NBER WORKING PAPER SERIES

IS RECREATIONAL MARIJUANA A GATEWAY TO HARDER DRUG USE AND CRIME?

Joseph J. Sabia
Dhaval M. Dave
Fawaz Alotaibi
Daniel I. Rees

Working Paper 29038
http://www.nber.org/papers/w29038

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
July 2021

Dr. Sabia acknowledges support from the Center for Health Economics & Policy Studies (CHEPS), which has received grants from the Charles Koch Foundation and Troesh Family Foundation. We thank Samuel Safford, Drew McNichols, and Rebecca Margolit for outstanding research assistance. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Is Recreational Marijuana a Gateway to Harder Drug Use and Crime?
Joseph J. Sabia, Dhaval M. Dave, Fawaz Alotaibi, and Daniel I. Rees
NBER Working Paper No. 29038
July 2021
JEL No. I12,I18,K14

ABSTRACT

Recreational marijuana laws (RMLs), which legalize the possession of small quantities of marijuana for recreational use, have been adopted by 18 states and the District of Columbia. Opponents argue that RML-induced increases in marijuana consumption will serve as a "gateway" to harder drug use and crime. Using data covering the period 2000-2019 from a variety of national sources (the National Survey of Drug Use and Health, the Uniform Crime Reports, the National Vital Statistics System, and the Treatment Episode Data Set) this study is the first to comprehensively examine the effects of legalizing recreational marijuana on hard drug use, arrests, drug overdose deaths, suicides, and treatment admissions. Our analyses show that RMLs increase adult marijuana use and reduce drug-related arrests over an average post-legalization window of three to four years. There is little evidence to suggest that RML-induced increases in marijuana consumption encourage the use of harder substances or violent criminal activity.

Joseph J. Sabia
San Diego State University
Department of Economics
Center for Health Economics
& Policy Studies
5500 Campanile Drive
San Diego, CA 92182
and IZA & ESSPRI
jsabia@sdsu.edu

Dhaval M. Dave
Bentley University
Department of Economics
175 Forest Street, AAC 195
Waltham, MA 02452-4705
and IZA
and also NBER
ddave@bentley.edu

Fawaz Alotaibi
Claremont Graduate University
150 E. 10th Street
Claremont, CA 91711
fawaz.alotaibi@cgu.edu

Daniel I. Rees
Department of Economics
University of Colorado at Denver
Campus Box 181
Denver, CO 80217
and NBER
Daniel.Rees@ucdenver.edu

1. Motivation

"There's not nearly enough evidence as to whether or not marijuana is a gateway drug."

- Joseph R. Biden (2019)

"Let's be clear: marijuana isn't a gateway drug and should be legalized."

- Kamala D. Harris (2019)

Recreational marijuana laws (RMLs) legalize the possession, sale, and consumption of marijuana for recreational purposes. To date, 18 states and the District of Columbia have adopted RMLs (Anderson and Rees 2021; NORML 2021); at the federal level, there is a push to remove marijuana from the Controlled Substances Act (Fandos 2021).

Proponents of legalizing recreational marijuana point to evidence that light-to-moderate marijuana consumption generates few adverse health effects (National Academies of Sciences, Engineering and Medicine 2017), and contend that it might even lead to public health gains as users of substances such as alcohol and opioids substitute to marijuana (Bachhuber et al. 2014; Powell et al. 2018). They note that the annual costs associated with enforcing the prohibition on marijuana run into the hundreds of billions of dollars (American Civil Liberties Union 2019) and those who are convicted of marijuana-related crimes can face substantial labor market penalties (Pager 2003; Agan and Starr 2018; Dobbie et al. 2018; Mueller-Smith and Schnepel 2021; Agan, Doleac and Harvey 2021). Finally, proponents of RMLs argue that there are substantial racial disparities in how the prohibition on marijuana is enforced: despite comparable marijuana usage rates, Blacks are 3.6 times more likely than Whites to be arrested for marijuana-related offenses (Federal Bureau of Investigation 2020; Edwards and Mandubuonwu 2020).[1]

[1] Among other arguments for lifting the prohibition on marijuana include (i) generating a safer consumer product through increased market competition and government regulation of a legitimate market (Fernandez 2019), (ii) reducing violence by limiting market power of and profits to illegal criminal cartels (Gavrilova et al. 2019), and (iii) increasing tax revenue to state coffers (Marijuana Policy Project 2021a).

According to Gallup (2020), support for legalizing legalization has doubled over the last two decades (from 34 percent in 2001 to 68 percent in 2020). Nonetheless, critics — including some policymakers and public health experts — have expressed several concerns regarding legalization. First, they argue that RMLs could increase the likelihood of smoking marijuana on a regular basis, leading to adverse health outcomes such as chronic cough and phlegm production as well as more frequent chronic bronchitis episodes (National Academies of Sciences, Engineering and Medicine 2017). Moreover, even if the direct marijuana-related health effects are small, legalization opponents warn that legalization for recreational purposes will, through a "gateway effect," encourage the use of and addiction to harder drugs such as cocaine, heroin, fentanyl, and methamphetamine. In fact, a number of high-profile studies in the public health literature show associations between liberalizing access to marijuana and harder drug use and crime (Bleyer and Barnes 2018; Hunt et al. 2018; Wong and Lin 2019; Olfsin et al. 2019). Fears about a "gateway effect" of marijuana have been voiced by presidents, vice presidents, drug czars, senators, congressmen, and state and local officials, including state attorneys general (see DeAngelo and Redford 2015).[2] Drawing on the gateway hypothesis, opponents of legalization further express concerns that these laws will generate spillovers that increase marijuana use among underage youth, which can have direct negative and long-lasting effects on their cognitive development (NIDA

[2] In 2010, then-Vice President Joe Biden stated,

> "I still believe [marijuana] is a gateway drug. I've spent a lot of my life as chairman of the Judiciary Committee dealing with this. I think it would be a mistake to legalize."

While as a 2020 presidential candidate, Mr. Biden's position on the question of legalization evolved, many politicians, particularly in the House Republican caucus, still hold this view. In 2021, Rep. Andy Harris (R-MD) stated,

> "In the midst of an increase in opioid addiction deaths during the coronavirus pandemic, it seems strange…to fully legalize marijuana, a known gateway drug to opioid addiction."

2020). Finally, critics note that RMLs may have external spillovers on jurisdictions that have not adopted RMLs, transferring some of these adverse consequences across state borders.

The social welfare rationale for RMLs depends on whether the social benefits of legalization exceed any external costs. A key input in this cost-benefit calculus, and one point of contention between legalization proponents and opponents, is whether — and the direction and extent to which — RMLs have broader effects on the use of "harder" addictive substances. To the extent that the health and labor market costs of hard drug use are privately borne by well-informed agents who gain utility from its consumption, addiction to hard drugs will be rational (Becker and Murphy 1989) and reflected in the cross-price elasticity of demand for hard drugs with respect to marijuana. However, there are a number of reasons to expect that the costs of addiction to harder drugs will not be internalized. If preferences are time-inconsistent (Gruber and Koszegi 2001) and reflect hyperbolic discounting of future wellbeing, addictive drug use may exceed that which is socially optimal via "internalities." Moreover, for some younger hard drug users, decision-making over consuming addictive substances may not rational due to underdevelopment of the prefrontal cortex (Casey et al. 2008; Arain et al. 2013). Finally, addiction may lead to more crime — i.e., income-generating crime to finance one's addiction or violent offenses as a result of one's altered state of mind — thereby imposing costs of hard drug use on to third parties. Together, the external costs of legalization must be weighed against (i) the utility gains from consumption, as well as (ii) the cost savings from reduced incarceration, any reductions in drug cartel-induced violence, and reduced labor market penalties associated with criminal records to judge the efficacy of legalization from a social welfare perspective.

This study is the first to comprehensively examine the broader impacts of state recreational marijuana laws (RMLs) on a wide set of outcomes related to hard drug use, including illicit non-marijuana related consumption, drug-related arrests, arrests for property and violent offenses,

mortality due to drug-related overdoses, suicides, and admissions for drug addiction-related treatment. Using state-level panel data from 2000-2019 from a variety of national sources (the National Survey of Drug Use and Health, the Uniform Crime Reports, the Vital Statistics Multiple-Cause-of-Death Mortality Files, and the Treatment Episode Data Set) and a difference-in-differences identification strategy, we find that the enactment of an RML increased adult marijuana use by 1.6 to 3.6 percentage-points (18.7 to 42.5 percent) and reduced adult marijuana possession-related arrests by over 90 percent (1.33 arrests per 1,000 adult population). However, we find little evidence that RMLs significantly increased (i) "harder" drug use or nonmedical use of prescription opioids, (iii) overall arrests for property or violent offenses, or (iii) drug-related overdose deaths. Estimated RML effects are often of the opposite sign than would be predicted from a "gateway effect," particularly with respect to hard drug-related overdose deaths, where estimated RML effects are occasionally statistically distinguishable from zero at conventional levels. We can rule out, with 95 percent confidence, increases in illicit drug use other than marijuana of 0.2 to 0.3 percentage-points (5.8 to 9.3 percent, relative to the pre-treatment mean). Although there is suggestive evidence that legalizing recreational marijuana reduces heroin- and other opioid-related mortality, RMLs appear to be unrelated to treatment admission rates for addiction.

Finally, to more fully explore heterogeneity in the effect of RMLs across individual states, as well as to explore longer-run effects across the earliest RML adopters, we conduct synthetic control analyses. Our results show little evidence that the earliest-adopting RML states saw important long-run gateway effects following their enactment, though these analyses also point to some heterogeneity across state experiences.

As more states legalize recreational use of marijuana, and as longer post-RML data become available, it will become feasible to detect any additional longer-term impacts that materialize as the commercial marijuana markets develop further and mature. However, our analyses to date, which

encompasses the experiences of states that have legalized through 2020, uncover little evidence of RML-induced adverse health or crime effects. These results on the earliest set of RML adopters suggest that critics' fears that recreational marijuana would act as a gateway to harder drug use may be unfounded.

2. Background

2.1 History of Recreational Marijuana Laws

In November of 2012, Colorado and Washington became the first states to pass RMLs. Almost 9 years later, researchers are gaining a better understanding of how legalizing recreational marijuana affects outcomes of interest to policymakers and the public. Unlike most medical marijuana laws (MMLs), RMLs do not require a doctor's recommendation and do not require registration; anyone 21 years of age or older can possess limited amounts of marijuana, and purchases of marijuana are typically made at recreational dispensaries. All but two RML states (Illinois and New Jersey) allow adults to grow marijuana plants at home.[3]

In 2021, RMLs were signed or took effect in four additional states (Connecticut, New York, New Mexico, and Virginia), and the momentum to expand legal access to cannabis products continues nationwide. However, there is a paucity of evidence regarding the indirect, downstream effects of RMLs. For instance, although the initial push to legalize the use of marijuana for medicinal purposes was not in response to the opioid epidemic, there is now credible evidence of a negative relationship between MMLs and opioid-related mortality (Bachhuber et al. 2014; Powell et al. 2018), while the relationship between RMLs and opioid use has not been thoroughly documented. Policy at the state and local levels will ultimately determine whether legalization

[3] In Washington D.C., home cultivation is allowed, but its RML prohibits the exchange of money, goods, or services for marijuana; transfers of up to an ounce of marijuana, are, however, legal.

affects only those with acute medical needs (for instance, those who are suffering from cancer or some other easily diagnosed malady), or whether it means that all adults will have safe and easy access to marijuana for recreational purposes.

2.2 Medical Marijuana Laws, Harder Drug Use, and Crime

A number of studies have tested the "gateway hypothesis" in the context of MMLs. MMLs legalize, for allowable medical purposes, the possession, sale, and consumption of marijuana. As of December 2020, these laws have been enacted by 36 states (Anderson and Rees 2021). There is strong evidence that the adoption of state MMLs is associated with an increase in marijuana consumption among adults (Anderson and Rees 2011; Wen et al. 2015; Sabia and Nguyen 2017; Choi et al. 2018), with generally larger longer-run lagged effects, consistent with the timing of dispensary openings.

Turning to harder drug use, Anderson and Rees (2021) offer a comprehensive review of this literature. This literature provides little evidence that legalizing medical marijuana had an appreciable effect on self-reported cocaine use (Wen et al. 2015) or substance abuse treatment admissions for cocaine (Chu 2015).[4]

There is stronger evidence that marijuana and prescription opioids are related as substitutes (Anderson and Rees 2021). Bachhuber et al. (2014) finds that the adoption of MMLs is associated with a reduction in opioid-related mortality, but this relationship appears to be driven by prescription opioid deaths when dispensaries are present (Shover et al. 2019). The relationship between MML adoption and opioid-related deaths is much weaker during the post-2010 period when heroin and fentanyl were responsible for a much larger share of opioid-related deaths (Shover

[4] In addition, living near an MML dispensary was also essentially unrelated to cocaine-involved emergency department visits (Conyers and Ayres 2020).

et al. 2019). Along the same lines, there is compelling evidence that the enactment of MMLs reduced opioid prescribing (Bradford and Bradford 2016, 2017, 2018; Bradford et al. 2018; Wen and Hockenberry 2018; McMichael et al. 2020) and the opening of a medical marijuana dispensary is associated with a reduction in prescription opioid-related mortality (Smith 2020).[5] On the other hand, Chu (2015) found that legalizing medical marijuana increased drug treatment admissions for heroin.

A review of studies on how MMLs impact alcohol use, conducted by Anderson and Rees (2021), concludes from the weight of the evidence that medical marijuana and alcohol are substitutes. Both survey-based studies (Anderson et al. 2013; Wen et al. 2015; Sabia et al. 2017; Johnson et al. 2018; Andreyeva and Ukert 2019; Hollingsworth et al. 2020) and sales-based studies (Anderson et al. 2013; Baggio et al. 2020; Veligati et al. 2020) find that the enactment of MMLs led to a reduction in adult alcohol consumption. Moreover, Anderson and Rees (2013) also find that MML enactment led to a reduction in alcohol-related traffic fatalities.[6]

With regard to crime, as Anderson and Rees (2021) note, the impact of marijuana legalization is theoretically ambiguous:

> "Legalizing marijuana could shrink the black market and reduce its attendant violence or free up police resources, allowing law enforcement officials to reallocate their efforts toward reducing non-drug crime (Miron and Zwiebel 1995; Adda et al. 2014). Also, if legalization lowers the price of marijuana-- and demand is sufficiently inelastic-- then crimes committed to finance marijuana consumption could fall. On the other hand, increased marijuana use could lead to more violent behavior directly through a psychopharmacological effect or indirectly through a "gateway" effect (Pacula and Kilmer 2003; Morris et al. 2014)." (Anderson and Rees 2021, pp. 36-37)

[5] Moreover, Bradford and Bradford (2018) find that MML adoption was associated with reductions in anxiety- and sleep-related prescriptions.

[6] On the other hand, Conyers and Ayres (2020) show that emergency department visits involving alcohol among Arizonans was essentially unrelated to the opening of dispensaries to purchase medical marijuana.

In the main, the evidence suggests that the legalization of medical marijuana had either (i) little effect on property or violent offense arrests (Morris et al. 2014; Huber III et al. 2016; Chu and Townsend 2019), or (ii) reduced arrests (Gavrilova et al. 2019). Gavrilova et al. (2019) found that states bordering Mexico that adopted an MML experienced a 13 percent reduction in violent crime. The authors attribute this result to increased competition in the international marijuana market, which reduced "black market" power of Mexican drug trafficking organizations and reduced their incentives to invest in violence to deter illicit market entry (Miron and Zwiebel 1995; Gavrilova et al. 2019). Finally, Chu (2015) found that legalizing medical marijuana was associated with a 0–15 percent reduction in possession arrests for cocaine and heroin, consistent with the hypothesis that marijuana is a substitute for harder drugs.[7]

2.3 Existing Literature on Recreational Marijuana Laws

Studies assessing the effects of RMLs are very new, notably because the adoption of RMLs is a relatively recently phenomenon and a sufficient post-legalization window of time is required for a cross-section of adopters to identify internally and externally valid effects. A handful of studies have examined the relationship between RMLs and marijuana use (Cerdá et al. 2017; Anderson et al. 2019), while others have explored whether RMLs are related to the use of other substances that could be complements or substitutes for marijuana. Recent studies have found that legalization of recreational marijuana leads to less opioid prescribing (Wen and Hockenberry 2018) and fewer deaths involving prescription opioids (Chan et al. 2020; Stover et al. 2019). Evidence on the effects

[7] Evidence on the labor market effects of MMLs is also generally consistent with either (i) net health benefits, or (ii) no adverse health effects of legalization of medicinal marijuana. Ghimire and Maclean (2021) show that the enactment of MMLs is associated with a reduction in the likelihood of workers' compensation claims and the income received from such claims. They interpret these results as evidence that medicinal marijuana availability generates health-related benefits via workers being able to better treat medical conditions. Along the same lines, Nicolas and Maclean (2019) find evidence that older adults' labor supply increases with increased access to medical marijuana. Finally, Sabia and Nguyen (2018) find little support for the hypothesis that MMLs had important effects on employment or wages of working-age individuals (and only a small negative effect on wages for young adult males).

of RMLs on traffic fatalities is more mixed (Lane and Hall 2019; Hansen et al. 2020; Santaella-Tenorio 2020).

To date, there has been no published research on whether legalizing recreational marijuana leads to gateway effects on hard drug-related outcomes including overdose deaths, drug-related arrests, drug treatment admissions, and consumption of other illicit drugs such as cocaine, methamphetamines and opioids.

There are a handful of studies that have explored the impact of RMLs on alcohol use. Dragone et al. (2019) used data from respondents to the National Survey of Drug Use and Health (NSDUH) in Washington state and a regression discontinuity design (exploiting distance to a non-RML state border) to find that enactment of an RML led to a 20 percent decline in binge drinking. Focusing on Washington state, Miller and Seo (forthcoming) found that the adoption of the state's RML was associated with a 5 percent decline in alcohol sales. Finally, Alley et al. (2020) used data from the National College Health Assessment-II and a difference-in-differences estimation strategy to find that RML enactment led to a 6 percent decline in binge drinking among young adults enrolled in college.[8,9]

Only one recently published study has examined the association between RMLs and crime. Dragone et al. (2019) found that Washington's RML led to a significant reduction in rapes and property crime during 2013–2014. Because this study had only two years of post-legalization data

[8] Some studies in this literature have explored the effect of RMLs on traffic fatalities, following the seminal work of Anderson and Rees (2013). The findings in this literature, based on Colorado and Washington, are mixed, owed to both to differences in empirical strategies (synthetic controls using different matching variables vs difference-in-differences) state under study (Aydelotte et al. 2017; Hansen et al. 2020; Santaella-Tenorio et al. 2020).

[9] Kelly and Rasul (2014) study the decriminalization of marijuana in a borough of London and find some evidence that reducing the penalties for possession led to a reduction in alcohol consumption.

from a single state, Washington, it is not clear that its results extend to other years and states.[10] Whether other recreational marijuana states will experience reductions in crime, and whether the reduction in Washington is temporary or permanent, are open questions.[11]

2.4 Contributions

As summarized in Anderson and Rees (2021) and discussed above, the literature on the broader effects of MMLs is far more developed, and policymakers at times, out of necessity, have extrapolated from the effects of MMLs to inform the potential impact of RMLs due to the dearth of studies specifically addressing marijuana legalization. However, there are several reasons why the spillover effects of RMLs could look quite different from MMLs.

First, the population directly targeted by MMLs – registering patients in need, who stand to benefit from cannabis use upon a physician's recommendation – is a relatively small pool. Only a little over two percent of the population in medical marijuana states currently comprises registered patients (Marijuana Policy Project 2021b). Unless there are substantial spillovers to non-targeted populations, this inherently constrains the "first-stage" effect of the policy on marijuana use outcomes. Restrictions associated with MMLs make it likely that spillovers to broader populations remain in check. For instance, even the laxest MMLs require patient registration and a doctor's recommendation, and the strictest ones further require verifiable medical conditions and

[10] The most likely mechanism underlying this result is substitution away from alcohol as marijuana became available for recreational purposes. Previous studies provide evidence of a causal link between alcohol consumption and crime (e.g., Anderson et al. 2018).

[11] Three studies of which we are aware have explored the impact of local dispensary openings (or closings) for recreational marijuana on crime. These studies have examined the effects of recreational marijuana dispensaries in Denver, Colorado and Los Angeles, California. Using an instrumental variables (IV) approach, Brinkman and Mok-Lamme (2019) found that a dispensary opening in Denver is associated with a 19 percent decline in crime. Using a difference-in-differences approach Burkhardt and Goemans (2019) found that recreational dispensary openings in Los Angeles were associated with a decline in violent crime in geographically proximate, higher-income neighborhoods. On the other hand, Chang and Jacobson (2017) find that motor vehicle thefts near recreational dispensaries were positively related to dispensary closures.

distribution only through state-licensed dispensaries. Consequently, MMLs have been found to raise marijuana use by a limited amount – on the order of 1-2 percentage points at most (Anderson and Rees 2011; Wen et al. 2015; Sabia and Nguyen 2017; Choi et al. 2018). In contrast, RMLs have few restrictions, beyond the age verification, and, by definition apply to a much broader population of current and potential recreational users.

Second, the limited first-stage response of the MMLs further checks any downstream effects on harder drug use and associated adverse events such as crime. RMLs, on the other hand, by reaching a much larger population and having a stronger first-stage impact on marijuana consumption, have the capacity to have more substantial spillover effects on other substance use and related outcomes.

The one exception to the limited potential of MMLs for downstream effects relates to opioids, where the sub-population targeted by MMLs (i.e. patients suffering from medical conditions such as chronic pain, who may benefit from cannabis use) is also the one that would be predicted to have an intrinsically higher demand for opioid painkillers. Thus, the availability of medical marijuana for this population appears to have reduced their need for opioids. Here too, however, RMLs may have a very different impact on opioid use, because these policies are reaching a broader population beyond just patients with medical conditions by commercializing the marijuana market and expanding availability. Moreover, as the opioid epidemic has shifted from Rx opioids to heroin and synthetic opioids, over the same time period that states were adopting marijuana legalization, the impact of these laws on Rx vs. illicit opioid use may also be different.

Finally, it is important to note that every state which adopted RMLs had an MML in place previously (see Table 1 in Anderson and Rees, 2021). Thus, the relevant local average treatment effect (LATE) being identified with RMLs is the incremental effect of liberalizing and expanding the marijuana market for recreational users on top of having liberalized it for medicinal purposes, a

different LATE than the one identified in the MML literature. Hence, responses to RMLs may differ from MMLs because of the nature of the "treatment" as well as heterogeneity across the marginal individuals being impacted by these policies.

