. In the context of consumption, greater spending on prevention may lead to lower consumption[21], concurrent with any policy signalling effects. True state expenditures on prevention and treatment are infeasible because of the different levels of government and the various institutions that are involved in these activities. We therefore proxy state prevention and treatment spending concurrently, with federal Substance Abuse Prevention and Treatment (SAPT) block grants[22]. These funds are appropriated by

[20] See SAMHSA (2010) for details of the survey questionnaire and estimation methodology.
[21] Or, if the 'forbidden fruit' effect dominates – higher consumption.
[22] This data was graciously provided by the authors of Dave and Mukerjee (2011).

Congress for use by states on an application basis, and account for approximately 40% of public funds spent on such activities by the states (Cowell, McCarty & Woodward, 2003). According to Mark et al. (2007), about 8 percent of these funds were spent on treatment in 2003 - the majority tending to go to prevention activities. The other major sources of treatment funding are Medicaid and other state funds (Mark et al., 2007).

Recognising that most drug prevention messages are disseminated through the education system (in schools, for example) and the health care sector, we include state expenditure on education and health care in our models. We additionally control for educational participation by including the estimated percentage of the population with at least a bachelors degree.

The actions of the federal government with regard to states that enact MMPs is also particularly relevant – federal raids on dispensaries, and federal court cases against patients and physicians can all have important signalling effects that potentially counteract state MMP signalling effects. Even though federal action varies from state to state, we assume that the signals from federal government actions are homogenous for all states, and our estimation method using state fixed-effects also helps to control for any federal signalling.

The impact of any signalling effect is premised on the idea that individuals are informed and aware of the policy change. There is a substantial literature investigating the determinants and correlates of social and political engagement, and this informs our selection of engagement controls (see, for example, Erbe, 1964; Powell, 1982; Rosenstone, 1982; Blais, 2006). Socio-economic status tends to be positively correlated with engagement (Rosenstone, 1982), so we include several state-level measures of socio-economic status: unemployment rate, poverty rate,

personal income per capita, and percentage of the population without health insurance. Demographic characteristics such as age, education and race are similarly associated with voter turnout (Blais, 2006), so we include a host of demographic variables described later. We additionally include lagged state suicide rate per hundred thousand people – suicide arguably being the ultimate gesture of social and political disengagement.

We also control for the level of enforcement due to its potential effects on marijuana consumption decisions (deterrence, market effects, and stigmatisation effects). More specifically, higher enforcement could have a larger deterrence effect on marijuana consumption decisions; it could lead to more market disruption causing higher prices, lower availability, and the incarceration of consumers; and it could lead to more problematic use through the stigmatisation of offenders. Finally, given the potential sample-selection issue mentioned with regards to the NSDUH data, controlling for enforcement is critical. We include two variables to control for drug law enforcement levels: lagged total arrests for drug offenses (including both trafficking and possession) and lagged total arrests for drug possession offenses[23].

Finally, we include several other demographic variables. These include state population, and estimated percentages of males; of those aged between 15 and 24; of blacks and of Hispanics. Although the epidemiological literature points to time-variant marijuana smoker profiles, males and youths are usually found to be more likely to use marijuana than the rest of the population, while blacks and Hispanics are less likely to use marijuana (see, for example Saffer and Chaloupka, 1998; Bachman, Johnson and O'Malley, 1998). We include these variables to control for any heterogeneity that may have an impact on marijuana use, as well as for their political-

[23] This data was graciously provided by the authors of Dave and Mukerjee (2011).

engagement explanatory power. *Table A4* in the Appendix provides details and sources for our various control variables.

Because we are looking at state-level policy changes, migration becomes an issue – namely, our results will be biased if the introduction of a MMP induces some people to migrate into or out of MMP states. While the MMP may induce patients with qualifying illnesses and symptoms to migrate to a MMP state, they make up a very small proportion of the population and further aren't the subpopulation of marijuana users that we are interested in. MMPs don't create incentives for non-patients to migrate to MMP states, which would be much more problematic for our analysis. In addition, our key population of interest – youth aged 12-17 – will usually be in the care of parents or other adults, and are unlikely to have much sway in migration decisions. Any bias induced by such a migration effect will bias our results in favour of the 'wrong message' argument – consumption rates would increase for the additional users. While this bias will likely be small if at all evident, the fact that it is unidirectional means that we can qualify our results accordingly.

V. EMPIRICAL EVIDENCE

1. Empirical Model

In order to test the 'wrong message' argument empirically, we employ a least squares panel regression approach. Our basic model is:

$$NSDUH_{st} = \alpha + \beta\, policy_{st} + \lambda method_{t} + \delta controls_{st} + \tau_{t} + \nu_{s} + \varepsilon_{st}, \qquad (1)$$

In model (1), the dependent variable is one of our three variables of interest from the NSDUH state estimates ($risk$, $pastmonth$, $firstuse$), and *policy* is a vector of

variables capturing whether a state has a MMP and the institutional process by which it was implemented - the variables *BALLOT* and *SENATE*. The variable *method* is a binary indicator equal to zero in years 1999-2001, and equal to one in years 2002-2008 to control for the change in NSDUH survey methodology in 2002, and *controls* is a vector that includes the state-level control variables outlined in the previous chapter. Finally, we include time (τ_t) and state (ν_s) fixed effects, with ε_{st} being stochastic disturbance.

We estimate model (1) for the three marijuana related estimates from NSDUH for each of the four age subpopulations for which estimates are available. We use the STATA statistical software package for all estimation. Our estimation procedure involves first considering just those states that introduced an MMP between 1996 and 2008, and then including control states. We select control states based on their historical sympathy for liberal drug policy - namely those that have explicitly implemented a marijuana decriminalisation policy and those that have a pending or failed medical marijuana law[24]. We also consider a 50 state specification, in which all states are used as controls. The latter specification is potentially problematic, as it relies on the assumption that the treated states counterfactual outcomes and all other states observed outcomes have the same trend over time. To address this issue we provide estimates for our policy coefficients by estimating 50 49-state specifications, where each state is methodically omitted from the sample.

