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SEF WORKING PAPER 6/2018

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Working Paper 6/2018
ISSN 2230-259X (Print)
ISSN 2230-2603 (Online)

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Commentary to: *Medical marijuana laws and adolescent marijuana use in the United States: A systematic review and meta-analysis*

Past-month marijuana use among adolescents does not increase after the passage of medical marijuana laws in the U.S. It is crucial for future research to explore causal mechanisms affecting different types of marijuana users to bring a deeper understanding of behavioral responses to marijuana polices.

Keywords: marijuana, medical marijuana law, marijuana use

Sarvet et al., after a comprehensive review of the literature, conclude that medical marijuana laws (MMLs) in the United States do not appear to increase marijuana use among adolescents. This conclusion may relieve one major concern that has been expressed about these laws, but it also raises further interesting questions.

The authors do highlight some evidence that the frequency of marijuana use among adolescents may indeed increase after MML passage. Changes in other measurements of marijuana use could be hidden behind the null effect on past-month use. For example, MMLs could increase marijuana usage at the intensive margin but not the extensive margin. That is, MMLs could encourage existing casual users to become regular or heavy users. As the majority of social costs are incurred by a small number of heavy users, the effects of MMLs on the intensive margin must be evaluated carefully, as this is a significant policy implication.

The causal mechanisms for the null effect on adolescents are particularly intriguing, given the consistent recent findings that MMLs are associated with increases in adult marijuana use [1-5]. Why do MMLs affect adolescents differently from adults? For example, could MMLs reduce the black-market supply and so limit adolescents' access to marijuana? Or could making a substance legal or semi-legal reduce teenagers' preference for it? It is puzzling, as Cerdá, Wall [6] recently find, that the passage of recreational marijuana laws has contributed to an increase in adolescent marijuana use in Washington, but not in Colorado.

Understanding the causal mechanisms is thus important for evaluating different policy settings and designing effective marijuana policies.

Since state MMLs differ in important aspects (such as patient registration requirements and the legality of dispensaries), there is likely substantial heterogeneity in their effects. Because most studies use individual-level data instead of state-level data, the estimate for the MML indicator reflects an average of each MML effect weighted by state population. One subtle implication is that the estimated effect could be driven by MMLs in few states with large populations. Indeed, as MMLs grow more heterogeneous, evaluating the impacts of specific provisions will become an important but challenging task.

One statistical issue in particular has been largely neglected in the literature as provision-specific effects have been estimated. Agiven provision may come from only a single MML, or at most a few. As a result, without a sufficiently large number of policy changes, the estimated standard errors for provision-specific indicators reported in the current literature are likely biased [7]. In general, a synthetic control approach could be a useful technique, as it is more flexible than the standard fixed-effects regression analysis [8-10].

It is crucial to ensure the quality of data when estimating effects based on a small number of states. As data such as that provided in the National Longitudinal Survey of Youth (NLSY) are not representative at the state level, provision-specific or state-specific estimates from different datasets will not necessarily be comparable. Non-survey data tend to contain substantial measurement error. For example, in the Treatment Episode Data Set (TEDS), the total number of admissions in Washington was only about half of the previous level after 1999 because admissions for detoxification services were not reported after 1999. (Washington passed its MML in November 1998.) Measurement error can lead to bias in provision-specific or state-specific estimates since the noise cannot be averaged out without a large number of MMLs.

A spillover effect is a possible confounder in the current context. As MMLs can change people's perceptions of marijuana even in states that do not have such laws, a difference-in-difference research design may underestimate the impacts of these laws on behaviors related to marijuana use. For example, while Keyes, Wall [11] find no effect of MMLs on the perceived harmfulness of marijuana, perceived harmfulness among adolescents has significantly decreased in both MML and non-MML states. The decreases in non-MML states could be actually driven by MMLs. The potential contamination of the control group should be treated more carefully in future research.

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