This study is the first to use nationally representative data across all 50 states and the District of Columbia to comprehensively explore the broader impacts of RMLs, providing some of the first evidence on how marijuana legalization is affecting illicit drug use, heavy alcohol use, arrests for drug and non-drug offenses, and objectively-measured adverse drug-related events including drug-related overdose deaths and admissions into substance abuse treatment services. Where permissible, we conduct analyses for both adults ages 21 and older, who would be legally permitted to purchase marijuana in RML states, and underage adults (ages 18-20) who continue to be prohibited from purchasing marijuana. Our findings provide key evidence evaluating the ongoing, occasionally contentious, political debate on legalizing marijuana use, and inform whether recreational marijuana use is a "gateway" to addiction to harder drugs and criminal behavior.

3. Data

3.1 National Survey of Drug Use and Health (NSDUH)

We begin by using data from the 2002-2019 National Survey of Drug Use and Health (NSDUH) to measure marijuana and hard drug use among adults ages 18 and older. While the individual geographically-identified NSDUH data are not readily available to scholars outside of the Substance Abuse and Mental Health Services Administration, two-year overlapping state averages are publicly available over the 2002-2019 period.[12] Data on substance use is provided in each survey wave.

[12] For instance, SAMHSA makes available state-specific estimates for 1999-2000, 2000-2001, and so on. We use these overlapping state panels in the analyses, and match information on RMLs based on the month and year of enactment (and in supplementary analysis, based on the month and year of the availability of retail distribution). Our indicator

First, to assess the "first stage" effects of RMLs on adult marijuana use, we use responses to the following survey item:

> "During the past 30 days, on how many days did you use marijuana or hashish?"

Over the 2002-2019 period, we find that 7.4 percent of respondents ages 18 and older reported marijuana use in the prior 30 days. To measure harder drug use, we use responses to the following survey items to generate state-by-year prevalence of cocaine use, illicit drug use other than marijuana, and binge drinking:

> "These questions are about cocaine, including all the different forms of cocaine such as powder, crack, free base, and coca paste. During the past year, on how many days did you use any form of cocaine?"
>
> "During the past 30 days, on how many days did you use an illicit drug other than marijuana? (Includes heroin, hallucinogens, inhalants, cocaine, and the nonmedical use of prescription-type pain relievers, tranquilizers, stimulants, and sedatives)?"
>
> "During the past 30 days, on how many days did you have five or more drinks (for males) or four or more drinks (for females) on the same occasion (i.e., at the same time or within a couple of hours of each other)?"

Over the sample period, we find that 2.1 percent of adults ages 18 and older reported cocaine use in the last year, 3.4 percent reported illicit drug use other than marijuana in the prior 30 days, and 25.0 percent reported binge drinking in the last month. In supplemental analysis, we also explore methamphetamine use, which are available in a more limited fashion in the 2015-2019 state-by-two-year public reports, and non-medical use of prescription opioids, which was asked in two forms during the 2002-2014 period and in a slightly different manner following 2014.[13]

---

captures the fraction of the two-year period that the RML was in effect, ranging from 0 (for state-years that fully precede RML adoption) to 1 (for state-years that fully follow RML adoption). For adoption dates that fall within the two-year aggregates, we define the indicator to equal the fraction of the 24 months that the RML was in effect.

[13] In its administration of the NSDUH, the Substance Abuse and Mental Health Services Administration changed its asking of questions related to prescription pain reliever misuse in the 2014-15 wave, noting

Trends in each of our primary NSDUH measures (over the 2002-2019 period for which the public use state aggregated NSDUH data are available) are shown in Appendix Figure 1, first for the full sample and then by whether the state adopted an RML. While we find that marijuana use rose more in RML-adopting states than non-adopting states after 2012, the first year of state enactment (in Colorado and Washington), we find little evidence that rates of other substance use rose more in RML as compared to non-RML states.

3.2 Uniform Crime Reports (UCR)

To explore the impact of recreational marijuana laws on criminal arrests, we will use data from the 2000-2019 Uniform Crime Reports (UCR). The UCR data cover arrests in all 50 states and the District of Columbia, including 98 percent of the U.S. population. Arrest data are collected via voluntary reports from more than 16,000 city, county, and state agencies.[14] Arrest data will understate the true levels of crime because not every crime results in an arrest, or even a report to law enforcement agencies (Gould et al. 2002). However, Lochner and Moretti (2004) document a high correlation in arrest reports from UCR and actual crimes when data are available on each (Lochner and Moretti 2004).[15] However, it is possible that RMLs by diverting law enforcement resources away from marijuana-related arrests may impact the probability (positive or negatively) of

"Several changes were made to the prescription drug questions for the 2015 NSDUH. These changes were designed to address limitations in the survey design used in prior years. Special attention was paid to revising the modules that measure prescription drug misuse or "nonmedical" use because of public health concerns about misuse of prescription drugs, such as increases in the number of drug poisoning deaths involving opioid pain relievers like hydrocodone, oxycodone, and methadone (Centers for Disease Control and Prevention, 2013; Paulozzi, 2012)." See: https://www.samhsa.gov/data/sites/default/files/NSDUH-RedesignChanges-2015.pdf

[14] Florida (a non-RML state) is excluded from the UCR analyses due to lack of reporting; data are available for only three of the 20 years over our sample period. We also exclude the District of Columbia and Wisconsin in the year 2000, as law enforcement agencies did not report arrest data for this year.

[15] Moreover, measurement error is unlikely to be correlated with adoption of RMLs, which suggests that our estimated marginal effects (at least in percentage terms) will be unbiased.

observing an arrest for other offenses. We discuss this possibility below and its implications for interpreting effects on crime. In addition, we note that arrest counts do not necessarily capture unique individuals, as there may be multiple arrests for the same offender over time.

We calculate state-by-year arrest counts from the UCR and then generate arrest rates per 1,000 state population using data from the Surveillance, Epidemiology, and End Results (SEER) Program. Our arrest analysis focuses on adults ages 18 and older, as well as arrests among those ages 18-to-20, for whom possession and cultivation of marijuana under RMLs remains illegal, as well as for those ages 21 and older.

We focus on three main classifications of arrests: *Drug Arrests* (drug possession arrests and drug sales arrests), *Violent Arrests* (homicide, robbery, and aggravated assault), and *Property Arrests* (larceny, burglary, motor vehicle theft, and arson). Over the sample period, there were 5.6 drug-related arrests per 1,000 adult population, 1.8 violent arrests per 1,000 adult population, and 4.5 property arrests per 1,000 population.

Appendix Table 1 shows means of each of these arrest measures and Appendix Figure 2 shows trends in each of these measures over the 2000-2019 period. In addition, the UCR disaggregates drug (possession and sales) arrests into four categories of drugs: (1) marijuana, (2) powder cocaine, crack cocaine, heroin, and other opium derivatives, (3) truly addicting synthetic narcotics and (4) other dangerous non-narcotic drugs (i.e., methamphetamine). Forty-nine (49) percent of all adult drug-related arrests are attributable to marijuana arrests. Appendix Figure 3 shows evidence of declines in marijuana-related arrests in RML states relative to non-RML states in the period following the adoption of RMLs (2012 and later).

3.3 National Vital Statistics System (NVSS) Multiple-Cause-of-Death Mortality Files

To explore the impact of RMLs on adverse health consequences associated with potential substitution into harder drugs, we use the National Vital Statistics System (NVSS) multiple cause-of-death mortality files, 2000-2019 and focus on overdose deaths (per 100,000 population) related to cocaine-, heroin-, fentanyl-, other opioids (i.e., prescription painkillers), methamphetamine-, and alcohol. Our primary interest is in deaths with the following International Classification of Disease, Tenth Revision (ICD-10) multiple cause-of-death codes: T40.5 (cocaine), T43.6 (methamphetamine), T40.1 (heroin), T40.4 (fentanyl), T40.0, T40.2, T40.3, T40.6 (non-heroin-, non-fentanyl-related opioids). Deaths related to alcohol abuse are calculated based on the ICD-10 codes (Polednak 2016).[16] Finally, drawing on a possible link between legalization of access to medical marijuana and suicide (Anderson et al. 2014; Bartos et al. 2020), we also extend our mortality analysis to include suicides. Appendix Figure 4 shows trends in drug- and alcohol-related overdoses, with RML states experiencing relatively smaller (larger) increases (declines) in overdose deaths related to cocaine and opioids, vis-à-vis non-RML states, after about 2013-2015.

3.4. Treatment Episode Data Set (TEDS)

Finally, to explore the impact of RMLs on an alternate indicator of substance use disorders related to heavy marijuana use and use of other harder drugs, we turn to admission flows into substance abuse treatment facilities from the Treatment Episode Data Set (TEDS) over the period 2000-2018. Facilities, receiving any public funding, are required to report data on all clients admitted for substance abuse treatment to their state's reporting agency, which are then compiled

[16] We use the following codes to classify alcohol attributed deaths: F10.3-F10.9 (alcoholic psychosis), F10.0-F10.1 (alcohol abuse), F10.2 (alcohol dependence syndrome), G62.1 (alcohol polyneuropathy), G31.2 (degeneration of nervous system due to alcohol), G72.1 (alcoholic myopathy), I42.6 (alcohol cardiomyopathy), K29.2 (alcoholic gastritis), K70.0-K70.4, K70.9 (alcoholic liver disease), K85.2 and K86.0 (alcohol-induced pancreatitis), X45 and Y15 (alcohol poisoning), and finally X65 (suicide by exposure to alcohol).

by TEDS. For each admission, we observe the primary, secondary, and tertiary substance related to the treatment admission and also the personal characteristics of the patient along with the source of referral. Almost half of treatment referrals originate from within the criminal justice system. Other referrals are from the patients themselves, family and peers, and health care providers. We document treatment admissions for the following primary drug-related reasons: marijuana, cocaine, methamphetamine or amphetamine, heroin, other opioids, and alcohol. Treatment admission rates (per 1,000 population) are calculated based on the SEER data and reported in Appendix Table 1, with corresponding trends shown in Appendix Figure 5.

4. Empirical Methods

We use a difference-in-differences (DD) regression strategy to examine the effects of RMLs on each of the above-mentioned outcomes. Specifically, we begin by estimating the following two-way fixed effects (TWFE) regression equation:

$$Y_{st} = \beta_0 + \beta_1 RML_{st} + \boldsymbol{X}_{st}\boldsymbol{\alpha} + \tau_t + \delta_s + \varepsilon_{st}, \quad (1)$$

where Y_{st} denotes the outcome of interest in state *s* in year *t*. These include the prevalence of substance use (NSDUH), the arrest rate per 1,000 population (UCR), the mortality rate per 100,000 population (NVSS), and the rate of treatment admissions per 1,000 population (TEDS). The primary independent variable of interest, RML_{st}, is an indicator for whether a recreational marijuana law (RML) has been enacted.

In alternate specifications, we also replace RML_{st} with *Recreational Sales Allowed*$_{st}$, which is an indicator variable for the date at which marijuana sales were permitted in the state (see Anderson and Rees 2021, Table 1). Doing so allows us to explore any delayed treatment effect from when

legalization is enacted to when recreational sales began. While dispensaries are an important feature of the (medical and) recreational marijuana landscape, given that home cultivation is permitted in all but three of the RML states, one cannot a priori dismiss the possibility that supply (and consumption) of marijuana could have increased well before recreational sales through dispensaries became possible. We therefore explore the separate effects of both the enactment and the opening up of marijuana distribution at the retail level in the RML states. We also allow for border state RML policies to affect neighboring states, as well as interactive effects of own and border-state RML policies, in alternate models to assess spillovers from RML states to bordering non-RML states.

The vector $\boldsymbol{X}_{st}$ includes demographic controls (the share of the state population that is African American, Hispanic, and male; the share of the state population ages 25 and older who have a Bachelor's degree or higher; and the number of law enforcement agencies reporting arrests in the state); marijuana policy controls (whether the state has a medical marijuana law and whether the state has a marijuana decriminalization law); economic and political controls (whether the governor is a Democrat, state unemployment rate and per capita income), crime policy controls (whether the state has a shall issue law, whether the state has a stand-your-ground law, the natural log of police employment per 1,000 population); and state-level substance use policies (the real beer tax per gallon, whether the state has a must-access prescription drug monitoring program, whether the state has a naloxone access law, and whether the state has a Good Samaritan law), and social welfare policies (the state EITC refundable credit rate, the state minimum wage, and whether the state has expanded Medicaid as part of the Affordable Care Act).[17] Finally, τ_t is a year fixed effect, which accounts for common trends across states, and δ_s is a state fixed effect, which controls for

[17] The means of each of these control variables are listed in Appendix Table 2.

time-invariant state effects. All regressions are weighted by the state population, and standard errors are corrected for clustering at the state level (Bertrand et al. 2004).

Our key parameter of interest, β_1, is the estimated effect of a recreational marijuana law on the outcome of interest, through all reinforcing and competing pathways, ceteris paribus. This intent-to-treat estimate is identified from within-state variation in recreational marijuana laws as outlined in Figure 1 (see also, Table 1 of Anderson et al. 2021). Note that all legalizing states previously had adopted an MML and currently tax recreational marijuana post-legalization, and that is the treatment effect of interest which is being captured by the parameter β_1 – the effect of legalizing recreational marijuana, in addition to having liberalized its availability for medicinal purposes, while regulating and taxing retail sales. States follow a multitude of taxation approaches that include a price-based ad valorem tax or a weight-based excise tax, and the application of different tax rates for marijuana products of varying forms and THC content.[18]

We take several tacks to assess the credibility of the parallel trends assumption underlying our difference-in-differences approach. First, we explore the sensitivity of our estimate of β_1 to the exclusion/inclusion of the large set of controls included in the vector $\mathbf{X}_{st}$. In addition, to control for unmeasured state-specific time trends that unfold linearly, such as pro-marijuana sentiment, we augment the controls in equation (1) to include state-specific linear time trends ($\delta_s * t$):

$$Y_{st} = \beta_0 + \beta_1 RML_{st} + \boldsymbol{X}_{st}\boldsymbol{\alpha} + \tau_t + \delta_s + \delta_s * t + \varepsilon_{st}. \quad (2)$$

[18] Of the states that had legalized recreational marijuana by March 31, 2021 (16), 11 followed a pure ad-valorem taxation approach, and the other five states levy an excise weight-based tax or a combination of an excise tax and an ad valorem tax. IL is the only state that levies a graduated ad valorem tax based specifically also on the marijuana product's THC content (≥ 35% THC vs. < 35% THC). See https://taxfoundation.org/state-recreational-marijuana-taxes-2021/.

Next, we conduct event-study analyses in which we include mutually exclusive indicators for leads and lags of RML_{st}. This will permit us to assess differential pre-treatment trends in our outcomes up to four or more years prior to adoption to ensure that outcomes across the treatment and control states were trending similarly prior to the enactment of RMLs. Moreover, it will also allow us to examine lagged effects of RMLs, including their long-run effect, up to 4 or more years after enactment. This long-run effect may be important given that any gateway effects may take time to materialize. Moreover, delayed effects may also materialize from rising trends in marijuana potency and falling trends in marijuana prices (in both licit and illicit markets) following marijuana reforms (Anderson and Rees 2021; Chiu et al. 2021; Smart et al. 2017; Sevigny et al. 2014).[19]

Finally, new critiques of two-way fixed effects (TWFE) estimators suggest that in the presence of heterogeneous treatment effects over time, TWFE estimate of $\beta_1$may be biased (Goodman-Bacon 2021) and the evaluation of pre-treatment trends in event studies — as a test of common trends —unreliable (Sun and Abraham 2021). In particular, if earlier adopting RML states serve as controls for later adopting RML states, and earlier adopting states experience heterogeneous dynamic treatment effects, the TWFE estimator may be biased. Moreover, the differential timing of treatment relative to the state panel may result in differential weights given to particular treatment effects relative to the treatment state.

To assess and correct for these potential biases present in the standard two-way fixed effects setting, we apply an alternate difference-in-differences estimator proposed by Callaway and Sant'Anna (2021). Using never-adopting states as controls for treated states – thereby bypassing the problematic DD comparisons between later-adopters and early adopters – we re-estimate our

[19] Any general increase in THC content or consumption shift towards marijuana products with higher THC potency will be captured by the period effects.

event studies using the Callaway and Sant'Anna (2021) estimator to (i) test for common pre-trends, and (ii) assess potential biases in the TWFE treatment effects.

5. Results

Our main findings are shown in Tables 1 through 9 and Figures 2 through 9. Supplemental analyses may be found in the appendices.

5.1 Substance Use

In panel I of Table 1A, we document "first-stage" effects of the enactment of RMLs on adult marijuana use. Across parsimonious (column 1) and more fully saturated models (columns 2), we find consistent evidence that RML adoption is associated with a 3.2 to 3.6 percentage-point increase in prior-month adult marijuana use, or about a 38 to 42 percent increase relative to the pre-treatment mean in RML-adopting states. In our most conservative specification, which includes state-specific linear time trends (column 3), we uncover an RML-induced 1.6 percentage-point increase in marijuana use, an effect that is statistically distinguishable from zero at the 5 percent level. This coefficient magnitude represents about an 18.7 percent increase relative to the pre-treatment mean. These RML effect sizes are about two to three times larger than the estimated effects of MMLs on marijuana use from the literature (Wen et al. 2015; Choi et al. 2019; Hollingsworth et al. 2021), which is to be expected as the legalization of recreational marijuana use targeted a much larger potential population of users than did the MMLs.[20]

[20] Also note that the RML treatment effect reflects the experience of an MML state further liberalizing marijuana use for recreational users, whereas the MML effect estimated in the literature is the initial treatment effect of a non-MML state liberalizing marijuana use for medical purposes.

In Figure 2A, we present event study analyses based on our fully-saturated TWFE estimator and in Figure 2B based on the Callaway-Sant'Anna (2021) estimator.[21] Three points are notable. First, in each case, we find that pre-treatment differentials, in terms of both levels and trends in marijuana use, between RML and control states are similar and balanced over the entire pre-policy period (lead effects are economically and statistically insignificant). Second, in each event study, the divergence in marijuana use between RML and control states manifests only following the enactment of the law, consistent with a causal link.

Third, that the treatment effect dynamics from the TWFE event study are highly similar to those produced using the Callaway-Sant'Anna (2021) approach is ex post validating and perhaps not altogether surprising. Note that one of the main sources of potential bias identified in the TWFE setting is its handling of earlier-treated units as a counterfactual for the later-treated units. With respect to RMLs, ten states plus D.C. adopted legalization over the sample period (see Figure 1); the vast majority of states have not enacted marijuana legalization over our sample period. Comparison of the treated units (earlier-treated or later-treated) with these non-adopters is not problematic (Goodman-Bacon 2020), even with dynamic treatment effects. And, given the preponderance of non-adopting states in our sample, these comparisons drive the bulk of the variation that is used to derive the RML treatment effect in the standard model.

The above assessment is confirmed by a formal Goodman-Bacon decomposition of the comparisons driving the estimated treatment effects in our marijuana analyses. This decomposition indicated that between 87.5 to 91.6 percent of the weight of our TWFE estimator can be attributed to the comparison of RML states versus never adopters and between 7.2 to 12.5 percent can be attributed to earlier versus later-adopting states. The potentially problematic comparison, which

[21] The Calloway-Sant'Anna (2021) estimator excludes state-specific linear time trends and other controls since the estimator explicitly weights each treatment-control comparison for each post-treatment period with an estimated propensity score that is a function of the other covariates.

uses early-adopting states as a counterfactual for later-adopting states, never drives more than 1.3 percent of the identifying variation in deriving the treatment effects in our DD estimation. In the analyses that follow, we draw conclusions from the weight of the evidence across consistent patterns and credible event studies that emerge from the results, and where there is any divergence, we give preference to the Callaway-Sant'Anna estimation results.

In the remaining panels of Table 1A, we explore whether RMLs led to spillovers into other substance use, as measured by cocaine (panel II), binge drinking (panel III), and illicit drug use other than marijuana (panel IV). The first-order own-effects of RMLs on marijuana use (1.6 to 3.6 percentage points) bound the size of the impacted population that may potentially shift their use of other substances, since any gateway-type spillovers into other substances are indirect and would plausibly operate only through changes in marijuana use first. In no case do we uncover evidence that RMLs are positively related to other substance use, including harder drug use. The precision of our estimates is such that, with 95 percent confidence, we can rule out increases in illicit drug use other than marijuana of greater than 0.2 to 0.3 percentage-points (well within the magnitude of the first-stage effect), or about 5 to 9 percent of the pre-treatment mean in RML-adopting states.[22] Supplemental analyses of effects on methamphetamine use and non-medical use of prescription opioids, reported in Table 1B, continue to show little evidence of any gateway effects of the legalization of recreational marijuana over an average post-legalization window of four years.

The average treatment effect of the RMLs on drug use may mask heterogeneity across younger and older adults given their baseline differences in the prevalence of substance use and also because young adults (under the age of 21) continued to be legally barred in RML states from purchasing and possessing marijuana. Appendix Table 3 presents separate effects on the

[22] Event study analyses, shown in Figures 2A and 2B, are consistent with our null findings on illicit substance use.

prevalence of marijuana and other drug use for younger adults (ages 18-25) and older adults (ages 26 and older). We find comparably sized percentage-point increases in marijuana use for both younger and older aged adults. Our results show that RMLs were associated with a 1.5 to 3.6 percentage-point increase in marijuana use among each age cohort.[23] With respect to binge drinking and use of other harder illicit substances, as with the combined sample, there is no indication of any substitution for either age group.[24] Only for nonmedicinal use of pain relievers (panel IV) is there some evidence that younger adults may substitute away from opioid misuse and toward marijuana, though this effect is sensitive to the inclusion of state-specific linear time trends.

5.2 Arrests

Next, we explore whether RMLs impact arrests (Tables 2-5). Before discussing these estimates, it is important to note that any effects on arrests reflect two potential mechanisms. First, changes in arrests may reflect changes in underlying criminal activity. Broadly, substance use can directly affect criminal activity through several pathways, including a pharmacological effect by affecting aggression or violent tendencies, an economic effect whereby drug users may resort to income-generating crime in order to finance their drug use habit, and/or a "systemic" effect as participants interact in illicit markets that inherently tend to resort to a high degree of violence and criminal activity in their sales and distribution networks (Corman and Mocan 2000; Dave et al. 2021). Legalizing marijuana, by impacting marijuana use and possibly other drug use, by impacting

[23] While the effect sizes are comparable in percentage-point terms, given their lower baseline prevalence these effect sizes translate into a relatively larger increase for older adults (ages 26 and older) than for the younger adults (23.8 percent vs. 8.2 percent relative to the pre-treatment mean, based on models with trend controls).
[24] Data availability in the NSDUH Small Area Estimation files preclude more detailed analysis of disaggregated age groups. We note that younger adults ages 18-25 combines adults (ages 21-25) that are legally able to purchase marijuana post-RML adoption as well as underage adults (ages 18-20) who are not able to do so. For the NSDUH, we are not able to separate how much of the increase in marijuana use is driven by these two sub-populations. However, our sub-analyses of other outcomes (arrests, mortality, and treatment admissions), where we are able to observe these outcomes across more disaggregated age categories, sheds further light on any problematic effects that may be materializing for underage adults (ages 18-20).

expenditures on drug consumption, and by shrinking the black market, could affect both property and violent crimes through each of these channels.