The WM argument predicts that states with MMPs will have higher consumption rates and lower risk perceptions. More specifically, it predicts that the coefficients on our policy variables, *BALLOT* and *SENATE*, will be positive and

[24] These states are: Connecticut, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Massachusetts, Minnesota, Mississippi, Nebraska, New Hampshire, New York, North Dakota, Ohio, Oklahoma, Texas, Virginia, and West Virginia.

significant for the consumption and first use rate dependent variables, and negative and significant for the risk perception dependent variable. From our signal strength hypothesis, the coefficient on *BALLOT* will be greater in magnitude then the coefficient on *SENATE* if we are observing a signalling effect.

We also consider the timing aspect of any potential policy signals and employ a ten-variable policy vector which captures the timing of ballot and senate enacted MMPs. If we are observing a policy signalling effect, then changes in marijuana metrics should not be evident in years prior to the policy change (anticipation effect) and should be persistent for some years after the change occurs. By investigating the timing of marijuana metrics changes we can differentiate between a policy signalling effect and a public discourse effect, and asses the validity of our specification.

2. Results

Table 2 presents results for the *risk* dependent variable over just the treated states, with sequential addition of controls - here the effect of policy signals are identified purely through the variation in the years in which MMP laws are introduced. In specifications 1-3, the dependent variable is the *risk* estimate from NSDUH for the entire 12+ population; specifications 4-6 use the estimate for the 12-17 year old population; specifications 7-9 use the estimate for 18-25 year olds; and specifications 10-12 use the estimate for the 26 and older population. The coefficients of interest are those on the *BALLOT* and *SENATE* variables[25].

Recall that the WM argument predicts that both ballot- and senate-initiated MMPs would lead to a decrease in *risk*, particularly for the school-age youth subpopulation. The results from *Table 2* are at odds with this prediction - *risk*

[25] Note: Due to space restrictions we do not provide estimates for our control variables, however these are available on request, as is our full data set and STATA command files.

increases in ballot states for all populations, except for college-aged youth. Note that senate-initiated MMPs have consistent signs with ballot-initiated MMPs, but that none are statistically significant to the 10 percent level. Although the signs are at odds with what the WM argument predicts, these results do support the signal strength hypothesis - that policy introduced by ballot initiative has stronger signalling effects than that introduced by senate bill. Note further that the coefficient on *BALLOT* is largest for school-aged youth - medical marijuana policy appears to be sending them the 'right message'; that marijuana is dangerous.

Table 3 presents equivalent results for the *pastmonth* estimates from NSDUH. Note that here the only significant policy coefficients are on school-aged youth in ballot states, and that, again, the direction of the sign is at odds with the WM argument's prediction. Past month consumption of marijuana decreases for school-aged youth following the introduction of a ballot MMP. The signs of coefficients are consistent with our signal strength hypothesis for school-aged youth in senate and ballot MMP states, however this doesn't hold true for the other subpopulations.

Table 4 presents results for the *firstuse* estimates. Here, results appear to be sensitive to use of controls, however note that none of the policy coefficients are consistently significant. For school aged youth, coefficient estimates are all negative and greater in ballot states (although statistically insignificant), and *firstuse* see a small marginally significant increase for college-aged youth in senate states. As for *pastmonth*, the signs of coefficients are inconsistent with our signal strength hypothesis in all subpopulations except for school-aged youth.

Table 2. Effect of MMP on *Risk*, Just Treated States

	All Ages			12-17 Years			18-25 Years			26 Years+		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	risk	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*	*risk*
BALLOT	0.240**	0.233**	0.162**	0.628***	0.632***	0.498***	0.006	-0.029	-0.102	0.230**	0.224**	0.162**
	(2.52)	(2.28)	(2.42)	(6.40)	(4.20)	(4.84)	(0.06)	(-0.20)	(-1.08)	(2.49)	(2.45)	(2.54)
SENATE	0.074	0.031	0.017	0.176*	0.127	0.105	0.019	-0.048	-0.064	0.076	0.043	0.030
	(1.06)	(0.30)	(0.18)	(2.06)	(1.15)	(0.86)	(0.36)	(-0.70)	(-1.19)	(1.02)	(0.41)	(0.30)
method	-0.510***	-0.569***	-0.636***	-0.526***	-0.635***	-0.729***	-0.439***	-0.472***	-0.566***	-0.483***	-0.536***	-0.595***
	(-8.77)	(-6.20)	(-7.85)	(-7.37)	(-4.81)	(-6.48)	(-8.03)	(-8.36)	(-11.51)	(-7.49)	(-5.33)	(-6.36)
Signalling Controls[a]	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Social Engagement Controls[a]	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enforcement Controls[a]	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Demographic Controls[a]	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State & Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	150	150	150	150	150	150	150	150	150	150	150	150
Adj. R-sq	0.611	0.609	0.628	0.394	0.416	0.457	0.599	0.629	0.689	0.563	0.558	0.568

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01; [a] see Table A4 in Appendix for details.**

Table 3. Effect of MMP on *Pastmonth*, Just Treated States

	All Ages			12-17 Years			18-25 Years			26 Years+		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	pastmonth	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*
BALLOT	0.000	-0.009	0.087	-0.518***	-0.397*	-0.246**	0.072	0.088	0.190	0.045	0.010	0.082
	(0.00)	(-0.05)	(0.76)	(-4.19)	(-1.95)	(-2.62)	(0.74)	(0.62)	(1.68)	(0.24)	(0.06)	(0.69)
SENATE	-0.005	-0.026	-0.036	-0.251***	-0.089	-0.104	-0.019	0.007	-0.001	0.017	-0.075	-0.076
	(-0.05)	(-0.30)	(-0.36)	(-4.05)	(-0.88)	(-0.96)	(-0.41)	(0.13)	(-0.01)	(0.17)	(-0.73)	(-0.68)
method	0.477***	0.491***	0.531***	0.024	0.318***	0.398***	0.368***	0.386***	0.406***	0.515***	0.469***	0.518***
	(6.09)	(4.45)	(4.52)	(0.23)	(3.07)	(3.84)	(10.51)	(5.58)	(5.01)	(4.98)	(3.27)	(3.61)
Signalling Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Social Engagement Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enforcement Controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Demographic Controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State & Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	150	150	150	150	150	150	150	150	150	150	150	150
Adj. R-sq	0.487	0.521	0.564	0.210	0.389	0.443	0.462	0.490	0.526	0.489	0.526	0.573