The second mechanism through which RMLs may impact arrests and crime is more indirect, by freeing up police resources, and allowing law enforcement officials to reallocate their efforts toward reducing non-drug crime (Miron and Zwiebel 1995; Adda et al. 2014). This channel can affect both the probability of an arrest, conditional on committing a crime, as well as underlying criminal activity through a deterrence effect from the reallocation of policing efforts.

We present estimates of the effects of RMLs on arrests, separately for drug-related offenses, violent offenses, and property offenses in Table 2.[25] Our event study analyses based on these outcomes are visually presented in Figure 3 (TWFE) and Figure 4 (Callaway-Sant'Anna), and reassuringly show similar trends across the treated and control states prior to RML adoption. Any divergence in the trends, where there appear to be effects, materialize only post-adoption.

Panel I reports effects for drug-related arrests, showing a significant decrease on the order of about one to two arrests (per 1,000 population), representing between a 20.7 and 31.5 percent decline relative to the baseline pre-treatment mean. The estimated treatment effect is insensitive to the inclusion of controls, consistent with the hypothesis that RMLs are enacted exogenously to drug arrests. Over 41 percent of drug arrests involve marijuana (Appendix Table 1); hence the reduction in drug arrests is validating as a "first-order" check and is consistent with the shift in policing resources away from identifying and arresting low-level drug offenders. In analyses to follow, we explore the specific drugs that drive these arrest results.

Across specifications in panel II, we find little evidence that the enactment of RMLs increased arrests for violent offenses. The effect magnitude in the saturated specification is

[25] In Appendix Table 4, we confirm that our estimated effects on arrests are not sensitive to functional form and present alternate models specifying the outcome as a natural log.

negative, reflecting a 6.9 percent decline, but this estimate is only statistically distinguishable from zero at the 10 percent level (t=1.66). The event studies confirm that the RMLs did not materially impact violent crime arrests, and we are able to rule out increases exceeding 1.2 percent with 95 percent confidence.

Turning to property crime arrests, there is some suggestive evidence of an uptick in the most saturated specification (on the order of about 0.27 arrests per 1,000 population or 6.2 percent) and also dynamically in the event study analyses. However, all of these estimates are highly imprecise and not statistically distinguishable from zero at conventional levels. As a result of the inherent noisiness of the property crime data, our 95 percent confidence intervals are unable to rule out non-trivially sized increases in property crime arrests. It is also difficult to disentangle whether any potential increase in property crime arrests reflects an increase in underlying criminal activity or a greater probability of a property crime being detected due to a shift in policing resources.[26]

In Table 3, we explore whether the effects we observe in Table 2 are masking important heterogeneity among (i) those who may not legally purchase or consume marijuana for recreational purposes under RMLs (those under age 21) compared to those for whom it is legal (those ages 21 and older), and (ii) males versus females. Our findings show no evidence of significant increases in violent, property, or total arrests for either those under or over age 21 or for males or females. For violent offenses (panel II), the sign on the estimated RML effect is as often positive as negative. For property arrests, the sign is positive in most cases, but the effect is always statistically indistinguishable from zero in our saturated specifications.

In sharp contrast to the lack of significant part I arrest declines, we find consistent stronger and more consistent evidence of significant declines in drug-related arrests (Panel I) for males and

[26] Burkhardt and Goemans (2019), in their study of local crime in Denver, Colorado, found that recreational dispensary openings were associated with an increase in vehicle break-ins within a mile of the dispensary's location.

females, and older adults (ages 21 and older). Effects are also negative for those ages 18-20, reflecting a decline in drug-related arrests of between 7.9 to 24.0 percent, though these are not statistically significant. These results for the young adults could suggest declines in use of law enforcement resources to target them for possession of marijuana, even if they are underage. This finding could also be indicative of a "drying up" of the black market for marijuana, diminishing the supply for recreational consumption by those under age 21.

Next, we explore arrests for individual type I violent and property offenses to ensure that the aggregated effects we obtain on type I offenses are not masking offense-specific heterogeneity in the effects of RMLs. Across specifications reported in Table 4, there is little evidence that RMLs are associated with statistically significant increases in arrests for type I offenses. Only for larceny and burglary (columns 4 and 5, panel II) do we detect that the enactment of an RML is associated with a 7 percent increase in arrests, though these effects are not statistically significant. The magnitudes of the estimates (and the direction of the effect for larceny) are also sensitive to the inclusion or exclusion of state-specific linear trends (panel I vs. II).

In Table 5, we (i) explore the source of the decline in drug-related arrests observed in Table 2, and (ii) differentiate between arrests for possession and sales. We find consistent evidence that RMLs reduce drug-related arrests for both possession and sales (panel I). This effect appears to be largely driven by declines in marijuana-related arrests (panel II). Marijuana-related possession arrests comprise approximately 27 percent of all drug-related arrests during pre-treatment years for RML adopting states. For all adults ages 18 and older, we find that RML enactment is associated with a decline in 1.33 marijuana possession arrests per 1,000 population (panel II, column I). This represents a very large (over 95 percent) decline relative to the pre-treatment mean in RML-adopting states; the magnitude of this effect is validating and provides a degree of confidence that our specification is picking up a plausibly causal effect of RMLs because arrests for marijuana

possession are precisely the outcome that should dry up virtually fully post-legalization. We also find evidence of an RML-induced 49.7 percent decline in arrests for marijuana sales for those ages 18 and older (column 2), consistent with the hypotheses that (i) the legitimate market has absorbed a substantial share of the underground market, or (ii) law enforcement agencies may be less likely to enforce laws related to illegal marijuana sales, particularly in smaller quantities, under an RML regime. We find evidence of marijuana-related arrest declines for those under and over the minimum legal sales age (columns 3-6) and for males (columns 7-8) and females (columns 9-10).

Turning to harder drugs, including cocaine/heroin (panel III), addicting synthetic narcotics (panel IV), and other dangerous non-narcotic drugs (panel V), we fail to uncover support for the hypothesis that RMLs lead to increases in arrests for either possession (odd-numbered columns) or sales (even-numbered columns) of other drugs. Largely for all groups, in fact, there is a significant negative relationship between RML adoption and heroin/cocaine-related arrests. The magnitudes suggest some substantial RML-induced declines in heroin and cocaine arrests, on the order of 8.7 to 17.6 percent for possession and 25.0 to 38.8 percent for sales, consistent with the hypothesis that marijuana and these harder drugs may be substitutes and with the hypothesis that RMLs change policing practices toward those who possess or sell drugs.

Event study analyses, shown in Figures 5 through 7 and Appendix Figure 6 suggest a pattern of findings consistent with a causal interpretation of the above drug-related findings. These results are also consistent with our NSDUH-based estimates, suggesting little evidence of "gateway effects" from increased use of recreational marijuana.[27]

5.3 Mortality

[27] In Appendix Figure 7, we show event study analyses for other, non-narcotic sales and possession arrests and find largely null results as well.

Next, in Table 6, we explore the impact of RMLs on substance use-related mortality and suicides. Panels I through VI present estimates of the effects of RMLs on overdose deaths involving cocaine (panel I), methamphetamine (panel II), heroin (panel III) and fentanyl (panel IV), opioids other than heroin and fentanyl (panel V), and alcohol (panel VI). These estimates underscore two main findings.[28] First, the results provide no evidence that the legalization of recreational marijuana led to significant increases in hard drug-related overdose deaths. Second and to the contrary, there is some evidence that deaths related to heroin, fentanyl, and other opioids (the latter category largely comprising prescription opioids) were negatively related to RML enactment. For instance, while the coefficients are imprecisely estimated, the effects from the most saturated model in column (3) suggest that the enactment of an RML is associated with a 17.4 to 35.0 percent decline in heroin and other opioid-related deaths; decline in overdose deaths from synthetic opioids is even more substantial, though also statistically insignificant.

Event study analyses from the Callaway-Sant'Anna approach, presented in Figure 8, support a causal interpretation to these estimates and further point to some reductions in cocaine overdose mortality as well (which is also suggested by the point estimates in the models without state-linear trends in Table 6 and in the Poisson estimation in Appendix Table 5). The decline in opioid-related mortality that we find for RMLs mirrors similar effects found for MMLs in prior studies (Bachhuber et al. 2014; Powell et al. 2018), indicating that marijuana and opioids are likely substitutes among the broader population. The reduction in the demand for other addictive substances might reflect improvements in mental health associated with marijuana policy reform (Anderson and Rees 2021), though we do not find much evidence when we consider suicide deaths

[28] We present mortality estimates from a fixed effects Poisson regression model in Appendix Table 5, in order to assess robustness to a non-linear functional form that accounts for the skewness of the outcome across states and the preponderance of zeroes for certain cells (see Rees et al. 2019). Our results, both in terms of magnitudes and patterns across drugs, are not sensitive to this model specification.

as a proxy for mental health (Panel VII in Table 6). It is also notable that estimates from Panel VI indicate positive effects on alcohol-related deaths; the effect magnitude, however, is highly sensitive to the inclusion of state-linear trends (coefficient declines by almost 80 percent in column 3 vs. column 2), and most importantly, the event study (panel f in Figure 8) shows little evidence that RMLs increased alcohol overdose deaths.[29]

In Table 7, we explore heterogeneity in the effects of RMLs on mortality by age (panels I and II) and gender (panels III and IV). Our results largely confirm RML-associated declines in overdose deaths related to heroin, fentanyl, and other opioids for older adults directly impacted by the liberalized recreational marijuana policy (adults ages 21 and older), and for both males and females. We do not find any meaningful effects for younger adults (ages 18-20) who are not able to legally participate in the commercial marijuana market post-legalization; while the effect for cocaine-related overdose deaths for underage adults is large and marginally significant, the event study analysis casts doubt on its interpretation as causal and shows no evidence that RMLs increased drug-related mortality for young adults.

5.4 Substance Use Treatment Admissions

Finally, in Tables 8 and 9, we turn to the TEDS to explore the impact of RMLs on substance use-related treatment admissions, as an alternate proxy for substance use disorders and adverse events related to marijuana and other drug use. We do not find any meaningful effects of marijuana legalization on flows into treatment facilities, associated with marijuana, cocaine, amphetamines, opioids or alcohol (Table 8). Effects are statistically insignificant across the board, and somewhat sensitive (in terms of both magnitude and many times even the direction of the

[29] Poisson estimates for alcohol-related overdose deaths are also close to zero in the extended specifications (Appendix Table 5).

effect) to excluding/including trend controls. The event study analyses, presented in Figure 9, also provide little support of any significant causal effects on treatment admissions.[30] These findings largely carry over into Table 9, where we report heterogeneous treatment effects by age and gender.

We note that due to variability in state reporting, the TEDS is an unbalanced panel, which affects which states and periods are identifying our estimates.[31] The TEDS data include one fewer year of data (the TEDS is available up to 2018, in contrast to the other datasets spanning 2019), with the average treated state observed in the TEDS for only about three years. Moreover, the state of Oregon does not identify any of the effects due to lack of reported data for the state over the post-treatment window.[32]

While found some suggestive evidence of a decrease in cocaine and opioid-related overdose deaths associated with the RMLs (Table 6), we do not uncover any corresponding "beneficial" effects on treatment admissions associated with these substances. In addition to the aforementioned difference in the identifying variation between the TEDS analyses and those for the other data sets, this also may be because the margins captured by each of these outcomes (overdose-related mortality vs. patients who are referred into treatment services for their substance use disorders) differ, with the former more responsive to RMLs. It is further possible that the

[30] Our main TEDS analyses are based on each studied substance being designated as the primary substance of abuse in order to more cleanly identify treatment admissions that can be attributed to the main drug of abuse. In Appendix Table 6, we explore whether our findings on "primary drug" treatment admission may mask important effects when one considers secondary or tertiary drugs that were also related to admissions. The latter also captures poly-drug use, and recognizes that many admissions can involve multiple substances of abuse. Our findings in Appendix Table 6 are largely consistent with those shown in Table 7.

[31] Delays and variability in the reporting from individual treatment facilities to state agencies to the TEDS system can cause considerable variability in the TEDS data across states and within states. Since this variability affects the total counts of admissions reported (rather than admissions specific to certain substances), controlling for total admissions can help adjust for any within-state over-time variance in the data that is driven by reporting issues. We therefore re-estimated all models for the TEDS controlling for total treatment admissions for each state and year (reported in Appendix Table 7 and panels (i) through (l) of Appendix Figure 8). Our estimates are not sensitive to this adjustment.

[32] The state of Michigan also identifies a very small share of the RML effect in the TEDS analyses because the state adopted an RML late in 2018.

dynamics across these outcomes may be different, and we do not observe a sufficiently long post-legalization time window to capture effects that may not yet have materialized.[33] Below, we turn to early-adopting RML states to explore longer-term effects of the RMLs and also to examine potential heterogeneity across individual state experiences that may be masked by these average treatment effects.

5.5 Robustness Checks

We close this study of gateway effects of increases in recreational marijuana use with four important robustness checks. First, we use information on the date on which recreational sales of marijuana were first permitted, which tended to lag the legalization of recreational marijuana by one to two years (see Table 1 of Anderson and Rees 2021). When we replace our main *RML* policy variable with *Recreational Sales Allowed* in Appendix Table 8, we find that while legalization of marijuana sales was associated with a 2.2 percentage-point increase in prior month adult marijuana use (column 1) and a (statistically insignificant) 20 percent decline in marijuana-related arrests (column 5), there is little evidence that the increase in marijuana use is a bridge to consuming other harder substances or problem alcohol use.[34]

Second, in Appendix Table 9, we explore the robustness of our findings to allowing "border" state effects of RMLs. While we continue to find significant "first-order" effects on

[33] We note that in the Callaway-Sant'Anna event study analyses (Figure 9), the final reported lag for marijuana, cocaine, and other opioid-related admissions is positive (in contrast to all of the previous lags which are close to zero and relatively flat), which may suggest a possible delayed uptick; all of these effects however are highly imprecisely estimated.

[34] As noted above, while recreational marijuana dispensaries are an important channel through while RMLs expand the availability of commercial marijuana, almost all RML states also allowed home cultivation. This presents another mode through which the availability and consumption of marijuana could increase post-enactment and before retail outlets proliferate in the state. In fact, if there are post-enactment effects, then classifying the "treatment" based on the date when commercial markets opened up in the state would attenuate the estimated treatment effects. In the estimates reported in Appendix Table 7, we find some indication of such attenuation; nevertheless, our general findings are not materially altered in this alternate specification of the treatment.

marijuana use and marijuana-related arrests, our results show relatively little evidence that border state RML policies, or the interaction of border state RML policies with own-state RMLs, generate important gateway effects.[35]

Third, we implemented a leave-one-out analysis (reported in Appendix Figure 8), where we re-estimated the treatment effects for our outcomes upon omitting each treated RML state in turn from the sample.[36] The consistency of the estimates for each outcome across the alternate samples instills a degree of confidence that our findings are not driven or dominated by the experiences of any single RML state.

Finally, we use a synthetic control design to explore whether there are heterogeneous effects of RML adoption on our key outcomes. [37] Our focus is on states for which we observe a post-legalization window of at least three full years (Washington, Colorado, Alaska, Oregon, California, and Massachusetts), allowing us to explore the longer-term effects of legalizing recreational marijuana.[38] We report the average effect over the post-treatment window, along with permutation-based p-values generated via placebo tests (Abadie et al. 2010).

[35] The one exception appears to be for alcohol-related treatment admissions.

[36] We report estimates from the fully saturated specification including trend controls.

[37] We construct the synthetic counterfactual for each treated state by matching on the outcome in all pre-treatment periods. To construct a counterfactual that is not contaminated from the effects of post-RML MML adoption by donors, we select the donor pool from within the non-RML states that also did not enact any MML in the post-treatment period. For instance, for Colorado, which enacted an RML on December 10, 2012, the donor pool consists of states that have not adopted any RML over the sample period and also not adopted any MML post-2012. Results are not sensitive to using a more restrictive donor pool, where we exclude any state that enacted an MML in the three years prior to the treatment state's RML adoption or anytime later. For each RML state, in order to facilitate the state-year synthetic control analyses, we assign the treatment period t based on the majority of the year in which the RML became effective. Thus, if an RML is enacted in year t, in June or earlier, we denote all years starting with t and later as treated; otherwise, we denote all years starting with t+1 and later as treated. For analyses of arrests, we drop Florida from the donor pool since UCR data are missing for the state from 2000-2016. The number of states in the donor pool ranges from 23 to 35.

[38] We exclude DC from this analysis since the constructed synthetic controls for various outcomes showed a poor pre-policy match. We also do not present estimates from the TEDS since it is an unbalanced panel.

Across each of the six RML states under study, synthetic control estimates provide fairly consistent evidence of first-order effects (i.e., increases in marijuana use and reductions in marijuana-related arrests). There is some heterogeneity in the magnitudes of these estimated effects, with the largest increases in marijuana use and the largest declines in marijuana-related arrests generally observed for the four earliest adopters with relatively longer post-policy follow-ups (4.5 years or more).[39]

Spillover effects on hard drug use and related overdose deaths are largely nil or negative. While we detect a small (and statistically insignificant) upticks in other illicit drug use in Colorado and Oregon, these effect sizes are less than one percentage point. Moreover, in both of these states, trends in overdose deaths related to opioids and cocaine provide evidence that marijuana and harder substances are substitutes, suggesting public health gains associated with the RMLs. [40] In Washington, there is little evidence of spillover effects to harder drugs and suggestive evidence that recreational marijuana and alcohol (as well as opioids) are substitutes.

Synthetic control estimates suggest that RMLs decreased marijuana-related arrests across all six states, but there is heterogeneity in how other arrests evolved in the post-treatment period. Arrests for other drug arrests decreased in three states (Washington, Alaska, and Massachusetts), increased modestly in Colorado, and remained essentially unchanged (relative to the synthetic control) in Oregon and California. Likewise, the results for Part I offenses were decidedly

[39] We note that the permutation-based p-values on our donor pool of 24 to 36 states imposes a high standard for achieving statistical significance, with the treatment effect having to rank at the very top (or rank among the top 2 or 3) along the distribution of placebo tests to achieve 5 (or 10) percent statistical significance.

[40] To take another example, the synthetic control estimates also indicate an increase in opioid-related deaths for California, though there is very little indication from the NSDUH with respect to an increase in other illicit drug use for the state. Moreover, the first-order effect on marijuana use in California was also among the lowest in terms of magnitudes, which limits the scope for further spillovers into other drugs and outcomes. Similarly, for MA, there is an indication of an increase in opioid-related and cocaine-related deaths; however, the trends show that these increases were underway even prior to the adoption of the RML, and the NSDUH shows little evidence of spillovers into illicit drug use other than marijuana.

mixed, suggesting that there was heterogeneity in how states diverted their policing resources across drug-related and non-drug related crimes.

In summary, the results from the synthetic control analyses provide strong evidence that RMLs boost marijuana consumption (and reduce marijuana arrests). However, there is little evidence to suggest that the increase in marijuana consumption consistently affects illicit substance use or overdose deaths. It is possible, however, that more substantial, sustained effects may materialize over time, although even for the earliest-adopting states (Washington, Colorado, and Oregon) we find either null effects or only trivial upticks in illicit drug use. The synthetic control analyses also point to considerable heterogeneity in how states responded in their reallocation of policing resources for other offenses.

6. Conclusions

One of the most prominent arguments offered by opponents of recreational marijuana laws is that they will generate adverse spillover, or "gateway", effects. Our study comprehensively explores potential gateway effects of legalizing recreational marijuana on a variety of outcomes related to harder drug use and crime. Across analyses of four national datasets (the NSDUH, the UCR, the NVSS Mortality Files, and the TEDS) we find little consistent evidence, at least thus far, of important gateway effects of RMLs. While RMLs are associated with increases in adult marijuana use and a reduction in marijuana-related arrests, we find little compelling evidence to suggest that RMLs result in increases in illicit drug use, arrests for part I offenses, drug-involved overdoses, or drug-related treatment admissions for addiction. In the main, a causal interpretation of our findings is supported by event study analyses, including those that account for heterogenous policy effects over time.

With regard to limitations of our analyses, we note that our estimates represent average treatment effects over the post-treatment windows available for our RML states. On average, this is approximately three to four years. If gateway effects take longer to unfold, future research will be necessary to detect them. Nonetheless, our synthetic control analyses of Washington and Colorado suggest that such long-run gateway effects have not materialized in the eight years following their adoption. In addition, it is certainly possible that nuisance crimes, those not captured by type I offenses could themselves be impacted by RMLs, which could be a useful path for future work. Finally, an important area of scholarship in this space includes whether RMLs generate adverse effects on marijuana use to minors.

While early evidence is mixed on the impact of marijuana liberalization on youth use (Anderson et al. 2019; Cerda et al. 2017), this question remains open for researchers to tackle. The research design we follow in this study provides an important and useful starting point for extending these analyses as more data become available and marijuana markets in legalized states evolve and mature.[41]

The findings of our study are of clear importance to policymakers and the public. The making of sound public policy depends, in part, upon carefully weighing the explicit costs of legalizing recreational marijuana against the utility gains from consumption and any savings from, for instance, reductions in crime or non-rational addition. Our results provide important evidence on both sides of this social welfare ledger.

[41] See Clemens et al. (2020), Currie et al. (2020), and Christensen and Miguel (2018) for a discussion of the value of pre-committed research designs and transparency in quasi-experimental policy analysis.

7. References

American Civil Liberties Union. 2013. "The War on Marijuana in Black and White: Billions of Dollars Wasted on Racially Charged Arrests," Available at: https://www.aclu.org/sites/default/files/field_document/1114413-mj-report-rfs-rel1.pdf

Adda, Jerome, Brendon McConnell, and Imran Rasul. 2014. "Crime and the Depenalization of Cannabis Possession: Evidence from a Policing Experiment." *Journal of Political Economy, 122*(5): 1130-1202.

Agan, Amanda, and Sonja Starr. 2018. "Ban the Box, Criminal Records, and Racial Discrimination: A Field Experiment." *The Quarterly Journal of Economics, 133*(1): 191-235.

Agan, Amanda Y., Jennifer L. Doleac, and Anna Harvey. 2021. "Misdemeanor Prosecution." NBER Working Paper No. w28600.

Alley, Zoe, David Kerr, and Harold Bae. 2020. "Trends in College Students' Alcohol, Nicotine, Prescription Opioid and Other Drug Use After Recreational Marijuana Legalization: 2008-2018." *Addictive Behaviors, 102*: 106212.

Anderson, D. Mark, Benjamin Hansen, and Daniel I Rees. 2013. "Medical Marijuana Laws, Traffic Fatalities, and Alcohol Consumption." *Journal of Law and Economics, 56*(2): 333-369.

Anderson, D. Mark, Daniel I. Rees, and Joseph J. Sabia. 2014. "Medical Marijuana Laws and Suicides by Gender and Age." *American Journal of Public Health, 104*(12): 2369–2376.

Anderson, D. Mark, Daniel I. Rees, and Erdal Tekin. 2018. "Medical Marijuana Laws and Workplace Fatalities in the United States." *International Journal of Drug Policy, 60*: 33-39.

Anderson, D. Mark, Benjamin Hansen, Daniel I. Rees, and Joseph J. Sabia. 2019. "Marijuana Laws and Teen Marijuana Use: New Estimates from the Youth Risk Behavior Surveys." *JAMA Pediatrics, 173*(9): 879-881.

Anderson, D. Mark, and Daniel I. Rees. 2021. "The Public Health Effects of Legalizing Marijuana". NBER Working Paper No. w28647.

Andreyeva, Elena and Benjamin Ukert. 2019. "The Impact of Medical Marijuana Laws and Dispensaries on Self-Reported Health." *Forum for Health Economics and Policy, 22*(2): 1-20.

Arain, Mariam, Maliha Haque, Lina Johal, Puja Mathur, Wynand Nel, Afsha Rais, Ranbir Sandhu, and Sushil Sharma. 2013. "Maturation of the Adolescent Brain." *Neuropsychiatric Disease and Treatment, 9*: 449.

Aydelotte, Jayson D., Lawrence H. Brown, Kevin M. Luftman, Alexandra L. Mardock, Pedro G. R. Teixeira, Ben Coopwood, and Carlos V. R. Brown. 2017. "Crash Fatality Rates After Recreational Marijuana Legalization in Washington and Colorado." *American Journal of Public Health, 107*(8): 1329-1331.

Bachhuber, Marcus A., Brendan Saloner, Chinazo O. Cunningham, and Colleen L. Barry. 2014. "Medical Cannabis Laws and Opioid Analgesic Overdose Mortality in the United States, 1999-2010." *JAMA Internal Medicine, 174*(10): 1668–1673.

Baggio, Michele, Alberto Chong, and Sungoh Kwon. 2020. "Marijuana and Alcohol: Evidence using Border Analysis and Retail Sales Data." *Canadian Journal of Economics, 53*(2): 563-591.

Bartos, Bradley J. Charis E. Kubrin, Carol Newark, and Richard McCleary 2020. "Medical Marijuana Laws and Suicide." *Archives of Suicide Research, 24*(2): 204-217.

Becker, Gary A. and Kevin M. Murphy. 1988. "A Theory of Rational Addiction," *Journal of Political Economy*, 96(4).

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan. 2004. "How much should we trust differences-in-differences estimates?" *The Quarterly Journal of Economics*, *119*(1): 249-275.

Bleyer, Archie, and Brian Barnes. 2018. "Opioid Death Rate Acceleration in Jurisdictions Legalizing Marijuana Use." *JAMA Internal Medicine, 178*(9): 1280-1281.

Biden, Joseph R. 2019. Available via *The Washington Post* at: https://www.washingtonpost.com/nation/2019/11/18/joe-biden-marijuana-gateway-drug-legalization/

Bradford Ashley and David Bradford. 2016. "Medical Marijuana Laws Reduce Prescription Medication Use in Medicare Part D." *Health Affairs, 35*(7): 1230-1236.

Bradford Ashley and David Bradford. 2017. "Medical Marijuana Laws May be Associated with a Decline in the Number of Prescriptions for Medicaid Enrollees." *Health Affairs, 36*(5): 945-951.

Bradford Ashley and David Bradford. 2018. "The Impact of Medical Cannabis Legalization on Prescription Medication Use and Costs under Medicare Part D." *Journal of Law and Economics, 61*(3): 461-487.

Bradford, Ashley, David Bradford, Amanda Abraham, and Grace Bagwell Adams. 2018. "Association between US State Medical Cannabis Laws and Opioid Prescribing in the Medicare Part D Population." *JAMA Internal Medicine, 178*(5): 667–672.

Brinkman, Jeffrey and David Mok-Lamme. 2019. "Not in My Backyard? Not So Fast. The Effect of Marijuana Legalization on Neighborhood Crime." *Regional Science and Urban Economics, 78*(9): 103460.

Burkhardt, Jesse and Chris Goemans. 2019. "The Short-run Effects of Marijuana Dispensary Openings on Local Crime." *Annals of Regional Science, 63*(1): 163-198

Callaway, Brantly, and Pedro H.C. Sant'Anna. 2021. "Difference-in-Differences with Multiple Time Periods." Forthcoming, *Journal of Econometrics*.

Casey, Betty Jo, Sarah Getz, and Adriana Galvan. 2008. "The Adolescent Brain." *Developmental Review, 28*(1): 62-77.

Cerdá, Magdalena, Melanie Wall, Tianshu Feng, Katherine M. Keyes, Aaron L. Sarvet, John Schulenberg, Patrick M. O'Malley, Rosalie L. Pacula, Sandro Galea, and Deborah S. Hasin. 2017. "Association of State Recreational Marijuana Laws with Adolescent Marijuana Use." *JAMA Pediatrics, 171*(2): 142-149.

Chan, Nathan W., Jesse Burkhardt, and Matthew Flyr. 2020. "The Effects of Recreational Marijuana Legalization and Dispensing on Opioid Mortality." *Economic Inquiry, 58*(2): 589-606.

Chang, Tom and Mireille Jacobson. 2017. "Going to Pot? The Impact of Dispensary Closures on Crime." *Journal of Urban Economics*, 100: 120-136.

Chiu, V., Leung, J., Hall, W., Stjepanović, D. and Degenhardt, L., 2021. "Public health impacts to date of the legalisation of medical and recreational cannabis use in the USA." *Neuropharmacology*, *193*, p.108610.

Choi, Anna, Dhaval Dave, and Joseph J. Sabia. 2019. "Smoke Gets in Your Eyes: Medication Marijuana Laws and Tobacco Cigarette Use." *American Journal of Health Economics, 5*(3): 303-333.

Christensen, G. and E. Miguel. 2018. "Transparency, reproducibility, and the credibility of economics research," *Journal of Economic Literature* 56(3), 920–80.

Chu, Yu-Wei Luke. 2015 "Do Medical Marijuana Laws Increase Hard-Drug Use?" *Journal of Law and Economics, 58*(2): 481–517.

Chu, Yu-Wei Luke and Wilbur Townsend. 2019. "Joint Culpability: The Effects of Medical Marijuana Laws on Crime." *Journal of Economic Behavior and Organization, 159*(3): 502-525.

Clemens, Jeffrey, Drew McNichols, and Joseph J Sabia. 2021. "The Long-Run Effects of the Affordable Care Act: A Pre-Committed Research Design Over the COVID-19 Recession and Recovery." NBER Working Paper No. 27999.

Conyers, Gregory and Ian Ayres. 2020. "A Lottery Test of the Effect of Dispensaries on Emergency Room Visits in Arizona." *Health Economics, 29*(8): 854-864.

Corman, H. and Mocan, H.N., 2000. A time-series analysis of crime, deterrence, and drug abuse in New York City. *American Economic Review*, *90*(3), pp.584-604.

Currie, J., H. Kleven, and E. Zwiers 2020. "Technology and big data are changing economics: Mining text to track methods." NBER Working Paper 26715

Dave, D., Deza, M. and Horn, B., 2021. Prescription drug monitoring programs, opioid abuse, and crime. *Southern Economic Journal*, *87*(3), pp.808-848.

DeAngelo, Gregory, and Audrey Redford. 2015. "Is Medical Marijuana a Gateway Drug?: The Effect of Medical Marijuana Legalization on Heroin Use Rates." Working Paper No. 1376-2016-109662. Available at: https://ageconsearch.umn.edu/record/229981/?ln=en

Dobbie, Will, Jacob Goldin, and Crystal S. Yang. 2018. "The Effects of Pretrial Detention on Conviction, Future Crime, and Employment: Evidence from Randomly Assigned Judges." *American Economic Review, 108*(2): 201-40.

Dragone, Davide, Giovanni Prarolo Paolo, and Vanin Giulio Zanella. 2019. "Crime and the Legalization of Recreational Marijuana." *Journal of Economic Behavior and Organization, 159*: 488-501.

Edwards, E. and Madubuonwu, B., 2020. A Tale of Two Countries: Racially Targeted Arrests in the Era of Marijuana Reform. *American Civil Liberties Union Research Report.*

Fandos, Nicolas. 2021. "In a Milestone, Schumer Will Propose Federal Decriminalization of Marijuana." New York Times , Accessed on July 14 at: https://www.nytimes.com/2021/07/14/us/politics/marijuana-legalization-schumer.html?action=click&module=Top%20Stories&pgtype=Homepage

Federal Bureau of Investigation. 2020. Uniform Crime Reports.

Fernandez, Jean-Gabriel. 2019. "Why Legal Marijuana is Safer." Available at: https://shepherdexpress.com/hemp/cannabis/why-legal-marijuana-is-safer/
Gavrilova, Evelina, Takuma Kamada, and Floris Zoutman. 2017. "Is Legal Pot Crippling Mexican Drug Trafficking Organisations? The Effect of Medical Marijuana Laws on US Crime." *Economic Journal, 129*(1): 375-407.

Gallup. 2020. "Gallup Poll Social Series: Crime," Available at: https://news.gallup.com/file/poll/323591/201109Marijuana.pdf

Ghimire, Keshar M. and Johanna Catherine Maclean. 2020. "Medical marijuana and workers' compensation claiming." *Health Economics*, 29(4): 419-434.

Goodman-Bacon, Andrew. 2021. "Difference-in-Differences with Variation in Treatment Timing." Forthcoming, *Journal of Econometrics.*

Gould, Eric D., Brian A. Weinberg, and David Mustard. 2002. "Crime Rates and Local Labor Market Opportunities in the United States: 1979–1997," *Review of Economics and Statistics,* 84(1): 45-61.

Gruber, Jonathan, and Botond Köszegi. 2001. "Is Addiction 'Rational'? Theory and Evidence." *The Quarterly Journal of Economics, 116*(4): 1261-1303.

Hansen, Benjamin, Keaton Miller, and Caroline Weber. 2020. "Early Evidence on Recreational Marijuana Legalization and Traffic Fatalities." *Economic Inquiry, 58*(2): 547-568.

Harris, Kamala D. 2019. Available via Twitter at: https://twitter.com/kamalaharris/status/1196473557833932803?lang=en

Hollingsworth, Alex, Coady Wing, and Ashley Bradford. 2020. "Comparative Effects of Recreational and Medical Marijuana Laws on Drug Use Among Adults and Adolescents." Available at: https://ssrn.com/abstract=3400519.

Huber III, Arthur, Rebecca Newman, and Daniel LaFave. 2016. "Cannabis Control and Crime: Medicinal Use, Depenalization and the War on Drugs." *B.E. Journal of Economic Analysis and Policy, 16*(4): 1-35.

Hunt, Priscillia, Rosalie Liccardo Pacula, and Gabriel Weinberger. 2018. "High on Crime? Exploring the Effects of Marijuana Dispensary Laws on Crime in California Counties." IZA Discussion Paper No. 11567.

Johnson, Julie, Dominic Hodgkin, and Sion Kim Harris. 2017. "The Design of Medical Marijuana Laws and Adolescent Use and Heavy Use of Marijuana: Analysis of 45 States from 1991 to 2011." *Drug and Alcohol Dependence, 170*: 1-8.

Kelly, Elaine and Imran Rasul 2014. "Policing Cannabis and Drug Related Hospital Admissions: Evidence from Administrative Records." *Journal of Public Economics, 112*: 89-114.

Lochner, Lance, and Enrico Moretti. 2004. "The Effect of Education on Crime: Evidence from Prison Inmates, Arrests, and Self-Reports." *American Economic Review, 94*(1): 155-189.

Marijuana Policy Project. 2021a. Retrieved from https://www.mpp.org/issues/legalization/marijuana-tax-revenue-states-regulate-marijuana-adult-use/ on July 12, 2021.

Marijuana Policy Project. 2021b. Retrieved from https://www.mpp.org/issues/medical-marijuana/state-by-state-medical-marijuana-laws/medical-marijuana-patient-numbers/ on July 8, 2021.

McMichael, Benjamin, Lawrence Van Horn, and W. Kip Viscusi. 2020. "The Impact of Cannabis Access Laws on Opioid Prescribing." *Journal of Health Economics, 69*(1): 102273.

Miller, Keaton and Boyoung Seo. Forthcoming. "The Effect of Cannabis Legalization on Substance Demand and Tax Revenues." *National Tax Journal.*

Miron, Jeffrey and Jeffrey Zwiebel. 1995. "The Economic Case Against Drug Prohibition." *Journal of Economic Perspectives, 9*(4): 175-192.

Morris, Robert G., Michael TenEyck, J. C. Barnes, and Tomislav V. Kovandzic. 2014. "The Effect of Medical Marijuana Laws on Crime: Evidence from State Panel Data, 1990-2006." *PloS One, 9*(3): e92816.

Mueller-Smith, Michael, and Kevin T. Schnepel. 2021. "Diversion in the Criminal Justice System." *The Review of Economic Studies, 88*(2): 883-936.

National Academies of Sciences, Engineering, and Medicine. 2017. *The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research.* Washington, D.C.: National Academies Press.

Nicolas, Lauren H. and Johanna Catherine Maclean. 2019. "The Effect of Medical Marijuana Laws on the Health and Labor Supply of Older Adults: Evidence from the Health and Retirement Study," *Journal of Policy Analysis and Management* 38(2): 455-480.

NIDA. 2020, May 27. Letter From the Director. Retrieved from https://www.drugabuse.gov/publications/research-reports/marijuana/letter-director on 2021, July 8.

NORML. 2021. Legalization. Available at: https://norml.org/laws/legalization/

Olfson, Mark, Melanie M. Wall, Shang-Min Liu, and Carlos Blanco. "Cannabis use and risk of prescription opioid use disorder in the United States." American Journal of Psychiatry 175, no. 1 (2018): 47-53.

Pacula, Rosalie L. and Beau Kilmer. 2003. "Marijuana and Crime: Is There a Connection Beyond Prohibition?" NBER Working Paper No. 10046.

Pager, Devah. 2003. "The Mark of a Criminal Record." *American Journal of Sociology, 108*(5): 937-975.

Polednak, Anthony P. 2016. "Surveillance of US Death Rates from Chronic Diseases Related to Excessive Alcohol Use." *Alcohol and Alcoholism, 51*(1): 54-62.

Powell, David, Rosalie Liccardo Pacula and Mireille Jacobson. 2018. "Do Medical Marijuana Laws Reduce Addictions and Deaths Related to Pain Killers?" *Journal of Health Economics, 58*(3): 29- 42.

Rees, Daniel I., Joseph J. Sabia, Laura Argys, Dhaval Dave, and Joshua Latshaw. 2019. "With a Little Help from My Friends: The Effects of Naloxone Access Laws and Good Samaritan Laws on Opioid-Related Mortality," *Journal of Law and Economics* 62(1): 1-27.

Sabia, Joseph J., Jeffery Swigert, and Timothy Young. 2017. "Medical Marijuana Laws and Body Weight." *Health Economics, 26*(1): 6-34.

Sabia, Joseph J. and Thanh Tam Nguyen. 2018. "The Effect of Medical Marijuana Laws on Labor Market Outcomes." *Journal of Law and Economics, 61*(3): 361-396.

Santaella-Tenorio, Julian, Christine M. Mauro, Melanie M. Wall, June H. Kim, Magdalena Cerdá, Katherine M. Keyes, Deborah S. Hasin, Sandro Galea, and Silvia S. Martins. 2017. "US Traffic Fatalities, 1985–2014, and Their Relationship to Medical Marijuana Laws." *American Journal of Public Health, 107*(2): 336–342.

Sevigny, E.L., Pacula, R.L. and Heaton, P. 2014. "The effects of medical marijuana laws on potency." *International Journal of Drug Policy*, *25*(2), pp.308-319.

Shover, Chelsea L., Corey S. Davis, Sanford C. Gordon, and Keith Humphreys. 2019. "Association between Medical Cannabis Laws and Opioid Overdose Mortality Has Reversed Over Time." *Proceedings of the National Academy of Sciences, 116*(26): 12624-12626.

Smart, R., Caulkins, J.P., Kilmer, B., Davenport, S. and Midgette, G., 2017. "Variation in cannabis potency and prices in a newly legal market: evidence from 30 million cannabis sales in Washington state." *Addiction*, *112*(12), pp.2167-2177.

Smith, Rhet A. 2020. "The Effects of Medical Marijuana Dispensaries on Adverse Opioid Outcomes." *Economic Inquiry, 58*(2): 569-588.

Sun, Liyang, and Sarah Abraham. 2020. "Estimating Dynamic Treatment Effects in Event Studies with Heterogeneous Treatment Effects." Forthcoming, *Journal of Econometrics*.

Veligati, Sirish, Seth Howdeshell, Sara Beeler-Stinn, Deepak Lingam, Phylicia Allen, Li-Shiun Chen, and Richard Grucza. 2020. "Changes in Alcohol and Cigarette Consumption in Response to Medical and Recreational Cannabis Legalization: Evidence from U.S. State Tax Receipt Data." *International Journal of Drug Policy, 75*: 102585.

Wen, Hefei, Jason M. Hockenberry, and Janet R. Cummings. 2015. "The Effect of Medical Marijuana Laws on Adolescent and Adult Use of Marijuana, Alcohol, and Other Substances." *Journal of Health Economics, 42*: 64-80.

Wen, Hefei and Jason M. Hockenberry JM. 2018. "Association of Medical and Adult-Use Marijuana Laws with Opioid Prescribing for Medicaid Enrollees." *JAMA Internal Medicine, 178*(5): 673–679.

Wong, Su-Wei, and Hsien-Chang Lin. 2019. "Medical Marijuana Legalization and Associated Illicit Drug Use and Prescription Medication Misuse Among Adolescents in the US." *Addictive Behaviors, 90*: 48-54.

Figure 1. Enactment Years of Recreational Marijuana Laws

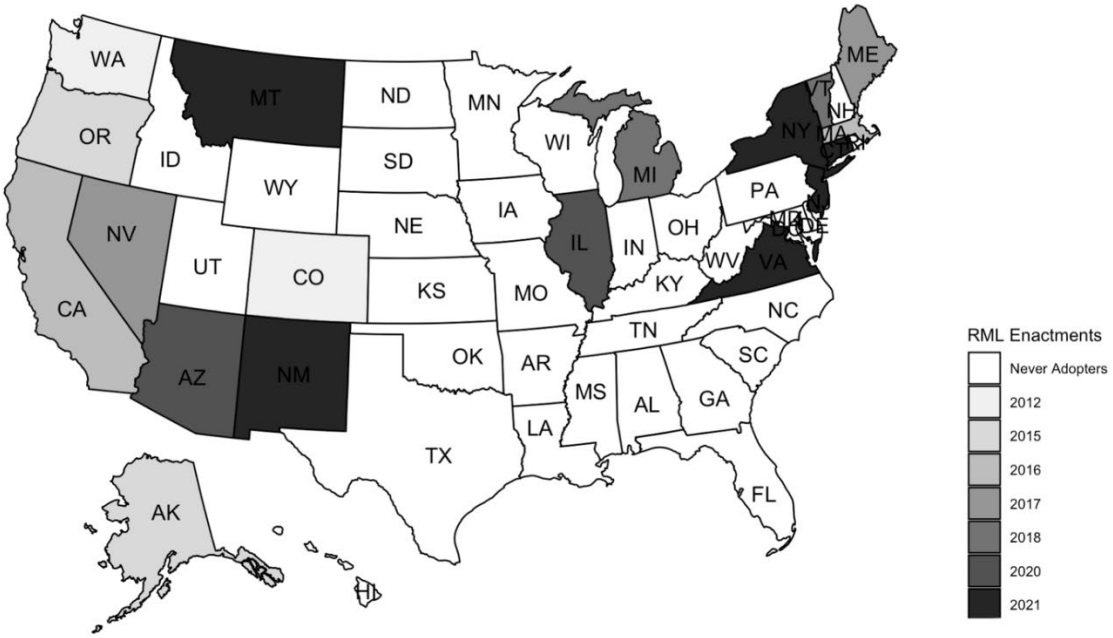
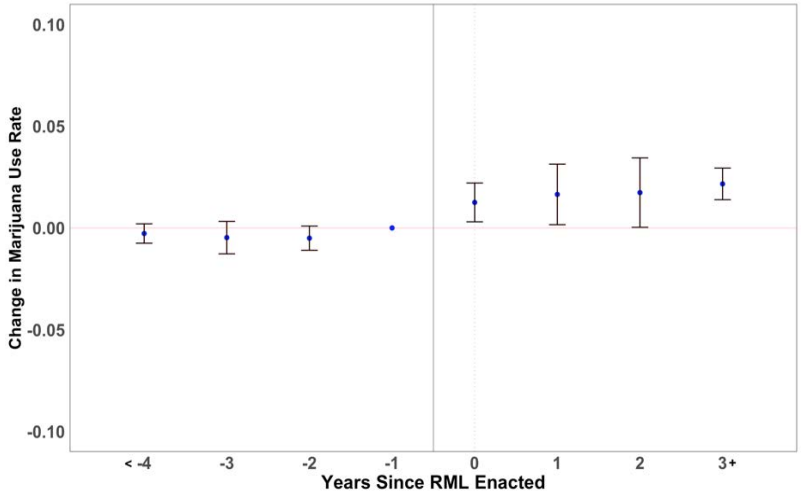
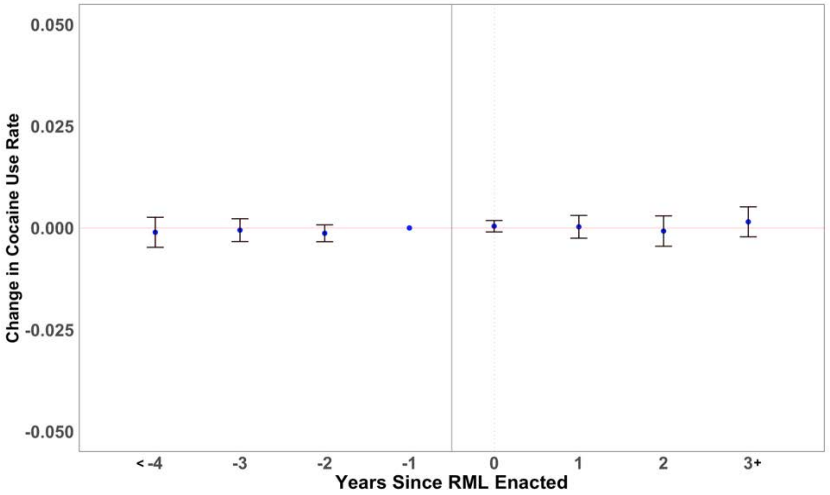