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01.**

Table 4. Effect of MMP on *Firstuse*, Just Treated States

	All Ages			12-17 Years			18-25 Years			26 Years+		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	firstuse	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*	*firstuse*
BALLOT	-0.154	-0.148*	-0.061	-0.214	-0.212**	-0.070	-0.227***	-0.210**	-0.162	0.046	0.083	0.119
	(-1.76)	(-2.07)	(-0.44)	(-1.38)	(-2.23)	(-0.40)	(-5.05)	(-2.18)	(-1.50)	(0.51)	(0.50)	(0.78)
SENATE	-0.035	0.088	0.096	-0.145	-0.029	-0.026	0.063	0.128*	0.150*	-0.147	-0.003	-0.004
	(-0.36)	(0.98)	(0.98)	(-1.64)	(-0.30)	(-0.24)	(1.22)	(1.82)	(1.98)	(-1.13)	(-0.04)	(-0.05)
method	0.345***	0.520***	0.590***	-0.092	0.232	0.320*	0.405***	0.487***	0.549***	0.293***	0.478***	0.533**
	(4.08)	(4.15)	(4.59)	(-0.64)	(1.34)	(1.91)	(6.89)	(4.54)	(4.51)	(4.38)	(3.39)	(2.85)
Signalling Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Social Engagement Controls	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Enforcement Controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
Demographic Controls	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes
State & Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	150	150	150	150	150	150	150	150	150	150	150	150
Adj. R-sq	0.233	0.395	0.419	0.069	0.292	0.347	0.356	0.366	0.361	0.060	0.126	0.127

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01.**

The results presented so far paint a broad picture in which MMPs do have policy signalling effects, although these are most proximate on risk perceptions and less so on actual consumption patterns. Further, the direction of the effect is consistently in opposition to what the WM argument predicts, particularly for school-aged youth, which is our key subpopulation of interest.

We proceed by introducing some control states - we include those states that decriminalised marijuana since the 1970s, and those that have a failed or pending medical marijuana policy[26]. *Table 5* presents results for each dependent variable - specifications 1-4 present results for the four age brackets for *risk* ; specifications 5-8 present results for the four age brackets for *pastmonth*; and specifications 9-12 present results for the four age brackets for *firstuse* reporting only for simplicity our key variables of interest. All specifications include our full set of controls. We can see that the results are consistent to those without the control states: *risk* is positive and significant for all except college aged youth in ballot states; *pastmonth* is negative and marginally significant for school-aged youth in ballot states. The introduction of control states has changed results for *firstuse*: senate states now see a significant increase in the 12 years plus, school aged and college aged youth subpopulations, while ballot states see a decrease for college aged youth and an increase for those over 26 years. These results go against our signal strength hypothesis and undermine the interpretation of this as a policy signalling effect.

Next, we also considered an extension to our analysis where all 50 states are included in the analysis. This requires the assumption that 'treated' states counterfactual outcomes and control states observed outcomes are trending in the

[26] These states are: Connecticut, Delaware, Florida, Idaho, Illinois, Iowa, Kansas, Massachusetts, Minnesota, Mississippi, Nebraska, New Hampshire, New York, North Dakota, Ohio, Oklahoma, Texas, Virginia, and West Virginia.

same way over time. Again, results are consistent with the inclusion of all states (see *Table 5*). The only significant difference is an increase in college aged youths' past month marijuana use in ballot states. The magnitude of effects for *firstuse* are again inconsistent with our signal strength hypothesis.

Given that some states, particularly unique treated states like California, may be driving the aggregate results observed so far, we also consider a repeated 49-state design in which each state is methodically omitted from the sample. *Table 6* presents the range of estimates for each policy type and marijuana metric per subpopulation from these models[27]. Note that results are again consistent in terms of sign and significance. We consistently see an increase in *risk* for all subpopulations except for college aged youth in ballot states with no significant effects in senate states. In addition, *pastmonth* goes down for school aged youth in ballot states, and *firstuse* rates increase for college aged youth in senate states and those 26 and over in ballot states.

The results we have presented so far indicate that there may be policy signalling effects associated with MMPs, however these tend to go in the opposite direction to that predicted by the WM argument and its proponents. It may be the case, however, that the observed effects are not policy signals, but rather reactions to the increased attention marijuana receives when such a policy is introduced. We explore this aspect by introducing a more detailed policy vector into our model - we include indicators for whether an MMP will be introduced in 2 years, in 1 year; in the present year; was introduced 1 year ago, or 2 or more years ago; for each institutional mechanism. If we are observing a policy signalling effect then changes in marijuana metrics should not be observed in the years before an MMP is introduced

[27] For each dependent variable we regressed our model 50 times, each time omitting a different state, and present here the lowest and highest estimates obtained and the variation in significance level observed. Our full set of controls were employed in each regression.

(anticipation effects) and should be consistent for some years after its introduction. *Table 7* presents the results for this policy vector. Given the consistency of results with the full 50 state design, we include all states as controls.

Here the results are less consistent than when we used the two dichotomous policy indicators. We observe a marginally significant decrease in risk perceptions of marijuana's harms for the whole 12+ subpopulation two years prior to the introduction of a ballot MMP. For our subpopulation of interest, school-aged youth, we see a highly significant increase in risk perceptions in the year a ballot MMP is introduced. For this subpopulation there is no anticipation effect, however the fact that the effect doesn't carry on over subsequent years indicates that this may actually be a public-discourse effect rather than a policy signalling effect: in the year of the introduction of a ballot-initiated MMP, the issue is higher up on the public agenda and more visible, leading to a shift in *risk*, however when it falls off the public agenda (after being passed) the effect also disappears. For college aged youth, we see a consistent, significant decrease in *risk* beginning at least two years prior to the introduction of a ballot MMP. The fact that risk perceptions are changing prior to the introduction of the law indicates that the effect we are capturing is unlikely to be a policy signalling effect, and moreover, for this subpopulation, our model may be failing to include important determinants of marijuana risk-perceptions. We see a similar pattern for this subpopulation when it comes to *pastmonth* and *firstuse* - consumption is increasing (in line with the WM argument) however it begins before the policy change, undermining the interpretation of this result as being due to medical marijuana policy.