Figure 2A. Event-Study Analyses of the Effect of RMLs on Adult Drug Use, NSHUH

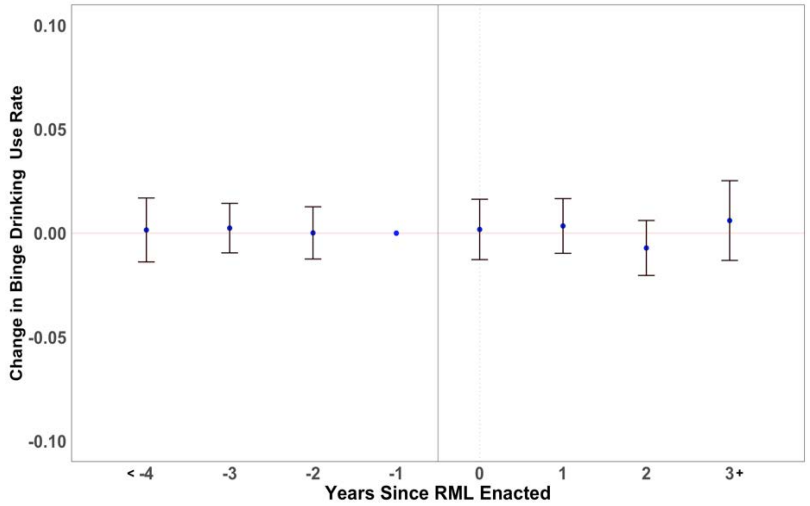
Panel (a): Marijuana Use



Panel (b): Cocaine Use



Panel (c): Binge Drinking



Panel (d): Illicit Drug Use Other Than Marijuana

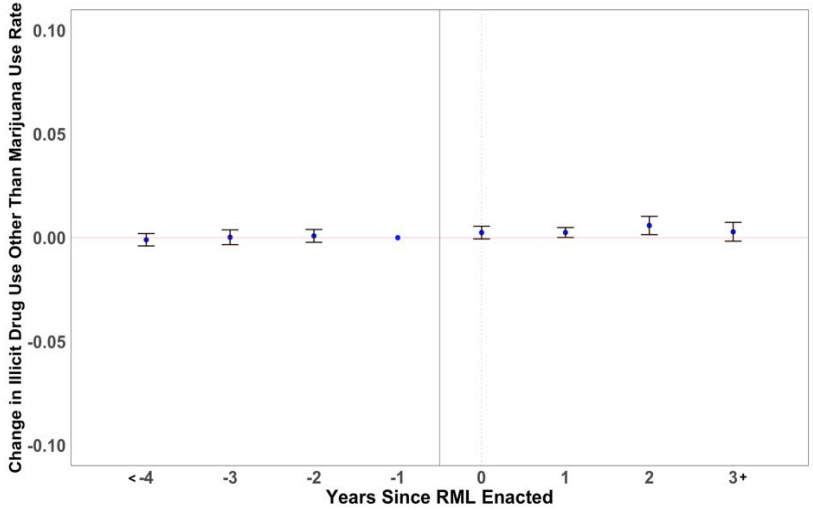
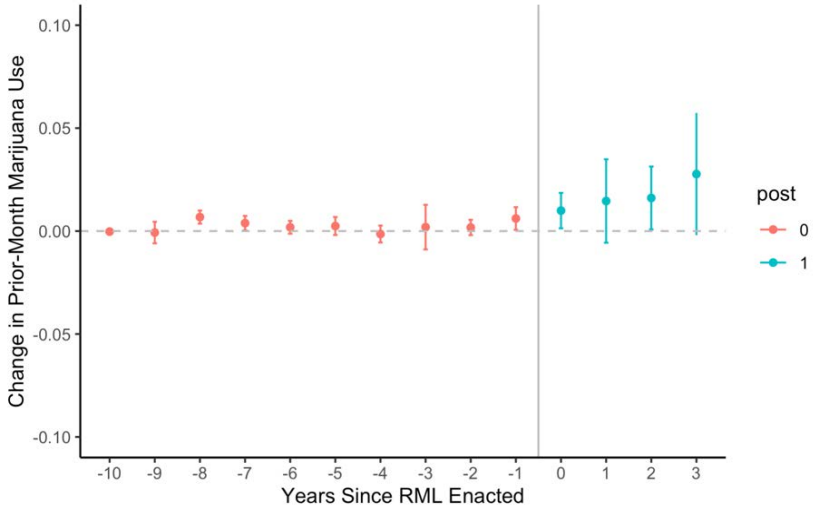
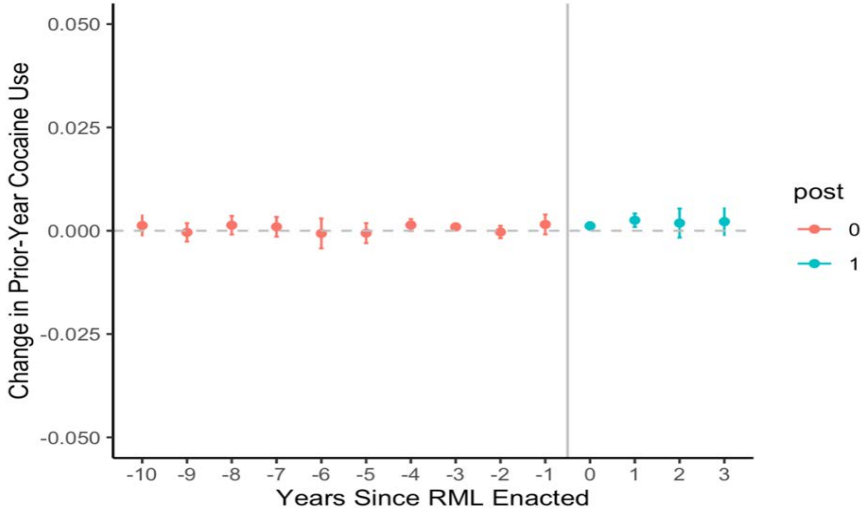


Figure 2B. Callaway-Sant'Anna (2021) Event-Study Analyses of the Effect of RMLs on Adult Drug Use, NSDUH

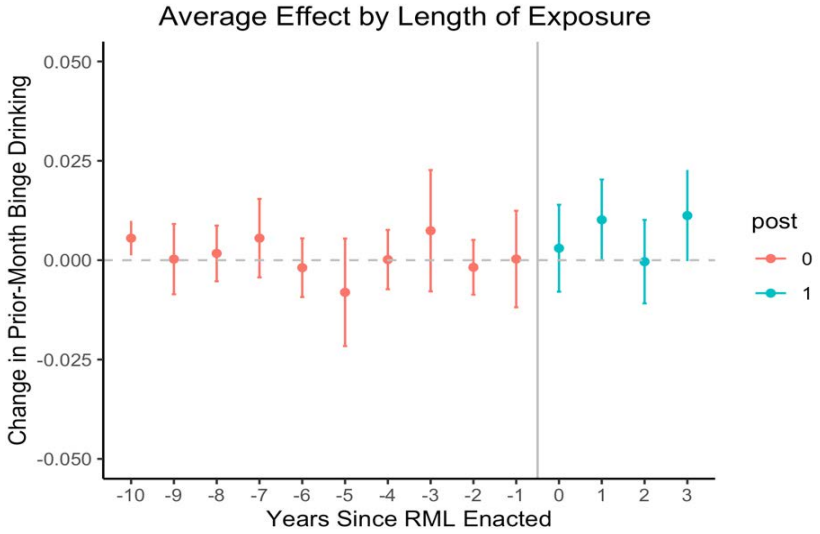
Panel (a): Marijuana Use



Panel (b) Cocaine Use



Panel (c): Binge Drinking



Panel (d): Illicit Drug Use other than Marijuana

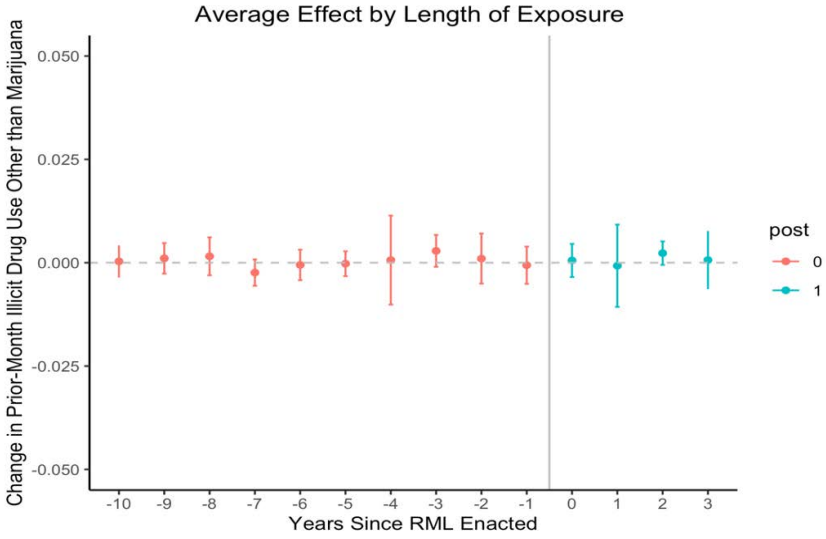
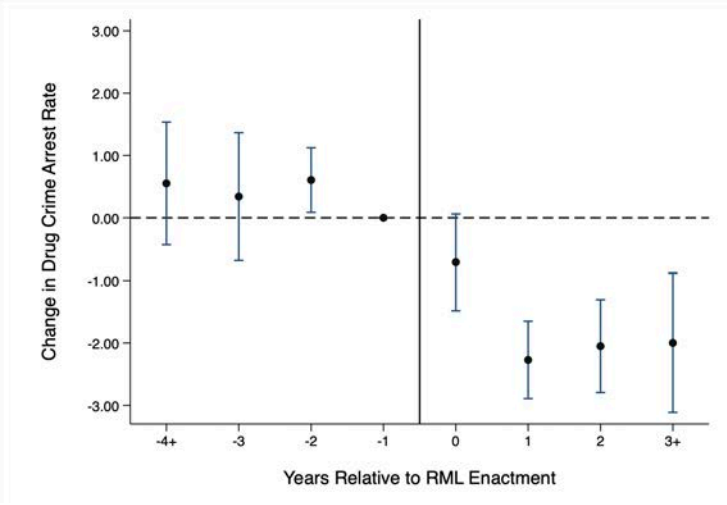
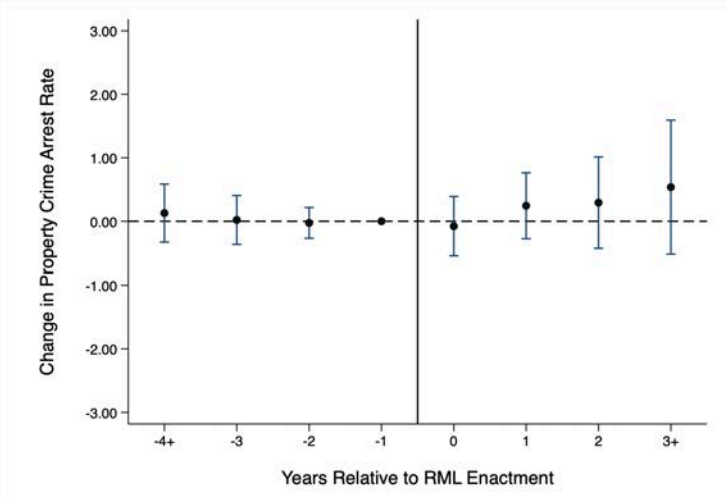


Figure 3. Event-Study Analyses of the Effect of RMLs on Adult Arrest Rates, UCR

Panel (a): Drug Arrests



Panel (b): Property Arrests



Panel (c): Violent Arrests

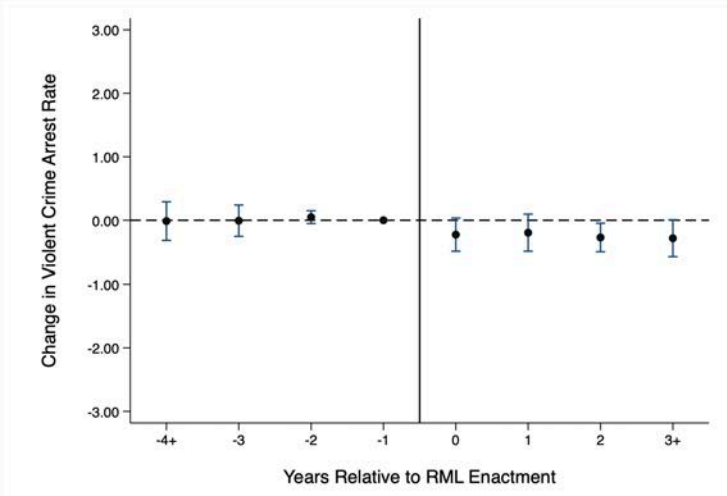
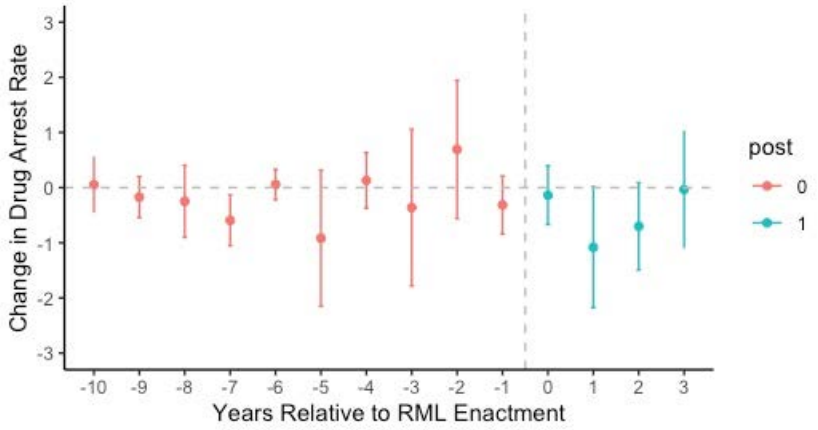
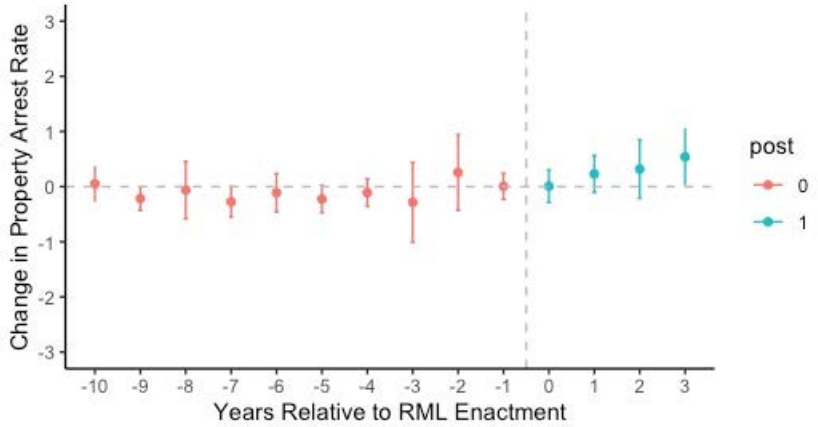


Figure 4. Callaway-Sant'Anna (2021) Event-Study Analyses of Adult Arrest Rates, UCR

Panel (a): Drug Offense Arrests



Panel (b): Property Offense Arrests



Panel (c): Violent Offense Arrests

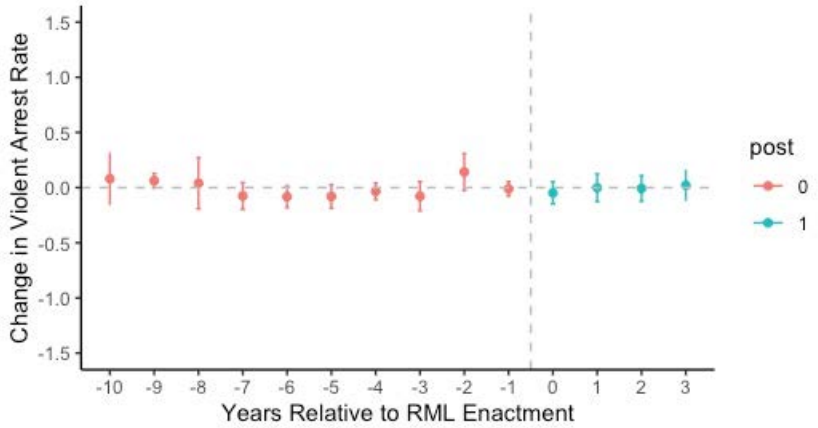
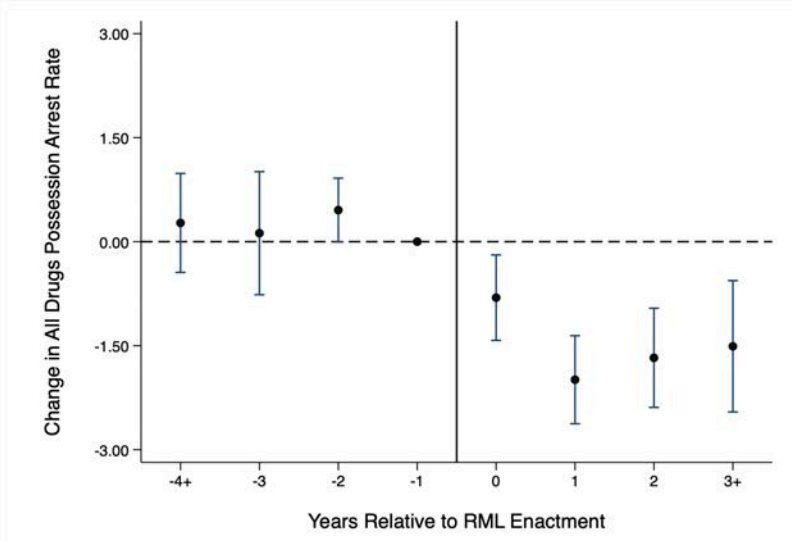
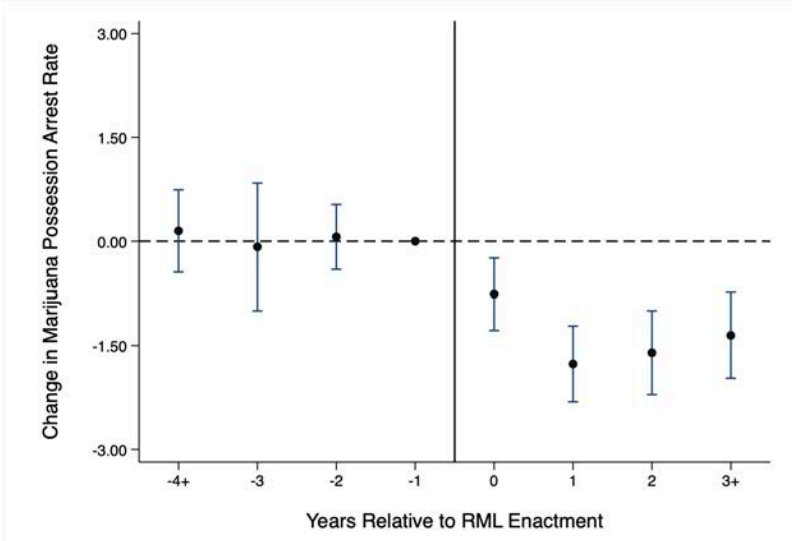


Figure 5. Event-Study Analyses of the Effect of RMLs on Adult Drug Possession Arrest Rates, UCR

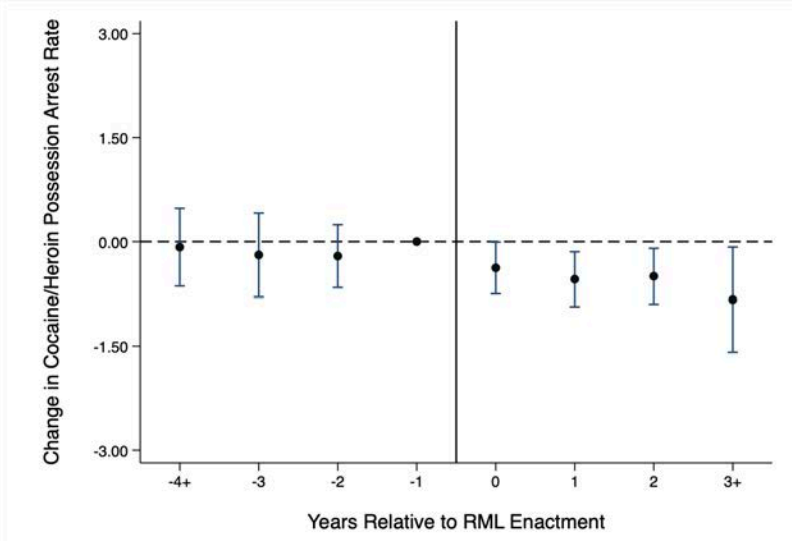
Panel (a): Drug Possession Arrests



Panel (b): Marijuana Possession Arrests



Panel (c): Cocaine/Heroin Possession Arrests



Panel (d): Synthetic Narcotics Possession Arrests

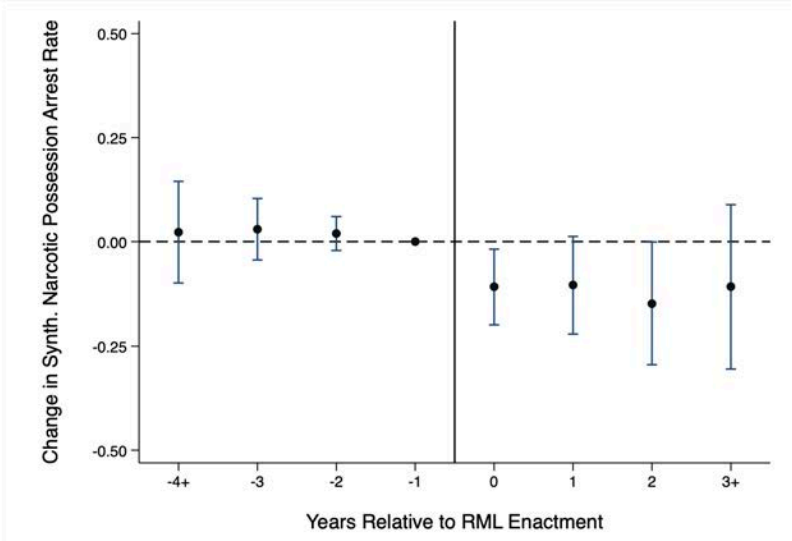
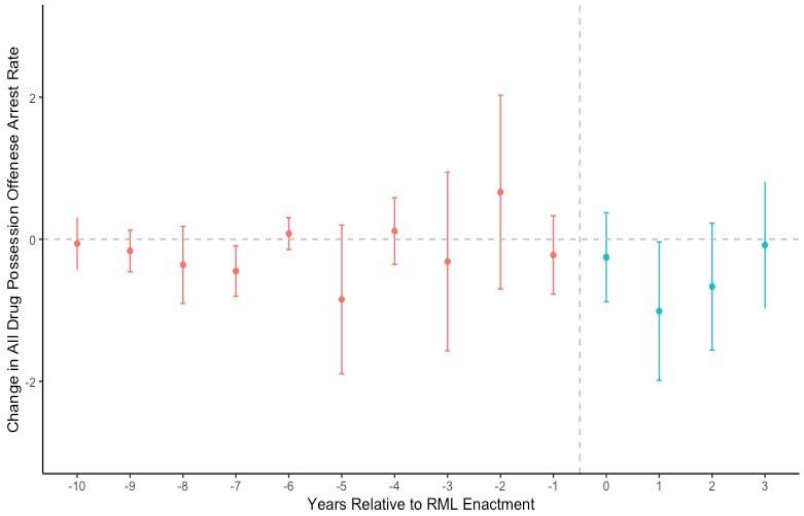
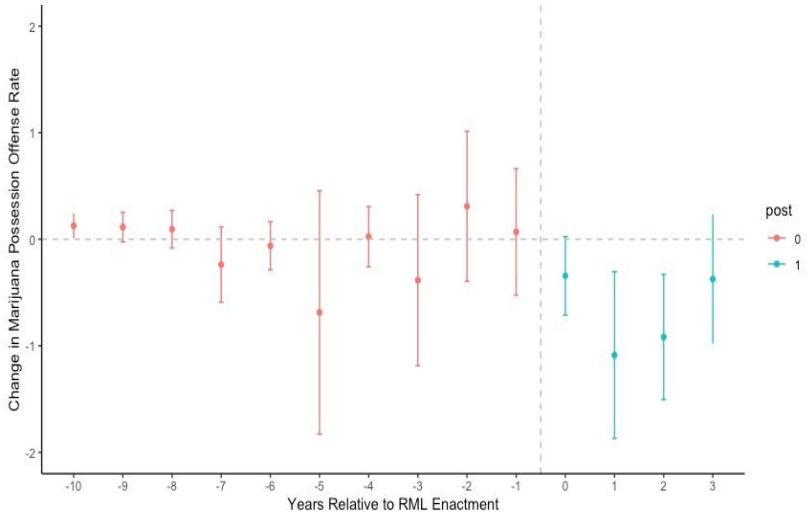