Table 5. Robustness Tests

Dependent Variable	*risk*	*risk*	*risk*	*risk*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*firstuse*	*firstuse*	*firstuse*	*firstuse*
Age Sample	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+
Treated States and Control States												
specification	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
BALLOT	0.101**	0.271***	-0.058	0.101**	0.081	-0.196*	0.129	0.095	0.045	0.021	-0.097*	0.266**
	(2.35)	(5.26)	(-0.83)	(2.45)	(0.65)	(-1.93)	(1.28)	(0.73)	(0.86)	(0.29)	(-1.93)	(2.33)
SENATE	0.001	-0.007	-0.024	0.009	0.011	0.026	0.030	-0.028	0.150**	0.127*	0.148**	-0.052
	(0.03)	(-0.14)	(-0.73)	(0.20)	(0.15)	(0.53)	(0.64)	(-0.37)	(2.17)	(2.03)	(2.37)	(-0.73)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State & Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	340	340	340	340	340	340	340	340	340	340	340	340
adj. R-sq	0.654	0.461	0.669	0.587	0.552	0.412	0.465	0.547	0.367	0.388	0.326	0.074
F	76.33	21.65	65.59	42.50	40.62	49.48	11.79	95.31	85.13	11.93	29.85	14.31
50 State Sample												
specification	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)
BALLOT	0.107***	0.242***	-0.059	0.111***	0.094	-0.155**	0.141*	0.098	0.087*	0.074	-0.036	0.171**
	(2.95)	(5.34)	(-0.93)	(3.38)	(0.91)	(-2.26)	(1.69)	(0.89)	(1.70)	(1.16)	(-1.11)	(2.34)
SENATE	0.009	0.007	-0.014	0.014	0.014	-0.000	0.028	-0.015	0.111*	0.077	0.130**	-0.037
	(0.29)	(0.17)	(-0.47)	(0.47)	(0.25)	(-0.00)	(0.78)	(-0.25)	(1.79)	(1.53)	(2.50)	(-0.70)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State & Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	500	500	500	500	500	500	500	500	500	500	500	500
adj. R-sq	0.692	0.486	0.630	0.638	0.544	0.407	0.470	0.541	0.407	0.428	0.361	0.285

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01**

Table 6. Policy Variable Estimate Range for Reiterated 49-State Sample

		BALLOT		*SENATE*	
Dependent Variable	Age Sample	estimate range	significance range	estimate range	significance range
risk	12 Years+	1.24 - 2.351**	(-0.005 - -0.0005)	-0.249 - 1.224	(-0.944 - -0.022)
	12-17 Years	2.60 - 3.978***	(-5.5e-5 - -5e-7)	-0.528 - 0.714	(-0.981 - -0.397)
	18-25 Years	-1.769 - 0.761	(-0.572 - -0.006)	-0.985 - 0.354	(-0.796 - -0.20)
	26 Years +	1.559 - 2.408**	(-0.002 - -4.1e-5)	-0.173 - 1.576	(-0.871 - -0.008)
pastmonth	12 Years+	-0.152 - 0.878	(-0.791 - -1.6e-9)	-0.421 - 0.348	(-0.998 - -0.020)
	12-17 Years	-1.169 - -0.528*	(-0.092 - -0.002)	-0.243 - 0.270	(-0.999 - -0.343)
	18-25 Years	-0.092 - 2.706	(-0.927 - -2.1e-6)	-0.282 -0.92	(-0.628 - -0.271)
	26 Years +	-0.047 - 0.760	(-0.93 - -7.3e-8)	-0.544 - 0.123	(-0.937 - -0.002)
firstuse	12 Years+	0.055 - 0.085	(-0.279 - -0.034)	0.059 - 0.199	(-0.284 - -0.021)
	12-17 Years	0.084 - 0.344	(-0.647 - -0.117)	0.171 - 0.506	(-0.467 - -0.033)
	18-25 Years	-0.454 - -0.052	(-0.742 - -0.054)	0.654 - 1.231*	(-0.047 - -4.4e-5)
	26 Years +	0.014 - 0.033*	(-0.070 - -0.012)	0.021 - 0.001	(-0.952 - -0.101)

Notes: *** statistically significant to at least 0.05 level; ** 0.01 level; *** 0.001 level.**

Table 7. Policy Timing Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	risk	*risk*	*risk*	*risk*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*firstuse*	*firstuse*	*firstuse*	*firstuse*
	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+
BPOLm2	-0.031	0.121	-0.104*	-0.039	0.255*	-0.017	0.183**	0.326**	0.140*	0.046	0.076	0.114
	(-0.48)	(1.43)	(-1.87)	(-0.57)	(1.93)	(-0.18)	(2.05)	(2.18)	(1.71)	(0.62)	(1.06)	(1.43)
BPOLm1	-0.001	0.047	-0.062***	0.002	0.097**	0.007	0.068**	0.115**	0.049	0.019	0.027	0.137
	(-0.05)	(1.57)	(-4.20)	(0.10)	(2.03)	(0.21)	(2.28)	(2.03)	(1.22)	(0.53)	(1.15)	(1.29)
BPOL	0.020	0.056***	-0.035**	0.022	0.032	-0.038	0.039*	0.035	0.059	0.038	0.055*	0.002
	(1.35)	(3.04)	(-2.36)	(1.35)	(0.86)	(-1.24)	(1.95)	(0.82)	(1.62)	(1.23)	(1.99)	(0.06)
BPOLp1	-0.021	-0.016	-0.035***	-0.019	0.063	0.025	0.039**	0.077	0.043	0.015	0.065**	-0.024
	(-1.36)	(-1.02)	(-2.98)	(-1.22)	(1.48)	(0.91)	(2.21)	(1.45)	(0.91)	(0.41)	(2.36)	(-0.97)
BPOLp2	-0.044*	-0.021	-0.027***	-0.048*	0.050	0.040*	0.009	0.070	0.028	-0.015	0.048*	0.037
	(-1.98)	(-1.08)	(-3.97)	(-1.83)	(1.33)	(1.89)	(0.50)	(1.51)	(0.66)	(-0.50)	(1.72)	(1.43)
SPOLm2	0.023	0.020	0.020	0.027	0.026	0.055	-0.001	0.002	0.135	0.112	0.114**	-0.024
	(0.66)	(0.51)	(0.96)	(0.71)	(0.39)	(1.12)	(-0.03)	(0.03)	(1.66)	(1.62)	(2.38)	(-0.51)
SPOLm1	0.021**	0.015	-0.016	0.027***	0.002	0.032*	-0.007	-0.008	0.027	0.059***	0.010	-0.034
	(2.14)	(0.53)	(-0.57)	(3.27)	(0.14)	(1.78)	(-0.63)	(-0.46)	(1.53)	(3.17)	(0.53)	(-0.90)
SPOL	0.004	0.032	-0.007	0.004	0.032*	0.026	0.019***	0.027	0.023	0.038	0.002	-0.008
	(0.35)	(1.50)	(-0.65)	(0.32)	(1.77)	(1.53)	(2.80)	(1.04)	(0.94)	(1.63)	(0.13)	(-0.24)
SPOLp1	0.005	0.015	0.029	0.002	0.012	0.037	0.001	0.009	0.008	0.066***	-0.037**	-0.047
	(0.52)	(0.46)	(1.00)	(0.22)	(0.59)	(1.67)	(0.11)	(0.32)	(0.31)	(2.76)	(-2.34)	(-0.97)
SPOLp2	0.007	-0.014	0.002	0.009	0.004	0.023*	-0.020**	0.011	-0.025	-0.007	-0.035	-0.036
	(0.73)	(-1.00)	(0.12)	(0.89)	(0.33)	(1.84)	(-2.33)	(0.61)	(-1.45)	(-0.30)	(-1.32)	(-0.86)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	500	500	500	500	500	500	500	500	500	500	500	500
adj. R-sq	0.691	0.481	0.638	0.636	0.557	0.406	0.467	0.556	0.399	0.409	0.375	0.293

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01.**

We also observe what could be a lagged increase in *pastmonth* for those 12 years and older and those over 25 years in ballot states - this could be a policy signal effect and would be consistent with the WM argument. Note, however, that these subpopulations include legitimate medical users, and that the equivalent signs for senate states are inconsistent with our signal strength hypothesis for those aged over 26 years.

The results for senate-initiated MMPs are erratic and may be due to the fact that the effects are being identified by only five states. Broadly the picture painted by the policy timing vector is less robust and consistent. It is worth noting here that we only have ten years of data, and this could well be insufficient or to infrequent to capture the full timing dynamics of policy effects.

We explore one final aspect of possible signalling effects - we consider whether signalling effects may have changed as medical marijuana gained broader legitimacy – California's law was the first state medical marijuana law and state level provisions have been appearing more and more in recent years. States that enacted MMPs after 1999 had a much more reliable reference point, and signalling effects could be expected to be less ambiguous for these states. More generally, the fact that medical marijuana had gained more legitimacy by the turn of the century, and the fact that people (or more specifically, parents) were more likely to have a realistic understanding of what such a policy actually entails, could have influenced how policy signalling effects manifest in youth marijuana use. We address this potential issue by omitting those states that introduced a MMP prior to 2000, and re-estimating our model with the detailed timing policy variables. *Table 8* presents the results. Here we observe a possible public discourse effect on *risk* for the whole 12+ and 26+ populations in ballot states, again in the opposite direction to the prediction of the

WM argument. For school aged youth, the pattern of effects in ballot states is consistent with our expectations of a policy signalling effect - it begins the year the MMP is introduced, and continues (even increases) for at least 2 years. For senate states there is a similar pattern but none of the coefficients are significant or consistent with our signal strength hypothesis. Importantly, this potential policy signalling effect is one of youth receiving the 'right message', with *more* youth perceiving marijuana to be of great risk. For college aged youth, the pattern again involves anticipation effects, beginning two years prior to the policy. This subpopulation is receiving the 'wrong message' but it is unclear why an anticipatory effect should already begin at least two years prior to the policy change.

In terms of consumption, we see a delayed increase in *pastmonth* for the whole 12+ population and for adults 26 and older, however this increase does not continue into the second year after the introduction of an MMP, and these subpopulations include legitimate medical users. Again college-aged youth have increasing consumption in ballot states but this begins prior to the policy change. School-aged youth see no effect on consumption for ballot-initiated MMPs. In senate states we see a lagged increase for 12+ and college aged youth. There is, however, an anticipatory decrease for college aged youth two years prior to the policy change. School aged youth see increases in *pastmonth* 2 years prior to and 1 year after a senate enacted MMP policy.