Figure 6. Callaway-Sant'Anna (2021) Event-Study Analyses of Adult Drug Possession Arrest Rates, UCR

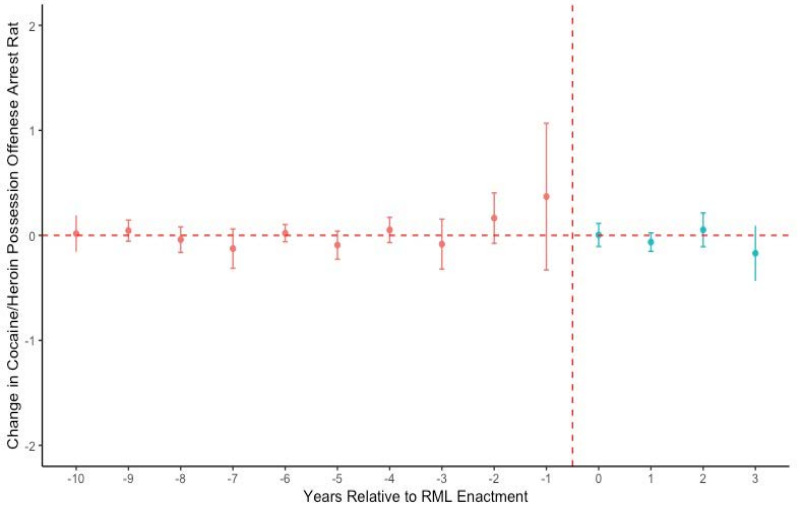
Panel (a): Drug Possession Arrests



Panel (b): Marijuana Possession Arrests



Panel (c): Cocaine/Heroin Possession Arrests



Panel (d): Synthetic Narcotics Possession Arrests

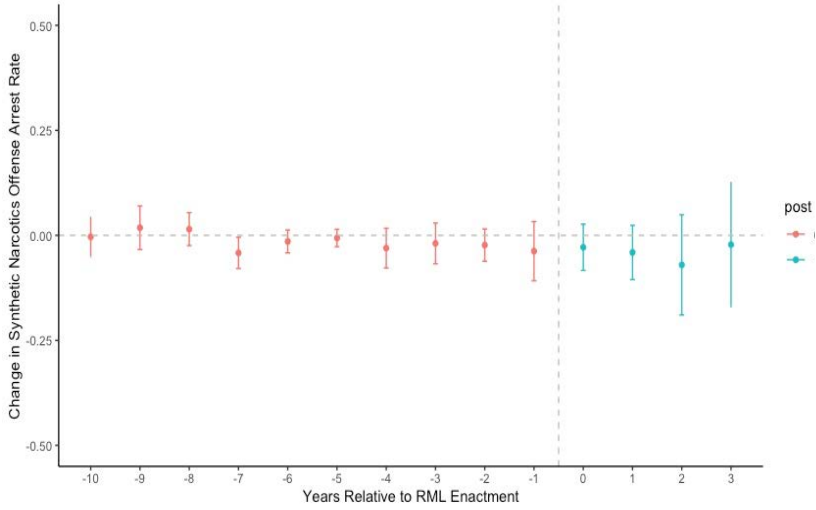
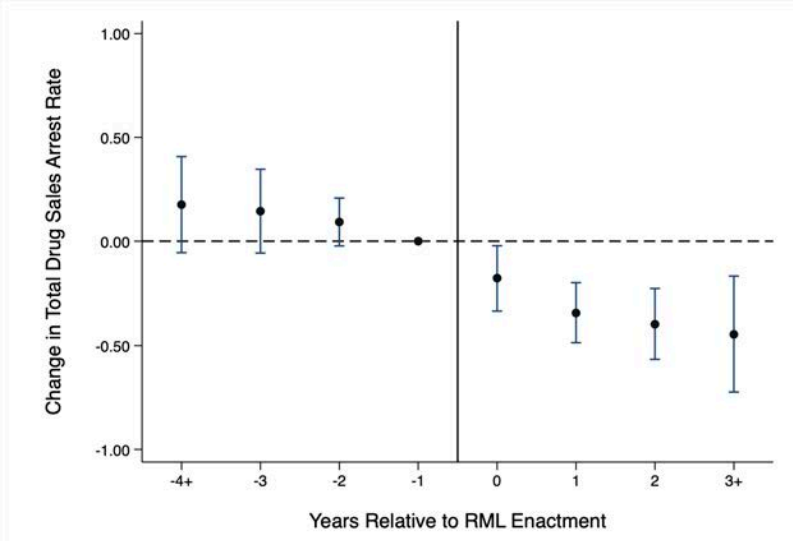
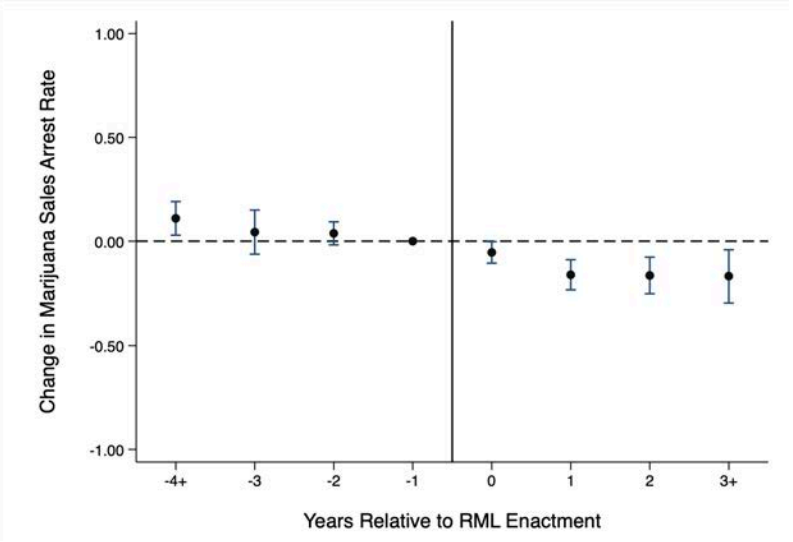


Figure 7. Event-Study Analyses of the Effect of RMLs on Adult Drug Sales Arrest Rates, UCR

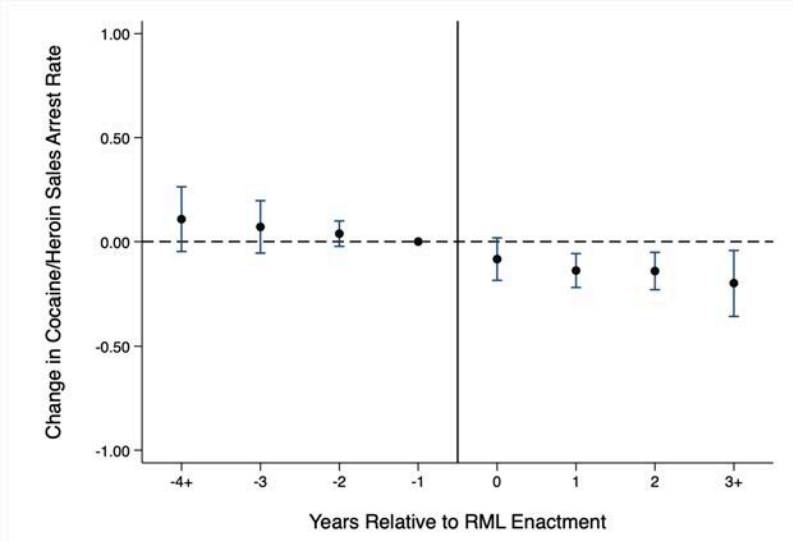
Panel (a): Drug Sales Arrests



Panel (b): Marijuana Sales Arrests



Panel (c): Cocaine/Heroin Sales Arrests



Panel (d): Synthetic Narcotics Sales Arrests

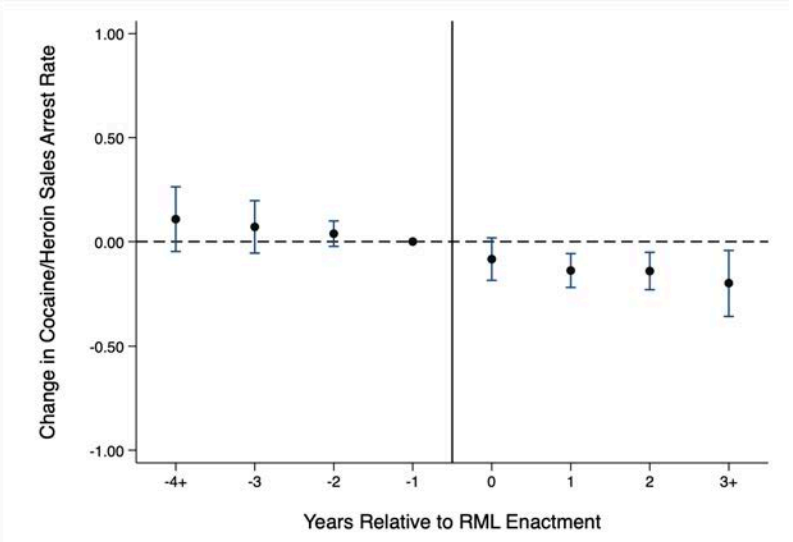
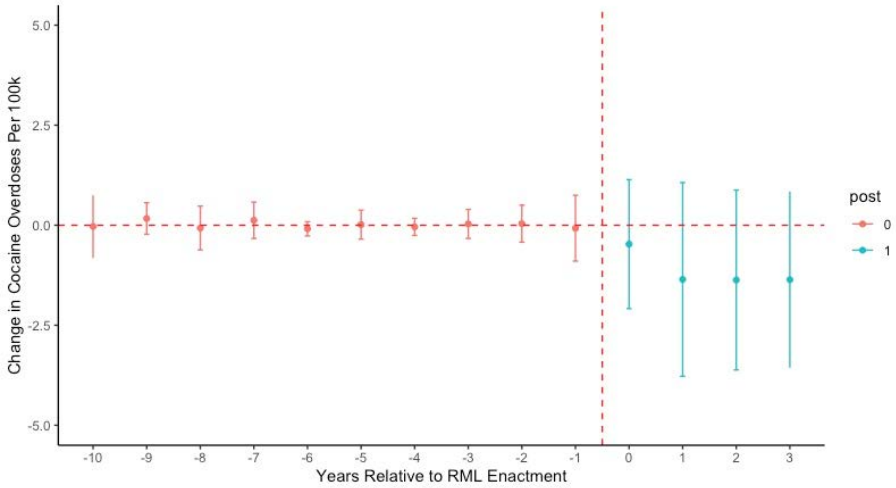
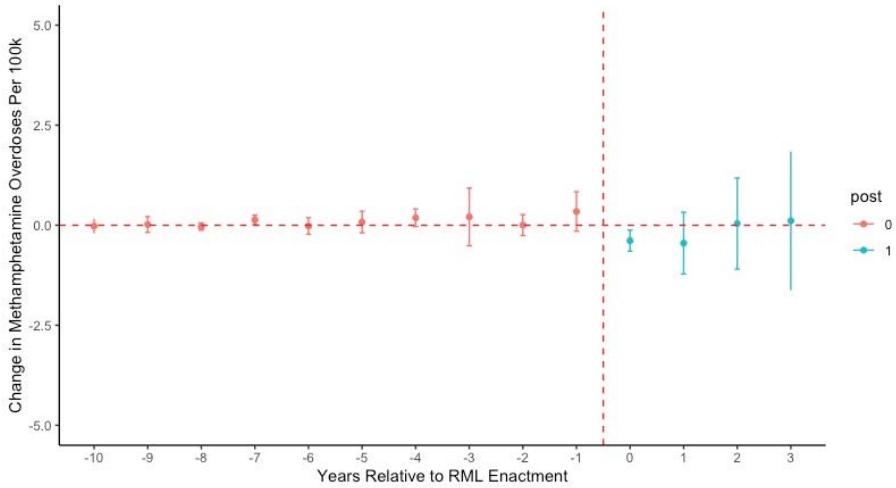


Figure 8. Callaway-Sant'Anna (2021) Event-Study Analysis of the Effect of RMLs on Substance Use-Involved Mortality and Suicides, NVSS Mortality Files

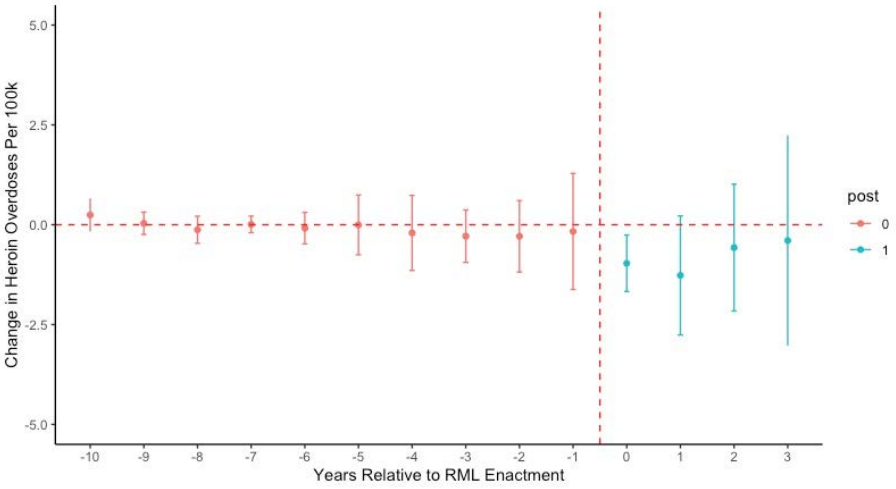
Panel (a): Cocaine Deaths



Panel (b): Methamphetamine Deaths



Panel (c): Heroin Deaths



Panel (d): Fentanyl Deaths

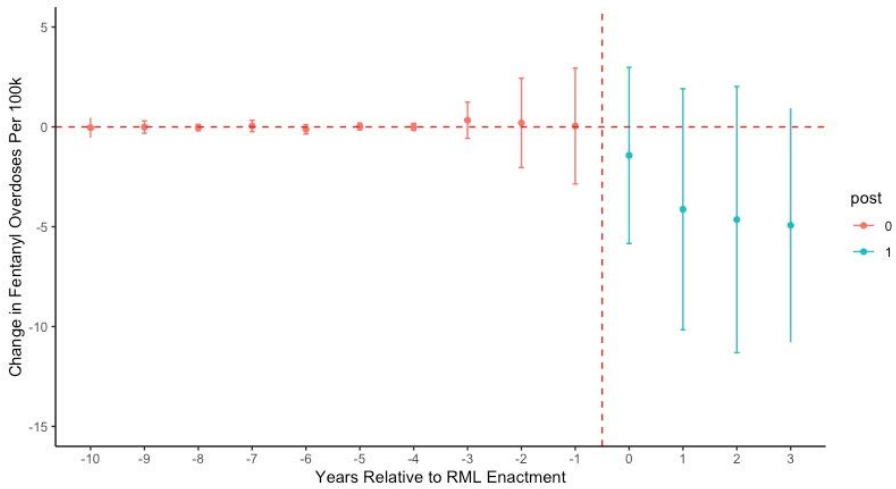
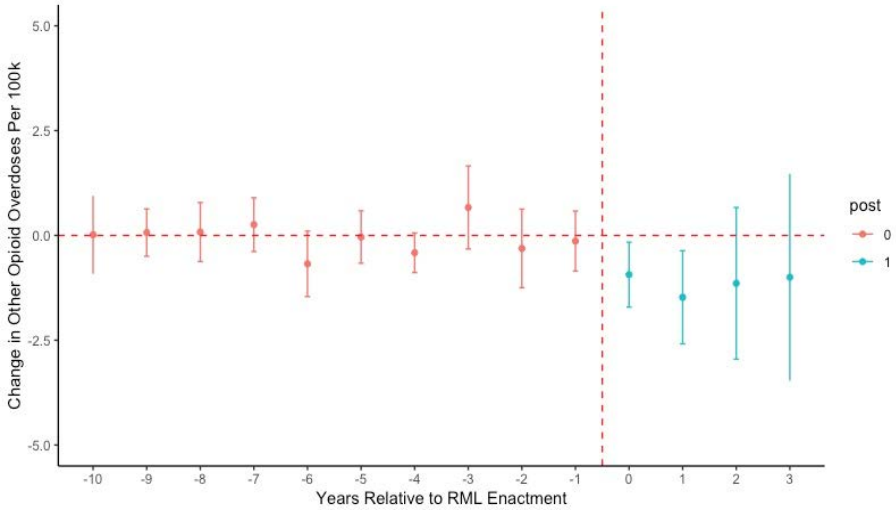
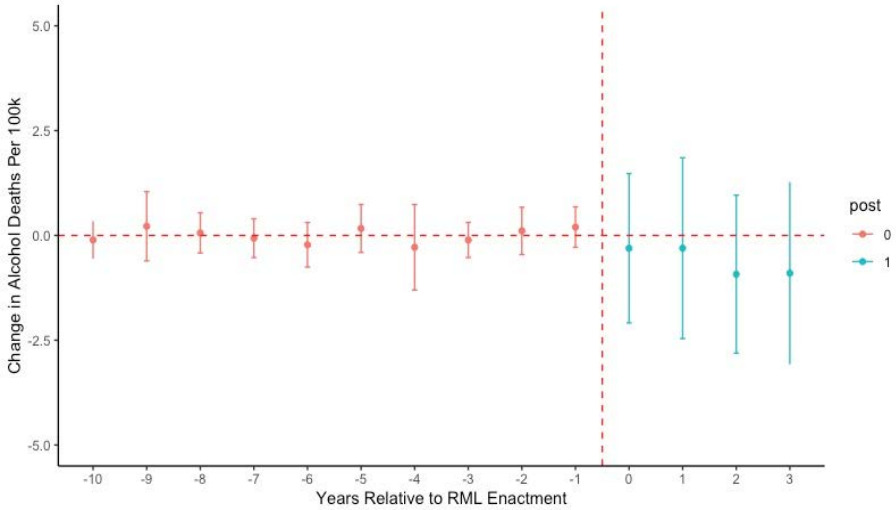


Figure 8, Continued

Panel (e): Other Opioid Deaths



Panel (f): Alcohol Deaths



Panel (g): Suicide Deaths

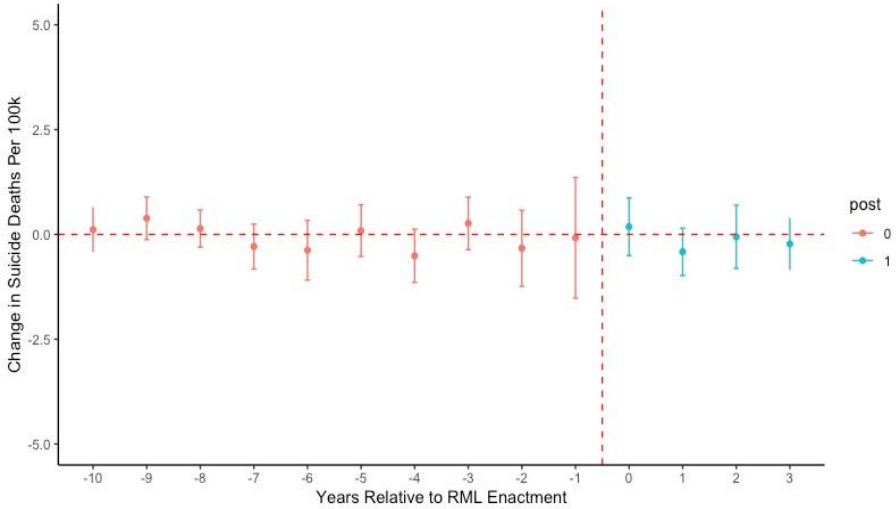
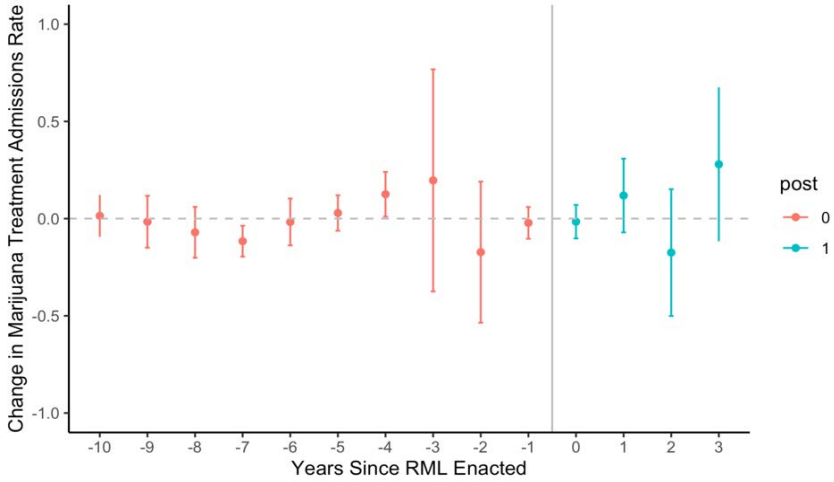
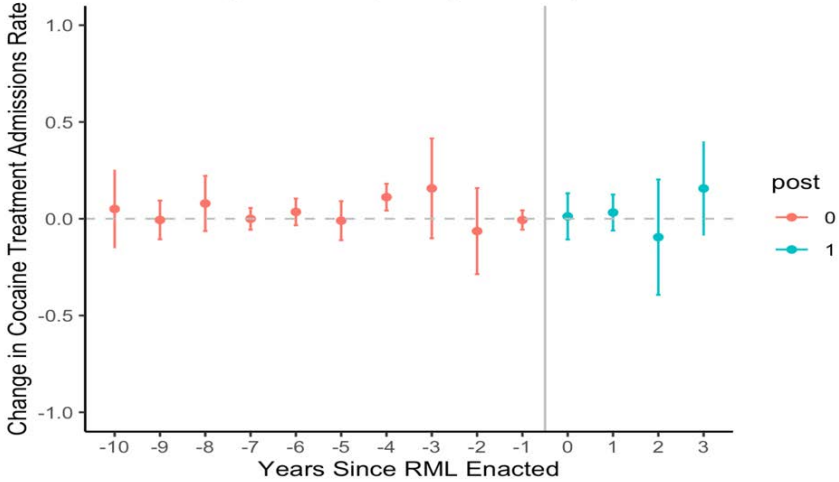