Table 8. Policy Timing Variables Excluding Early MMP-Adopting States

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	risk	*risk*	*risk*	*risk*	*pastmonth*	*pastmonth*	*pastmonth*	*pastmonth*	*firstuse*	*firstuse*	*firstuse*	*firstuse*
	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+	12 Years+	12-17 Years	18-25 Years	26 Years+
BPOLm2	-0.016	0.127***	-0.056	-0.027	0.149	-0.050	0.101**	0.205*	0.082	0.010	0.052	-0.027
	(-0.32)	(3.23)	(-1.43)	(-0.50)	(1.65)	(-0.79)	(2.06)	(1.89)	(1.36)	(0.18)	(1.04)	(-0.58)
BPOLm1	-0.004	0.062***	-0.047***	-0.006	0.107***	-0.007	0.073***	0.137***	0.082***	0.046	0.015	0.285**
	(-0.19)	(3.19)	(-5.15)	(-0.23)	(2.82)	(-0.25)	(3.61)	(2.98)	(2.74)	(1.56)	(0.65)	(2.44)
BPOL	0.034**	0.037***	-0.025***	0.040**	0.047	-0.005	0.044***	0.050	0.047	0.033	0.041	-0.016
	(2.36)	(5.26)	(-3.41)	(2.47)	(1.39)	(-0.24)	(3.52)	(1.10)	(1.17)	(0.95)	(1.27)	(-0.54)
BPOLp1	-0.019	-0.001	-0.038***	-0.019	0.076	0.016	0.044**	0.099	0.055	0.022	0.067*	-0.025
	(-0.86)	(-0.08)	(-2.90)	(-0.78)	(1.46)	(0.49)	(2.38)	(1.44)	(0.98)	(0.50)	(2.00)	(-1.16)
BPOLp2	-0.045	-0.012	-0.033***	-0.049	0.062	0.034	0.010	0.094	0.042	-0.006	0.050	0.052*
	(-1.50)	(-0.90)	(-3.76)	(-1.38)	(1.30)	(1.38)	(0.51)	(1.49)	(0.83)	(-0.17)	(1.44)	(1.69)
SPOLm2	0.015	0.023	0.027	0.016	0.044	0.066	0.001	0.031	0.156*	0.127*	0.127**	-0.009
	(0.38)	(0.53)	(1.11)	(0.36)	(0.61)	(1.26)	(0.02)	(0.40)	(1.77)	(1.73)	(2.43)	(-0.18)
SPOLm1	0.022*	0.016	-0.012	0.027**	0.003	0.038*	-0.009	-0.007	0.029	0.065***	0.010	-0.055
	(1.99)	(0.55)	(-0.38)	(2.54)	(0.19)	(1.95)	(-0.72)	(-0.36)	(1.53)	(3.30)	(0.47)	(-1.30)
SPOL	0.002	0.036	-0.008	0.001	0.037*	0.025	0.021**	0.035	0.030	0.043*	0.006	-0.001
	(0.14)	(1.51)	(-0.57)	(0.06)	(1.89)	(1.41)	(2.56)	(1.22)	(1.18)	(1.70)	(0.27)	(-0.02)
SPOLp1	0.002	0.018	0.029	-0.002	0.019	0.039	0.004	0.019	0.014	0.072***	-0.036*	-0.039
	(0.23)	(0.52)	(0.89)	(-0.26)	(0.81)	(1.64)	(0.33)	(0.61)	(0.53)	(2.90)	(-1.96)	(-0.72)
SPOLp2	0.006	-0.017	0.002	0.009	0.008	0.030**	-0.021**	0.016	-0.029	-0.010	-0.040	-0.036
	(0.57)	(-1.21)	(0.10)	(0.73)	(0.60)	(2.43)	(-2.11)	(0.84)	(-1.60)	(-0.36)	(-1.40)	(-0.70)
All Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	440	440	440	440	440	440	440	440	440	440	440	440
adj. R-sq	0.686	0.475	0.625	0.634	0.545	0.422	0.458	0.551	0.407	0.429	0.366	0.388

Notes: t-statistics in parentheses; * indicates p<0.1, ** indicates p<0.05, * indicates p<0.01.**

There is a lagged increase in *firstuse* for the 12+ and 26+ subpopulations in ballot states. Taken together with the results for *pastmonth*, it appears that more 26+ adults begin using marijuana the year after an MMP is introduced, however this lasts only one year, while *firstuse* rates for school aged youth in senate states increase, beginning 1 year prior to the policy change, and lasting for at least 2 years after. There is, however, no significant effects in ballot states for this subpopulation and the magnitude in senate states dominate those in ballot states.

VI. CONCLUSIONS

Liberal drug policy is often met with heated debate, and one common argument raised against reform is that these policies 'send the wrong message' to users and potential users, particularly children and youth. We have characterised this position as arguing that liberal drug policy sends a signal with behavioural implications, and we have exploited the timing and nature of state-level medical marijuana laws in the US to empirically test the 'wrong message' (WM) argument.

Considering all the results presented, it appears that the WM argument is broadly flawed. We observe changes in marijuana metrics potentially due to a signalling effect, but medical marijuana laws tended to send the 'right message'. More specifically, the percentage of school-aged youth and those over 26 who perceive a great risk of using marijuana once a month tended to increase in states after medical marijuana laws. Medical marijuana tended to be less proximate on marijuana use metrics, as opposed to risk-perceptions, but there were some modest decreases in consumption for this demographic. This result directly contradicts the WM argument. MMP policy effects were consistently more visible and greater for ballot-initiated legislation, lending support to our signal strength hypothesis.

An important and consistent result was that although marijuana use metrics generally 'improve' after an MMP for school aged youth and those over 26 years, they tend to move in the opposite direction for those aged between 18 to 25. While this was evident in many of the specifications we employed, the changes for this subpopulation appeared to occur substantially before the introduction of an MMP policy. It is therefore unclear whether one can speak of an anticipatory effect. Further, it bears mention that this subpopulation includes the demographic most likely to begin experimenting with drugs - those of college age. The range of informal social control factors that appear to this subpopulation may be more important than our model assumes - at this age, many young people begin moving out of home, entering college, beginning work, and generally finding themselves in new social environments, with a host of new informal social control factors. Those aged 12-17 are more likely to be living at home and attending school, and thus potentially more susceptible to anti-drug messages.

We are also not too hasty to characterise the observed effects of MMPs as being policy signalling effects, given the results from our regressions using the detailed policy timing vector. While results do lend some support to the notion of policy signals, the scope of the dataset, covering just ten years, makes separating policy signals from public discourse effects difficult. The annual frequency may be further complicating the issue, and monthly data may provide more consistent insights.

The broad implication is that arguments that legalising medical use 'sends the wrong message' are without merit in the context of policy debates. Further, while signalling effects were consistently identified for risk perceptions, the direction of these effects was contrary to what the WM argument predicts. They also fail to

manifest consistently in consumption and use metrics, indicating that policy signals may not be important drivers of drug use behaviour, even if they do have an impact on risk perceptions[28]. It seems that, while such policy change may impact on marijuana use decisions, other factors are much more important in driving aggregate marijuana use. In this sense our results are consistent with prior literature on the WM argument - Khatapoush and Hallfors (2004) find that California's MMP had an effect on risk perceptions but not on use. They observe a decrease in risk perceptions, where we observed an increase, but these results are not necessarily at odds as it appears our findings are driven by late-adopter states. Taken together, it appears that signalling effects may have changed as medical marijuana gained legitimacy.

One particularly interesting aspect of our findings is that they lend support to a counterargument that is sometimes used by MMP advocates: that characterising marijuana as a medicine will reduce its appeal as a recreational intoxicant. Given our consistent finding of an increase in the percentage of the sub/population perceiving a great risk of using marijuana once a month - it seems quite possible that such a process may be occurring. To consider the issue from the other direction, it is possible that this shift is a reversal of a particularly strong forbidden fruit effect initiated by earlier, harsher drug laws. The forbidden fruit effect is widely hypothesised, however its true magnitude is difficult to estimate given a lack of an 'untreated' comparison.

Our results also compliment the findings from studies that look at mass media substance abuse prevention campaigns - these campaigns tend to be ineffective at curtailing use and sometimes have adverse effects on risk-perceptions and opinions, arguably via a forbidden fruit effect (see, e.g., Wakefield et al., 2006; Anderson,

[28] In this sense, perhaps our results may be driven by a reinforcing effect of MMP policy on pre-existing opinions or perceptions.

2010). Our results demonstrate that this effect may in fact go in both directions - many youth appear inclined to defy government messages, whatever they may be.

These conclusions notwithstanding, our analysis has several drawbacks and limitations that hamper the generalisability of our findings. Beyond the already-discussed sampling and methodological issues that using survey-derived estimates entail, the NSDUH estimates do not offer much information on the quantity consumed by those using marijuana. We tested the effects on consumption using an estimate of the percentage of the population that used marijuana at least once in the past month – but we don't have information to distinguish between those that used marijuana just once in the past month, and those that used it daily, for example. We therefore cannot make any firm conclusions about the signalling effect on quantity consumed from the results we have presented. It is possible that, although MMPs saw a small decrease in the percentage of people who used marijuana in the past month, those that did use it may have used it more.

One issue with our consideration of marijuana risk-perceptions is the potential endogeneity with MMP policy. It may well be the case that states that have a lower aggregate perception of risk associated with marijuana are more likely to consider and adopt a MMP. While this isn't a problem for our main results focusing on youth, it may be a source of bias in our results for the voting age population.

Our identification of signalling effects also warrants further consideration. We identify signalling effects by three assumptions:

- MMPs do not alter the black market or policy transmission channels for non-medical users, except through signalling effects.
- Policy changes are more visible if they occur via ballot initiative; and signalling effects are stronger where policy changes are more visible.

- The policy change is what causes behavioural changes, with public discourse serving as an information transmission channel.

While the second assumption appears to have been validated by the results, the first is potentially hazardous – if, for instance, informal social control factors are altered by a MMP, then we would be falsely ascribing the observed change to signalling effects. The latter is arguably probable, given the unquantifiable nature of social control factors and the way they are likely to vary for individuals and situations. In this case, the changes we captured at the aggregate level may be a combination of signalling effects, as well as other related but distinct factors.

Probably the strongest and most problematic assumption we make is that public discourse serves only as a transmission channel – by ascribing the observed changes to signalling effects we may be falsely identifying a more active and general process. Although we investigated this issue in robustness specifications, it warrants further consideration.

We might fit an alternative explanation to our results that is distinct from the signalling effects argument: the broad coverage that MMPs receive puts marijuana on the public agenda, causing many people to re-assess and reinforce their pre-held ideas about marijuana - concerned parents may be prompted to discuss the risks that marijuana poses with their children, with the specific fear that the policy change and subsequent discourse may otherwise 'send them the wrong message'. This purely illustrative but arguably realistic scenario highlights the problem with sweeping signalling effects arguments. Given that drug-related signals are sent from innumerable institutions, policies and individuals, it becomes very problematic to empirically disentangle and verify them at the aggregate level.

However, our results support the conclusion that the increase in youth risk-perceptions is a policy signalling effect - given that risk-perceptions are still positively affected by ballot enacted MMPs three years after the policy became effective, it seems safe to regard this as a policy signalling effect. But, when we consider measures of marijuana use, as opposed to just associated risk perceptions, we observe no such consistency. In this sense, policy signals appear to be only indirectly relevant to marijuana use, and as such of only secondary importance in policy debate. Given that policy can impact on much more proximate determinants of marijuana use, such as price, it seems quite inappropriate to focus on policy signals as an instrument for influencing use, or as a decisive argument about pending policy change.

VII. APPENDIX

Table A1. The 'Wrong Message' Argument in Practice

Comment	Source	WM 1	WM 2	WM 3	WM 4
Medical Marijuana					
"By characterizing the use of illegal drugs as quasi-legal, state-sanctioned, Saturday afternoon fun, legalisers destabilise the societal norm that drug use is dangerous." Andrea Barthwell, former Deputy Director of ONDCP Editorial, 2004	ProCon, 2011d	✓			
The medicinal marijuana movement and its media campaign have helped contribute to the changing attitude among our youth that marijuana is harmless, therefore contributing to the increase of marijuana use among our young people after 12 years of steady decline. California Narcotics Officers Association Policy Statement, 2002	ProCon, 2011d	✓	✓		
The confusing message about marijuana that these referenda send our children could not come at a worse time. In recent years, drug use by young people has increased at an alarming rate. Among eighth graders, the use of illicit drugs -- primarily marijuana -- has tripled. This increase has been fueled by a measurable decrease in the proportion of young people who perceive marijuana as dangerous... … With drug use by young people increasing, America must not send incorrect information to our youth about the risks of marijuana. ONDCP Policy Statement, 2002	ProCon, 2011d	✓	✓	✓	✓
The second reason [so many teens smoke pot in medical marijuana states] is these laws send the message that marijuana is safe. What else would teens believe when they see adults using it for everyday aches and pains?	Erhart, 2010	✓	✓	✓	✓