Figure 9. Callaway-Sant'Anna (2021) Event-Study Analyses of the Effect of RMLs on Substance Use Treatment Admissions, TEDS

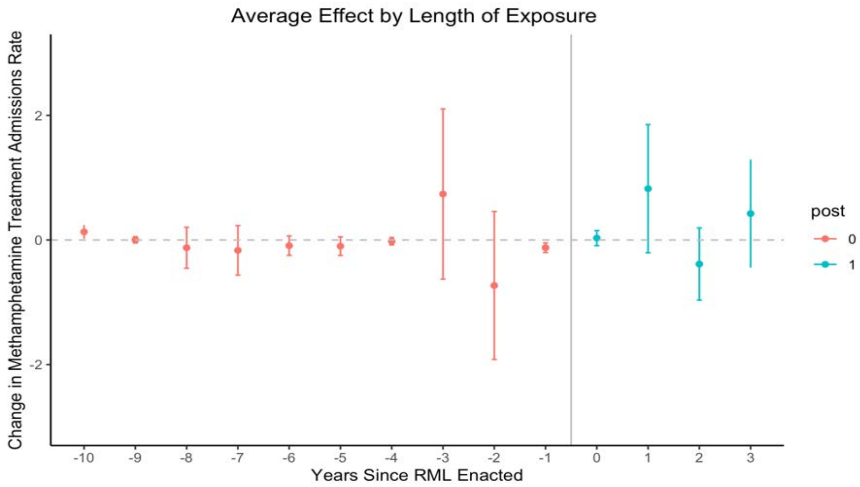
Panel (a): Marijuana Admissions



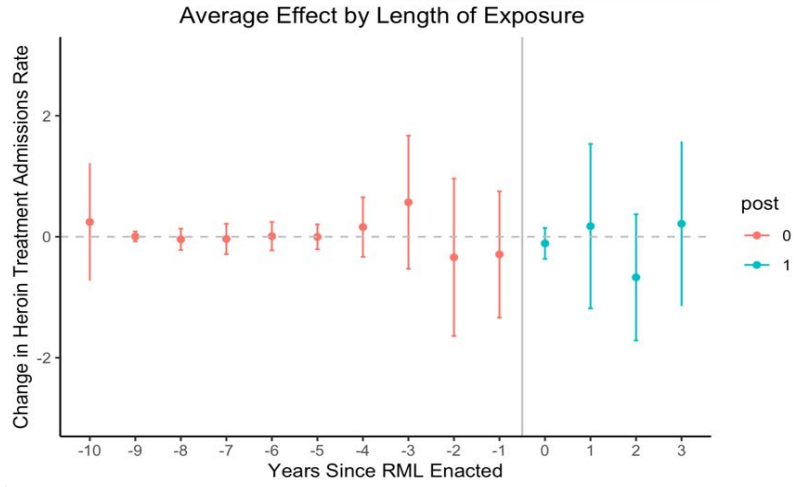
Panel (b): Cocaine Admissions



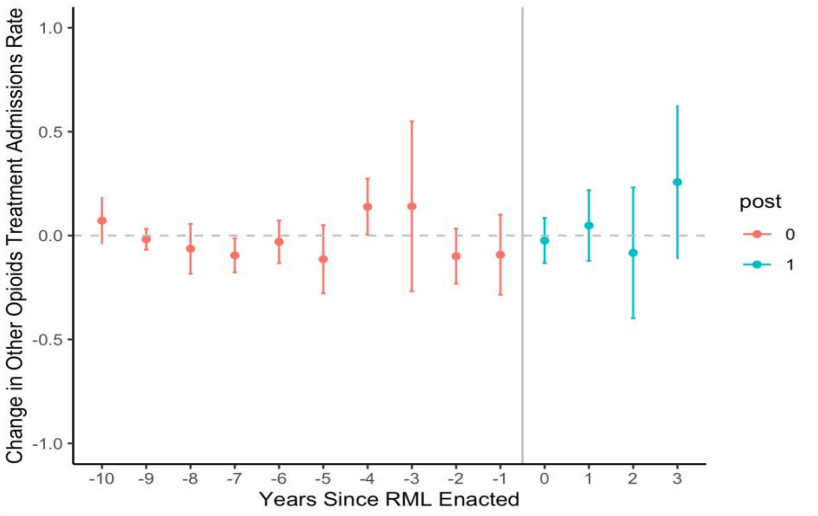
Panel (c): Meth/Amphetamine Admissions



Panel (d): Heroin Admissions



Panel (e): Other Opioids Admissions



Panel (f): Alcohol Admissions

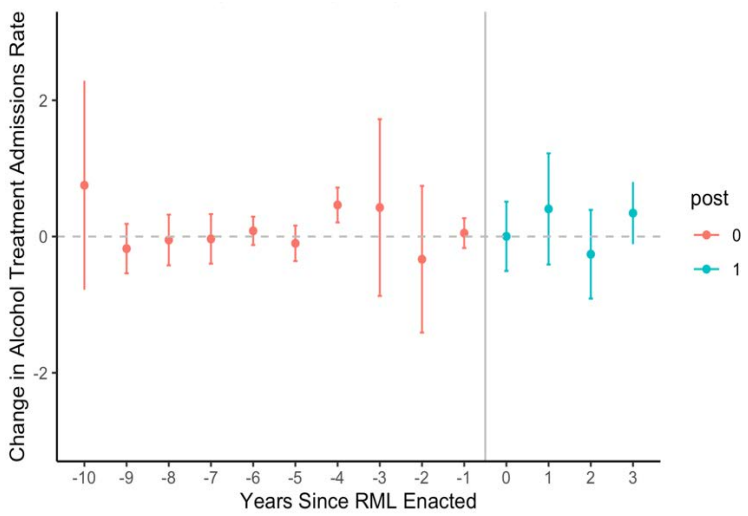


Table 1A. Estimates of the Effect of Recreational Marijuana Laws on Prevalence of Adult Substance Use, NSDHUH 2002-2019

	(1)	(2)	(3)
	Panel I: Prior-Month Marijuana Use *[N = 867; Pre-Treatment Mean = 0.085]*		
RML	0.0323***	0.0361***	0.0159*
	(0.0083)	(0.0045)	(0.006)
	Panel II: Prior-Year Cocaine Use *[N = 867; Pre-Treatment Mean = 0.023]*		
RML	0.0025**	0.0013	-0.0001
	(0.0009)	(0.0011)	(0.0013)
	Panel III: Prior-Month Binge Drinking[a] *[N = 816; Pre-Treatment Mean = 0.257]*		
RML	0.0069	0.0041	-0.0029
	(0.0052)	(0.0052)	(0.0036)
	Panel IV: Prior-Month Illicit Drug Use Other than Marijuana[a] *[N = 816; Pre-Treatment Mean = 0.038]*		
RML	0.0006	0.0004	0.0013
	(0.0011)	(0.0009)	(0.0011)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes

***p < .001 **p < .01 *p < .05

Notes: All regressions include state fixed effects, year fixed effects, and control for the number of law enforcement agencies reporting arrests. Sociodemographic controls include the state unemployment rate, per capita personal income, the proportion of state population that is Black, the proportion of the state population that is Hispanic, whether the governor is a Democrat; Policy controls include the presence of a medical marijuana law , the presence of a marijuana decriminalization law, beer tax per gallon, presence of alcohol- and drug-specific Good Samaritan laws, the presence of a naloxone access law, the presence of a must-access prescription drug monitoring program, cigarette tax per pack , the presence of e-cigarette tax, the natural log of law enforcement personnel per 1,000 population, state EITC refundable rate, the maximum Supplemental Nutrition Assistance Program (Food Stamp) benefit level for 4-person family, the higher of the state of Federal minimum wage, an indicator for whether the state has implemented an Affordable Care Act Medicaid expansion, the presence of a shall issue law, and the presence of a stand your ground law Regressions are weighted using the adult state population and standard errors are clustered at the state level.

[a]The binge drinking and illicit drug use (other than marijuana) measure is missing in the publicly available 2014-15 NSDUH state summary tables.

Table 1B. Estimates of the Effect of Recreational Marijuana Laws on Prevalence of Methamphetamine Use and Non-Medicinal Use of Pain Relievers, NSDUH

	(1)	(2)	(3)
	Panel I: Methamphetamine Use, 2015-2019 *[N = 204; Pre-Treatment Mean = 0.0073]*		
RML	-0.00067*	-0.0017	0.0003
	(0.00032)	(0.0014)	(0.0017)
	Panel II: Nonmedical Use of Pain Relievers, 2002-2014[a] *[N = 612; Pre-Treatment Mean = 0.046]*		
RML	-0.0048*	-0.0028	0.0006
	(0.0021)	(0.0015)	(0.0028)
	Panel III: Nonmedical Use of Pain Relievers, 2015-2019 *[N = 204; Pre-Treatment Mean = 0.041]*		
RML	-0.0016	0.0022	0.0009
	(0.0010)	(0.0016)	(0.0025)
	Panel IV: Nonmedical Use of Pain Relievers, 2002-2019[a] *[N = 816; Pre-Treatment Mean = 0.045]*		
RML	-0.0032**	-0.0023	0.002
	(0.0011)	(0.0011)	(0.0014)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

The NSDUH changed its asking of questions related to prescription pain reliever misuse: "Several changes were made to the prescription drug questions for the 2014-2015 NSDUH. These changes were designed to address limitations in the survey design used in prior years. Special attention was paid to revising the modules that measure prescription drug misuse or "nonmedical" use because of public health concerns about misuse of prescription drugs, such as increases in the number of drug poisoning deaths involving opioid pain relievers like hydrocodone, oxycodone, and methadone (Centers for Disease Control and Prevention, 2013; Paulozzi, 2012)." See: https://www.samhsa.gov/data/sites/default/files/NSDUH-RedesignChanges-2015.pdf

[a]The binge drinking, pain reliever misuse, and illicit drug use other than marijuana measures are missing in the publicly available 2014-15 NSDUH state summary tables

Table 2. Estimates of the Effect of Recreational Marijuana Laws on Adult Arrests Per 1,000 Population, UCR, 2002-2019

	(1)	(2)	(3)
		Panel I: Drug Arrests	
		[Pre-Treatment Mean DV = 6.33]	
RML	-1.308**	-1.057**	-1.993***
	(0.360)	(0.355)	(0.401)
		Panel II: Violent Arrests	
		[Pre-Treatment Mean DV = 2.75]	
RML	0.051	0.074	-0.190
	(0.085)	(0.098)	(0.114)
		Panel III: Property Arrests	
		[Pre-Treatment Mean DV = 4.36]	
RML	0.038	0.047	0.270
	(0.199)	(0.272)	(0.320)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	998	998	998

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Table 3. Age- and Gender-Specific Estimates of the Effect of RMLs on Adult Arrest Rate per 1,000 Population, UCR, 2000-2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Age 18-20		**Age 21+**		**Males 18+**		**Females 18+**	
				Part I: Drug Arrests				
RML	-1.320	-4.015	-1.046**	-1.883***	-1.326*	-3.152***	-0.747***	-0.890***
	(2.740)	(3.144)	(0.305)	(0.335)	(0.615)	(0.697)	(0.154)	(0.159)
Pre-Treatment Mean DV	[16.70]	[16.70]	[5.704]	[5.704]	[10.207]	[10.207]	[2.614]	[2.614]
				Panel II: Violent Arrests				
RML	0.171	-0.454	0.072	-0.176	0.118	-0.321	0.042	-0.070
	(0.284)	(0.301)	(0.090)	(0.106)	(0.171)	(0.185)	(0.038)	(0.050)
Pre-Treatment Mean DV	[6.516]	[6.516]	[2.520]	[2.520]	[4.543]	[4.543]	[1.025]	[1.025]
				Panel III: Property Arrests				
RML	-1.111	1.048	0.118	0.223	0.100	0.312	0.018	0.221
	(0.713)	(0.886)	(0.271)	(0.296)	(0.348)	(0.437)	(0.209)	(0.217)
Pre-Treatment Mean DV	[15.70]	[15.70]	[3.673]	[3.673]	[5.870]	[5.870]	[2.914]	[2.914]
State & Year FE & # Agencies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observable Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Linear Trends?	No	Yes	No	Yes	No	Yes	No	Yes
N	998	998	998	998	998	998	998	998

***p < .001 **p < .01 *p < .05

Notes: All regressions include state and year fixed effects and all observable controls listed in the notes to Table 1A. Regressions are weighted using the relevant state population and standard errors are clustered at the state level.

Table 4. Estimates of Effects of RMLs on Adult Individual Type I Offense Rate per 1,000 Population, UCR, 2000-2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Assault	**Robbery**	**Murder**	**Larceny**	**Burglary**	**Motor Vehicle Theft**	**Arson**
				Panel I: All Observable Controls			
RML	0.036	0.051	-0.0005	-0.075	0.037	0.050	0.005
	(0.091)	(0.029)	(0.004)	(0.227)	(0.042)	(0.048)	(0.003)
Pre-Treatment Mean DV	[2.423]	[0.435]	[0.051]	[3.133]	[1.169]	[0.499]	[0.030]
				Panel II: Includes State-Specific Linear Time Trends			
RML	-0.174	-0.031	-0.0008	0.223	0.083	-0.006	0.002
	(0.089)	(0.037)	(0.006)	(0.296)	(0.069)	(0.039)	(0.003)
Pre-Treatment Mean DV	[2.423]	[0.435]	[0.051]	[3.133]	[1.169]	[0.499]	[0.030]
N	998	998	998	998	998	998	998

***p < .001 **p < .01 *p < .05

Notes: All regressions include state and year fixed effects and all observable controls listed in the notes to Table 1A. Regressions are weighted using the relevant state population and standard errors are clustered at the state level.

Table 5. Estimates of Effects of RMLs on Adult Drug-Related Arrests Per 1,000 Population, UCR, 2000-2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Possession	*Sales*	*Possession*	*Sales*	*Possession*	*Sales*	*Possession*	*Sales*	*Possession*	*Sales*
	Age 18+		**Age 18-20**		**Age 21+**		**Males Ages 18+**		**Females Ages 18+**	
					Panel I: All Drug Arrests					
RML	-1.791***	-0.366***	-5.910***	-0.876**	-1.732***	-0.353***	-2.848***	-0.630***	-0.784***	-0.114***
	(0.342)	(0.096)	(1.557)	(0.356)	(0.310)	(0.091)	(0.568)	(0.166)	(0.146)	(0.033)
Pre-Treat Mean DV	[5.21]	[1.10]	[13.77]	[2.86]	[5.02]	[1.07]	[8.31]	[1.86]	[2.23]	[0.38]
					Part II: Marijuana Arrests					
RML	-1.334***	-0.159***	-5.180***	-0.461**	-1.268***	-0.153***	-2.147***	-0.283***	-0.554***	-0.041***
	(0.193)	(0.040)	(1.467)	(0.218)	(0.172)	(0.036)	(0.327)	(0.070)	(0.081)	(0.013)
Pre-Treat Mean DV	[1.39]	[0.32]	[7.46]	[1.30]	[1.21]	[0.29]	[2.43]	[0.58]	[0.39]	[0.07]
					Panel III: Heroin and Cocaine Arrests					
RML	-0.261**	-0.139**	-0.368**	-0.330*	-0.263**	-0.134**	-0.464**	-0.250**	-0.072	-0.035*
	(0.122)	(0.059)	(0.158)	(0.169)	(0.123)	(0.057)	(0.203)	(0.102)	(0.053)	(0.020)
Pre-Treat Mean DV	[1.71]	[0.41]	[2.90]	[0.85]	[1.71]	[0.40]	[2.64]	[0.68]	[0.83]	[0.14]
					Panel IV: Truly Addicting Synthetic Narcotics Arrests					
RML	-0.073	-0.019	-0.048	-0.024	-0.075*	-0.018	-0.102	-0.028	-0.046*	-0.010
	(0.044)	(0.014)	(0.096)	(0.023)	(0.044)	(0.014)	(0.063)	(0.020)	(0.027)	(0.009)
Pre-Treat Mean DV	[0.13]	[0.04]	[0.25]	[0.06]	[0.13]	[0.04]	[0.19]	[0.06]	[0.07]	[0.02]
					Panel V: Other Dangerous Non-Narcotic Arrests					
RML	-0.123	-0.048	-0.314	-0.060	-0.126	-0.048	-0.135	-0.069	-0.112	-0.028**
	(0.159)	(0.031)	(0.218)	(0.094)	(0.159)	(0.030)	(0.233)	(0.052)	(0.095)	(0.012)
Pre-Treat Mean DV	[1.98]	[0.34]	[3.17]	[0.65]	[1.97]	[0.34]	[3.05]	[0.55]	[0.95]	[0.15]
FE & # Agencies?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observable Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State Linear Trends?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	998	998	998	998	998	998	998	998	998	998

***p < .001 **p < .01 *p < .05

Notes: All regressions include state and year fixed effects and all observable controls listed in the notes to Table 1A. Regressions are weighted using the relevant state population and standard errors are clustered at the state level.

Table 6. Estimates of the Effect of Recreational Marijuana Laws on Deaths Per 100,000 Population, NVSS Mortality Files, 2000-2019

	(1)	(2)	(3)
	Panel I: Cocaine Deaths [Pre-Treat Mean = 2.071]		
RML	-1.788*	-1.157	0.094
	(0.742)	(0.830)	(0.591)
	Panel II: Methamphetamine Deaths [Pre-Treat Mean = 1.625]		
RML	1.417*	0.920	-0.211
	(0.550)	(0.608)	(0.500)
	Panel III: Heroin Deaths [Pre-Treat Mean = 1.945]		
RML	-1.398*	-1.052	-0.681
	(0.583)	(0.653)	(0.841)
	Panel IV: Fentanyl Deaths [Pre-Treat Mean = 1.287]		
RML	-4.110	-2.758	-1.208
	(2.300)	(2.318)	(1.649)
	Panel V: Other Opioid Deaths [Pre-Treat Mean = 6.337]		
RML	-1.708**	-1.673*	-1.101
	(0.609)	(0.656)	(0.748)
	Panel VI: Alcohol Deaths [Pre-Treat Mean = 14.102]		
RML	1.017	1.433**	0.295
	(0.740)	(0.458)	(0.400)
	Panel VII: Suicides [Pre-Treat Mean = 14.771]		
RML	-0.186	0.391	-0.002
	(0.419)	(0.360)	(0.207)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	1,020	1,020	1,020

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Table 7. Heterogeneity in Effects of RMLs on Deaths Per 100,000 Population, by Age and Gender, NVSS Mortality Files, 2000-2019

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cocaine	*Methamphetamine*	*Heroin*	*Fentanyl*	*Other Opioids*	*Alcohol*	*Suicides*
				Panel I: Ages 18-20			
RML	0.732*	0.103	0.153	-1.176	0.032	-0.063	-0.759
	(0.318)	(0.243)	(0.627)	(0.787)	(0.802)	(0.098)	(0.797)
Pre-Treatment Mean DV	[0.594]	[0.576]	[0.851]	[0.427]	[2.520]	[0.311]	[9.862]
				Panel II: Ages 21+			
RML	0.062	-0.235	-0.731	-1.205	-1.170	0.290	0.045
	(0.621)	(0.516)	(0.865)	(1.723)	(0.758)	(0.418)	(0.212)
Pre-Treatment Mean DV	[2.161]	[1.689]	[2.011]	[1.340]	[6.569]	[14.940]	[15.069]
				Panel III: Males			
RML	0.358	-0.154	-1.010	-1.507	-0.970	0.425	-0.317
	(0.959)	(0.723)	(1.298)	(2.534)	(1.071)	(0.705)	(0.370)
Pre-Treatment Mean DV	[3.089]	[2.377]	[3.147]	[1.583]	[8.115]	[21.053]	[23.575]
				Panel IV: Females			
RML	-0.165	-0.276	-0.384	-0.928	-1.226*	0.150	0.264
	(0.275)	(0.301)	(0.417)	(0.837)	(0.550)	(0.206)	(0.178)
Pre-Treatment Mean DV	[1.094]	[0.903]	[0.790]	[1.004]	[4.628]	[7.423]	[6.312]
State & Year FE?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observable Controls?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,020	1,020	1,020	1,020	1,020	1,020	1,020

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Table 8. Estimates of the Effect of Recreational Marijuana Laws on Adult Substance Use Treatment Admissions Per 1,000 Population, TEDS, 2000-2018

	(1)	(2)	(3)
	Panel I: Marijuana Admissions [Pre-Treat Mean = 0.72]		
RML	-0.090	-0.036	0.139
	(0.084)	(0.112)	(0.093)
	Panel II: Cocaine Admissions [Pre-Treat Mean = 0.66]		
RML	0.167	0.230*	0.058
	(0.143)	(0.114)	(0.078)
	Panel III: Meth/Amphetamine Admissions [Pre-Treat Mean = 1.31]		
RML	0.211	0.319	0.191
	(0.192)	(0.247)	(0.190)
	Panel IV: Heroin Admissions [Pre-Treat Mean = 1.82]		
RML	-0.211	-0.022	0.425
	(0.367)	(0.444)	(0.459)
	Panel V: Other Opioids Admissions [Pre-Treat Mean 0.48]		
RML	-0.116	-0.151	0.013
	(0.122)	(0.160)	(0.159)
	Panel VI: Alcohol Admissions [Pre-Treat Mean = 3.40]		
RML	0.216	0.257	0.066
	(0.460)	(0.537)	(0.329)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	937	937	937

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Table 9. Heterogeneity in Effects of RMLs on Drug Treatment Admissions Rate, by Age and Gender, 2000-2018