Mery Erhart, Director of Northern Arizona Substance Abuse Services Letter to the editor, 2010				
...there is a huge amount of public attention to equating medicine and marijuana. And that is the wrong message. I have met with high school kids from Portland to the Bronx. And when they talk about medicine and marijuana, they say this is sending the wrong message to us. Gil Kerlikowske, current director of ONDCP Radio Interview, 2010	Martin, 2010		✓	✓
We cannot afford to further erode youth attitudes towards drugs by allowing marijuana to be falsely depicted as a safe drug and as effective medicine. Labelling marijuana as 'medicine' sends the wrong message to children that it is a safe substance." General Barry McCaffrey, former director of ONDCP Comment made regarding California's MMP, 1996	Senate Judiciary Committee 1996[29]	✓		✓
The debate is about our kids. The debate is about the greater good for our society and what kind of message we're sending. And we don't need to go out of our way to help our kids get addicted to drugs.... If kids see marijuana as a medicine, they're apt to dismiss its harms. Among those are effects on the respiratory system and impaired judgment.... If we make it acceptable in society to smoke dope, our children are more inclined to do that. Scott Burns, spokesman for ONDCP Comment in newspaper article on Montana MMP, 2004	ProCon, 2011b	✓	✓	✓
Legalizing smoked marijuana, giving it the government's stamp of approval, sends the message to kids that drug use is not only harmless, but normal. Drug Free America Foundation Online article on medical marijuana, 2004	ProCon, 2011b	✓		✓

[29] Cited in Khatapoush & Hallfors, 2004

California voters passed Proposition 215, the nation's first medical marijuana initiative, in November 1996. The issue received intense press coverage and California's teenagers got the message: their past-month marijuana use increased by nearly one-third that year, from 6.5% to 9.2% according to the National Household Survey on Drug Abuse. Although use declined the next year, it has increased every year since then. The figures are 1995--6.5%, 1996--9.2%, 1997–6.8%, 1998–7.4%, and 1999–8.4% Sue Rusche, Founder and President of National Families in Action Magazine Article, 2002	ProCon, 2011b		✓		✓
Medical excuse marijuana laws could directly increase use of marijuana by young people if the rules for acceptable diagnoses are lax and if there is no clear oversite of who makes marijuana recommendations and how he laws are applied. […] The overall atmosphere with the softening of marijuana laws does potentially risk young people seeing diminished risk in using marijuana. Dr. Eric Voth, Chairman of the Institute on Global Drug Policy Expert opinion website	Voth, 2011	✓	✓	✓	✓

Note: WM1 – MMPs cause marijuana to be perceived as safer.
WM2 – MMPs cause marijuana use to increase.
WM3 – MMPs cause more people to start using non-medical marijuana.
WM4 – Youth are particularly susceptible to the 'wrong message' of MMPs.

Table A2. Policy Variables, Descriptive Statistics

Variable	Obs	Mean	Min	Max
BALLOT	561	.1515152	0	1
SENATE	561	.0445633	0	1
BPOLp2	561	.0071301	0	1
BPOLp1	561	.0106952	0	1
BPOL	561	.0124777	0	1
BPOLm1	561	.0124777	0	1
BPOLm2	561	.1247772	0	1
SPOLp2	561	.0089127	0	1
SPOLp1	561	.0089127	0	1
SPOL	561	.0089127	0	1
SPOLm1	561	.0089127	0	1
SPOLm2	561	.0338681	0	1

Table A3. Descriptive Statistics for NSDUH Estimates

Variable		Obs	Mean	Std. Dev.	Min	Max
1999-2008						
risk	12 Years+	510	39.30	6.00	24.89	55.3
	12-17 Years	510	34.58	4.75	22.61	48.03
	18-25 Years	510	24.44	5.37	10.24	41.28
	26 Years+	510	42.53	6.56	26.33	61.5
pastmonth	12 Years+	510	5.92	1.56	2.79	10.9
	12-17 Years	510	7.72	1.72	4.39	13.9
	18-25 Years	510	16.57	4.43	7.44	32.79
	26 Years+	510	3.84	1.26	1.27	7.99
firstuse	12 Years+	510	1.77	0.30	1.1	2.78
	12-17 Years	510	6.35	1.09	3.43	10.35
	18-25 Years	510	6.76	1.47	2.96	11.8
	26 Years+	510	0.14	0.05	0.02	0.64
2002-2008						
risk	12 Years+	357	37.86	5.60	24.89	51.97
	12-17 Years	357	33.73	4.49	22.61	46.8
	18-25 Years	357	23.19	4.96	10.24	37.13
	26 Years+	357	41.00	6.15	26.33	55.99
pastmonth	12 Years+	357	6.32	1.49	3.23	10.9
	12-17 Years	357	7.64	1.63	4.39	13.32
	18-25 Years	357	17.42	4.35	8.52	32.79
	26 Years+	357	4.20	1.17	2.05	7.99
firstuse	12 Years+	357	1.81	0.31	1.18	2.78
	12-17 Years	357	6.26	1.13	3.43	10.35
	18-25 Years	357	7.02	1.50	2.96	11.8
	26 Years+	357	0.15	0.06	0.02	0.64

Table A4. Control Variables

Variable	Description	Source
Signalling Controls		
saptgrant	Federal SAPT block grant, in millions of 2008 dollars	National Conference of State Legislatures
educexp	state education expenditure per capita, in 2008 dollars	USCB, Governments Division
healthexp	state health expenditure per capita, in 2008 dollars	USCB, Governments Division
pcminbachelor	estimated percentage of state population with a bachelor degree as a minimum	USCB, Current Population Survey
Social Engagement Controls		
nohlth	estimated percentage of state population with no health insurance coverage	USCB, Current Population Survey
unemprate	state unemployment rate	U.S. Bureau of Labor Statistics, Local Area Unemployment Statistics Program
povertyrate	state poverty rate	USCB, Housing and Household Economic Statistics Division
personalinc	state personal income per capita, in thousands of dollars	U.S. Bureau of Economic Analysis / U.S. Department of Commerce
suicide_rpht	number of suicides per 100,000 in the population	Center for Disease Control and Prevention
Enforcement Controls		
Drgposs	Total arrests in state related to drug possession or use	FBI, Uniform Crime Reports
Drugtot	Total arrests in state related to any drug abuse violation	FBI, Uniform Crime Reports
Demographic Controls		
population	state population, in millions	U.S. Census Bureau (USCB), Population Division
male	estimated percentage of state pop. that is male	USCB, Population Division
black	estimated percentage of state pop. that is black	USCB, Population Division
hispanic	estimated percentage of state pop. that is hispanic	USCB, Population Division
age1524	estimated percentage of state pop. aged between 15 & 24	USCB, Population Division

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