	(1)	(2)	(3)	(4)	(5)	(6)
	Marijuana	*Cocaine*	*Methamphetamine/ Amphetamine*	*Heroin*	*Other Opioids*	*Alcohol*
			Panel I: Ages 18-20			
RML	0.482	0.018	0.536*	0.433	-0.181	0.256
	(0.273)	(0.055)	(0.256)	(0.556)	(0.317)	(0.490)
Pre-Treat Mean DV	[2.78]	[0.35]	[1.56]	[1.75]	[0.60]	[2.96]
			Panel II: Ages 21+			
RML	0.120	0.061	0.172	-0.429	0.023	0.057
	(0.085)	(0.080)	(0.190)	(0.463)	(0.155)	(0.350)
Pre-Treat Mean DV	[0.59]	[0.68]	[1.29]	[1.82]	[0.47]	[3.43]
			Panel III: Males			
RML	0.175	0.041	0.201	0.532	0.0006	0.130
	(0.152)	(0.105)	(0.223)	(0.567)	(0.173)	(0.460)
Pre-Treat Mean DV	[1.03]	[0.82]	[1.47]	[2.52]	[0.51]	[5.05]
			Panel IV: Females			
RML	0.104*	0.073	0.177	0.322	0.025	-0.042
	(0.043)	(0.057)	(0.159)	(0.362)	(0.148)	(0.239)
Pre-Treat Mean DV	[0.42]	[0.50]	[1.15]	[1.15]	[0.45]	[1.81]
State & Year FE?	Yes	Yes	Yes	Yes	Yes	Yes
Observable Controls?	Yes	Yes	Yes	Yes	Yes	Yes
State Linear Time Trends?	Yes	Yes	Yes	Yes	Yes	Yes
N	937	937	937	937	937	937

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 1. Weighted Means of Dependent Variables

	Age 18+	*Age 18-25*	*Age 26+*
Panel I: National Survey Drug Use and Health			
Marijuana Use in Last Month	0.074 (0.025)	0.187(0.042)	0.055(0.023)
Cocaine Use in Last Year	0.021 (0.005)	0.056(0.014)	0.015(0.003)
Binge Drinking in Last Month	0.25 (0.027)	0.411(0.054)	0.227(0.027)
Illicit Drug Use Other than Marijuana in Last Month	0.034 (0.004)	0.077(0.012)	0.027(0.004)
Methamphetamine Use in Last Year	0.006(0.003)	0.008(0.004)	0.006(0.002)
Non-Medicinal Use of Pain Relievers in Last Year	0.044 (0.006)	0.099(0.027)	0.034(0.005)

Panel II: Uniform Crime Reports[a]					
	Pooled	*Age 18-20*	*Age 21+*	*Males*	*Females*
Property Arrest Rate	4.50 (1.68)	15.39 (6.40)	3.86 (1.49)	6.02 (2.29)	3.06 (1.22)
Violent Arrest Rate	1.81 (0.99)	4.70 (2.28)	1.64 (0.92)	3.01 (1.62)	0.67 (0.40)
Drug Arrest Rate	5.56 (2.46)	18.40 (9.55)	4.80 (2.19)	9.10 (4.00)	2.22 (1.14)
Drug Possession Arrest Rate	4.42 (2.36)	14.92 (8.75)	3.79 (2.09)	7.16 (3.78)	1.82 (1.10)
Drug Sale Arrest Rate	0.95 (0.56)	2.72 (2.19)	0.84 (0.48)	1.59 (0.99)	0.34 (0.19)
Marijuana Possession Arrest Rate	2.04 (1.28)	10.79 (7.97)	1.52 (0.94)	3.51 (2.22)	0.66 (0.46)
Marijuana Sale Arrest Rate	0.26 (0.19)	1.18 (0.98)	0.20 (0.15)	0.46 (0.34)	0.06 (0.05)
Total Marijuana Arrest Rate	2.30 (1.36)	11.97 (8.29)	1.73 (1.01)	3.97 (2.38)	0.73 (0.48)
Cocaine/Heroin Poss. Arrest Rate	1.13 (0.93)	1.88 (1.60)	1.08 (0.91)	1.78 (1.49)	0.51 (0.42)
Cocaine/Heroin Sales Arrest Rate	0.39 (0.37)	0.97 (1.38)	0.35 (0.32)	2.92 (2.51)	0.77 (0.67)
Total Cocaine/Heroin Arrest Rate	1.52 (1.17)	2.85 (2.66)	1.44 (1.11)	0.67 (0.67)	0.12 (0.10)
Narcotics Possession Arrest Rate	0.21 (0.23)	0.43 (0.43)	0.20 (0.22)	2.46 (1.94)	0.64 (0.48)
Narcotics Sales Arrest Rate	0.09 (0.12)	0.17 (0.25)	0.08 (0.11)	0.31 (0.33)	0.12 (0.13)
Other Non-Narcotic Possess Arrest Rate	1.02 (1.16)	1.80 (1.51)	0.98 (1.16)	1.55 (1.74)	0.52 (0.64)
Other Non-Narcotic Sales Arrest Rate	0.20 (0.19)	0.39 (0.41)	0.19 (0.18)	0.32 (0.30)	0.09 (0.09)
Assault Arrest Rate	1.50 (0.93)	2.81 (1.55)	1.30 (0.83)	2.24 (1.39)	0.58 (0.36)
Robbery Arrest Rate	0.35 (0.16)	1.51 (0.77)	0.23 (0.10)	0.55 (0.25)	0.07 (0.03)
Murder Arrest Rate	0.48 (0.26)	0.15 (0.09)	0.03 (0.01)	0.07 (0.04)	0.009 (0.007)
Larceny Arrest Rate	3.76 (1.60)	11.10 (5.13)	2.97 (1.33)	4.21 (1.85)	2.70 (1.19)
Burglary Arrest Rate	0.84 (0.45)	3.00 (1.70)	0.62 (0.33)	1.30 (0.64)	0.24 (0.21)
Motor Vehicle Theft Arrest Rate	0.32 (0.23)	1.09 (0.87)	0.24 (0.16)	0.48 (0.33)	0.10 (0.08)
Arson Arrest Rate	0.03 (0.02)	0.08 (0.06)	0.02 (0.02)	0.05 (0.03)	0.01 (0.01)

Panel III: NVSS Mortality Files[b]					
Cocaine Death Rate	2.94 (2.50)	0.94 (0.92)	3.05 (2.61)	4.42 (3.71)	1.54 (1.41)
Methamphetamine Death Rate	1.68 (2.37)	0.60 (0.76)	1.75 (2.47)	2.44 (3.43)	0.97 (1.38)
Heroin Deaths Rate	2.73 (3.01)	1.35 (1.39)	2.81 (3.13)	4.36 (4.65)	1.19 (1.52)
Fentanyl Death Rate	3.41 (6.37)	1.20 (2.19)	3.54 (6.63)	4.79 (9.65)	2.12 (3.35)
Other Opioid Death Rate	6.13 (3.28)	2.74 (2.02)	6.33 (3.41)	7.81 (4.15)	4.55 (2.72)
Alcohol Death Rate	11.51 (4.52)	0.28 (0.41)	12.16 (4.76)	17.46 (6.21)	5.89 (2.97)
Suicide Rate	15.82 (4.19)	11.35 (4.68)	16.09 (4.23)	25.68 (6.59)	6.52 (1.97)

[a]Arrest rates are calculated per 1,000 relevant state population
[b]Mortality rates are calculated per 100,000 relevant state population

Appendix Table 1, Continued

Panel IV: Treatment Episode Data Set[c]					
	Pooled	*Age 18-20*	*Age 21+*	*Males*	*Females*
Marijuana Admissions Rate	0.89 (0.60)	3.35 (2.35)	0.74 (0.51)	1.33 (0.97)	0.48 (0.28)
Cocaine Admissions Rate	0.79 (0.67)	0.40 (0.33)	0.81 (0.69)	0.99 (0.92)	0.60 (0.46)
Amphetamine/Meth Admission Rate	0.62 (0.80)	0.71 (1.03)	0.62 (0.80)	0.69 (0.91)	0.55 (0.70)
Alcohol Admission Rate	3.06 (2.89)	2.37 (2.74)	3.10 (2.93)	4.65 (4.64)	1.57 (1.27)
Heroin/Fentanyl Admissions Rate	1.40 (1.93)	1.25 (2.07)	1.41 (1.96)	1.94 (2.73)	0.91 (1.25)
Other Opioids Admissions Rate	0.48 (0.48)	0.56 (0.83)	0.47 (0.48)	0.53 (0.54)	0.44 (0.44)

[c]Admissions rates are calculated per 1,000 relevant state population

Appendix Table 2. Weighted Means of Independent Variables, 2000-2019

Variable name	*Mean*	*SD*	*Source*
ACA Medicaid Expansion	0.19	0.39	Kaiser Family Foundation, State Health Facts (Medicaid and Health Reform): https://www.kff.org/statedata/
Beer tax per gallon (nom $)	0.26	0.24	Urban Institute & Brookings Institution Tax Policy Center: https://www.taxpolicycenter.org/statistics/state-alcoholexcise-taxes
Cigarette tax per pack (nom $)	1.24	0.96	Tax Burden on Tobacco: https://chronicdata.cdc.gov/Policy/The-Tax-Burden-on-Tobacco-1970-2019/7nwe-3aj9
Marijuana Decriminalized	0.36	0.48	NORML Foundation: https://norml.org/laws/decriminalization/
Democrat Governor	0.43	0.49	Anderson and Rees (2011), and authors' own internet searches
Any E-cigarette tax	0.06	0.24	Hansen et al. (2021): "Do Tobacco 21 Laws Work?"
EITC refundable rate (nom $)	0.07	0.16	University of Kentucky Center for Poverty Research, National Welfare Data: https://ukcpr.org/resources/national-welfare-data
Log (law enforcement personnel per 1,000 pop)	0.82	0.23	FBI UCR: https://ucr.fbi.gov/crime-in-the-u.s/2011/crimein-the-u.s.-2011/police-employee-data
Minimum Wage (nom $)	7.03	1.47	Economic Policy Institute (Ben Zipperer): https://www.epi.org/data/
Medical Marijuana Law	0.32	0.46	Anderson and Rees (2021)
Naloxone Access Law	0.34	0.46	Rees, Sabia, Argys, Dave, and Latshaw (2019); Prescription Drug Abuse Policy System: http://pdaps.org/datasets/good-samaritan-overdose-laws-1501695153; and the Network for Public Health Law: https://www.networkforphl.org/wpcontent/uploads/2020/10/Fact-Sheet-Naloxone-Prescription-Mandates.pdf
Number law enforcement agencies reporting arrests	675.85	368.69	FBI UCR
Per capital personal income (nom $)	42199.31	9911.62	FRED: https://fred.stlouisfed.org/series/A792RC0A052NBEA
Must-access prescription drug monitoring program	0.122	0.317	Dave, Deza, and Horn (2021); Prescription Drug Abuse Policy System: http://pdaps.org/datasets/prescriptionmonitoring- program-laws-1408223416-1502818373; and Valant: https://www.valant.io/pdmp/
Share Non-Hispanic Black	0.128	0.08	Calculated using SEER Population Estimates (1990-2019 single-year age groups): https://seer.cancer.gov/popdata/download.html
Share Hispanic	0.15	0.12	Calculated using SEER Population Estimates (1990-2019 single-year age groups): https://seer.cancer.gov/popdata/download.html
Recreational Marijuana Law	0.046	0.20	Anderson and Rees (2021)
Good Samaritan Alcohol Law	0.06	0.23	Rees, Sabia, Argys, Dave, and Latshaw (2019); Prescription Drug Abuse Policy System: http://pdaps.org/datasets/good-samaritan-overdose-laws-1501695153; and authors' own searches
Good Samaritan Drug Law	0.19	0.38	Rees, Sabia, Argys, Dave, and Latshaw (2019); Prescription Drug Abuse Policy System: http://pdaps.org/datasets/good-samaritan-overdose-laws-1501695153; and authors' own searches
Shall Issue Law	0.64	0.47	Grossman and Lee (2008), Donohue and Ayers (2009), Aneja et al. (2012), Hinkston (2012), United States Government Accountability Office (2012), Arnold (2015), USA Carry (2015), and Giffords Law Center to Prevent Gun Violence (2021a)
Max SNAP benefit for 4-person family (nom $)	577.40	92.25	University of Kentucky Center for Poverty Research, National Welfare Data: https://ukcpr.org/resources/national-welfare-data
Stand Your Ground Law	0.38	0.47	McClellan and Tekin (2017), Giffords Law Center to Prevent Gun Violence (2021b), and authors' own searches of state legislative codes
State Unemployment Rate	5.90	2.09	FRED: https://fred.stlouisfed.org/release?rid=112

Appendix Table 3. Heterogeneity in the Effects of RMLs on Adult Substance Use, by Age, NSDUH

	(1)	(2)	(3)	(4)
	Age 18-25		**Age 26+**	
	Panel I: Marijuana Use, 2002-2019 [N = 867]			
RML	0.035***	0.017	0.036***	0.015*
	(0.007)	(0.013)	(0.005)	(0.006)
Pre-Treatment Mean DV	[0.20]	[0.207]	[0.063]	[0.063]
	Panel II: Cocaine Use, 2002-2019 [N = 867]			
RML	0.0013	-0.0001	0.0014	0.0005
	(0.001)	(0.001)	(0.001)	(0.0011)
Pre-Treatment Mean DV	[0.063]	[0.063]	[0.016]	[0.016]
	Panel III: Binge Drinking[a], 2002-2019 [N = 816]			
RML	-0.004	-0.004	0.005	-0.002
	(0.007)	(0.006)	(0.005)	(0.003)
Pre-Treatment Mean DV	[0.40]	[0.40]	[0.21]	[0.21]
	Panel IV: Nonmedical Use of Pain Relievers[a], 2002-2019 [*N =816]*			
RML	-0.014***	0.0003	-0.0004	0.002
	(0.004)	(0.003)	(0.0009)	(0.001)
Pre-Treatment Mean DV	[0.112]	[0.112]	[0.037]	[0.037]
	Panel V: Methamphetamine Use, 2015-2019 *[N = 204]*			
RML	-0.001	0.0008	-0.001	0.0002
	(0.001)	(0.002)	(0.001)	(0.0017)
Pre-Treatment Mean DV	[0.009]	[0.009]	[0.007]	[0.007]
	Panel VI: Illicit Drug Use Other than Marijuana[a], 2002-2019 *[N = 816]*			
RML	-0.003	-0.0001	0.001	0.0016
	(0.003)	(0.003)	(0.0007)	(0.001)
Pre-Treatment Mean DV	[0.082]	[0.082]	[0.029]	[0.029]
State & Year FE?	Yes	Yes	Yes	Yes
Observable Controls?	Yes	Yes	Yes	Yes
State Linear Time Trends?	No	Yes	No	Yes

***p < .001 **p < .01 *p < .05

Notes: All regressions include state fixed effects, year fixed effects, and control for the number of law enforcement agencies reporting arrests. Observable Controls ate listed in Table 1A.

[a]The binge drinking, pain reliever misuse, and illicit drug use other than marijuana measures are missing in the publicly available 2014-15 NSDUH state summary tables.

Appendix Table 4. Sensitivity of Estimates in Table 2 to Use of Log (Arrest Rate) Specification, UCR, 2000-2019

	(1)	(2)	(3)
	Panel I: Drug Arrests [Pre-Treatment Mean Log DV = 1.735]		
RML	-0.355*	-0.348**	-0.480**
	(0.135)	(0.108)	(0.119)
	Panel II: Violent Arrests [Pre-Treatment Mean Log DV = 0.878]		
RML	0.073	0.112	-0.107
	(0.067)	(0.073)	(0.092)
	Panel III: Property Arrests [Pre-Treatment Mean Log DV = 1.419]		
RML	0.007	0.078	0.050
	(0.063)	(0.076)	(0.097)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	998	998	998

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 5. Sensitivity of Mortality Results in Table 6 to Use of a Poisson Regression Model, NVSS Mortality Files, 2000-2019

	(1)	(2)	(3)
	Panel I: Cocaine Deaths [Pre-Treat Mean = 225.97]		
RML	-0.109	-0.184	-0.107
	(0.155)	(0.137)	(0.115)
	Panel II: Methamphetamine Deaths [Pre-Treat Mean = 330.13]		
RML	-0.255*	-0.184*	-0.073
	(0.104)	(0.087)	(0.063)
	Panel III: Heroin Deaths [Pre-Treat Mean = 251.87]		
RML	-0.227	-0.268*	-0.137
	(0.174)	(0.109)	(0.149)
	Panel IV: Fentanyl Deaths [Pre-Treat Mean = 130.23]		
RML	-0.297	-0.434**	-0.418***
	(0.169)	(0.129)	(0.108)
	Panel V: Other Opioid Deaths [Pre-Treat Mean = 823.43]		
RML	-0.204*	-0.144*	-0.019
	(0.082)	(0.070)	(0.077)
	Panel VI: Alcohol Deaths [Pre-Treat Mean = 2358.85]		
RML	-0.063***	-0.007	-0.003
	(0.018)	(0.020)	(0.020)
	Panel VII: Suicides [Pre-Treat Mean = 2145.04]		
RML	-0.058***	-0.029	-0.008
	(0.013)	(0.019)	(0.012)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	1,020	1,020	1,020

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 6. Sensitivity of TEDS Estimates to Use of Primary, Secondary, or Tertiary Substance Admission Rate, 2000-2018

	(1)	(2)	(3)
	Panel I: Marijuana Admissions [Pre-Treat Mean = 2.36]		
RML	0.089	0.348	0.408
	(0.290)	(0.361)	(0.250)
	Panel II: Cocaine Admissions [Pre-Treat Mean = 1.71]		
RML	0.249	0.331	0.063
	(0.267)	(0.196)	(0.159)
	Panel III: Meth/Amphetamine Admissions [Pre-Treat Mean = 1.88]		
RML	0.589	0.766*	0.413
	(0.304)	(0.380)	(0.339)
	Panel IV: Heroin Admissions [Pre-Treat Mean = 2.06]		
RML	-0.113	0.133	0.481
	(0.405)	(0.471)	(0.467)
	Panel V: Other Opioids Admissions [Pre-Treat Mean 0.83]		
RML	-0.238	-0.218	-0.0032
	(0.174)	(0.213)	(0.208)
	Panel VI: Alcohol Admissions [Pre-Treat Mean = 4.87]		
RML	0.519	0.704	0.344
	(0.525)	(0.625)	(0.391)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	937	937	937

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 7. Sensitivity of TEDS Estimates to Controlling for Total Admissions Rate, 2000-2018

	(1)	(2)	(3)
	Panel I: Marijuana Admissions [Pre-Treat Mean = 0.72]		
RML	-0.119	-0.107	0.087
	(0.083)	(0.097)	(0.101)
	Panel II: Cocaine Admissions [Pre-Treat Mean = 0.66]		
RML	0.148	0.177	0.023
	(0.114)	(0.104)	(0.087)
	Panel III: Meth/Amphetamine Admissions [Pre-Treat Mean = 1.31]		
RML	0.187	0.262	0.140
	(0.193)	(0.236)	(0.119)
	Panel IV: Heroin Admissions [Pre-Treat Mean = 1.82]		
RML	-0.307	-0.192	0.288
	(0.314)	(0.384)	(0.318)
	Panel V: Other Opioids Admissions [Pre-Treat Mean 0.48]		
RML	-0.148	-0.214	-0.036
	(0.118)	(0.153)	(0.146)
	Panel VI: Alcohol Admissions [Pre-Treat Mean = 3.40]		
RML	0.132	0.034	-0.120
	(0.426)	(0.415)	(0.279)
State & Year FE?	Yes	Yes	Yes
Sociodemographic Controls?	Yes	Yes	Yes
Policy Controls?	No	Yes	Yes
State Linear Time Trends?	No	No	Yes
N	937	937	937

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 8. Sensitivity of Results to Treatment Date When Recreational Sales Allowed

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Marijuana Use	*Cocaine*	*Binge Drinking*	*Misuse Pain Relievers*	*Meth Use*	*Marijuana Arrests*	*Cocaine or Heroin Arrests*	*Violent Arrests*	*Property Arrests*
Recreational Sales Allowed	0.022*	-0.0006	-0.002	0.0018	0.002	-0.430	-0.280	-0.110	0.432
	(0.009)	(0.0022)	(0.004)	(0.001)	(0.002)	(0.295)	(0.178)	(0.086)	(0.355)
N	867	867	816	(4)	(5)	998	998	998	998
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	Marijuana Admissions	*Cocaine Admissions*	*Amphetamine Admissions*	*Alcohol Admissions*	*Heroin Admissions*	*Other Opioid Admissions*	*Other Drug Admissions*	*Cocaine Deaths*	*Meth Deaths*
Recreational Sales Allowed	0.139	0.058	0.191	0.067	0.425	0.013	0.026	-0.324	0.627
	(0.093)	(0.078)	(0.190)	(0.329)	(0.459)	(0.159)	(0.039)	(0.445)	(0.358)
N	937	937	937	937	937	937	937	1,020	1,020
	(19)	(20)	(21)	(22)	(23)				
	Heroin Deaths	*Fentanyl Deaths*	*Other Opioid Deaths*	*Alcohol Deaths*	*Suicides*				
Recreational Sales Allowed	0.468	-2.318	-0.346	-0.296	0.114				
	(0.915)	(1.406)	(0.904)	(0.400)	(0.179)				
N	1,020	1,020	1,020	1,020	1,020				

***p < .001 **p < .01 *p < .05

Notes: Sociodemographic and policy controls are listed in the notes to Table 1A and state-specific linear time trends. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Table 9. Sensitivity of Estimated Effects of RMLs to Border State RML Policy

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Marijuana Use	*Cocaine*	*Binge Drinking*	*Misuse Pain Relievers*	*Meth Use*	*Marijuana Arrests*	*Cocaine or Heroin Arrests*	*Violent Arrests*	*Property Arrests*
RML	0.012*	-0.001	-0.005	0.002	-0.0005	-1.730***	-0.475*	-0.141	0.531
	(0.008)	(0.001)	(0.006)	(0.002)	(0.001)	(0.262)	(0.198)	(0.119)	(0.448)
BorderRML	0.0006	-0.0006	0.0008	-0.003*	-0.0004	-0.047	0.164	0.009	0.143
	(0.003)	(.0009)	(0.004)	(0.001)	(0.001)	(0.234)	(0.125)	(0.071)	(0.158)
RML*BorderRML	0.007	0.0017	0.005	0.001	0.0009	0.175	-0.161	-0.105	-0.560
	(0.010)	(0.001)	(0.007)	(0.002)	(0.001)	(0.313)	(0.225)	(0.110)	(0.447)
N	867	867	816	816	204	998	998	998	998
	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
	Marijuana Admissions	*Cocaine Admissions*	*Amphetamine Admissions*	*Alcohol Admissions*	*Heroin Admissions*	*Other Opioid Admissions*	*Other Drug Admissions*	*Cocaine Deaths*	*Meth Deaths*
RML	0.066	0.089	-0.105	-0.471	0.099	-0.051	0.014	0.626	-0.230
	(0.088)	(0.102)	(0.161)	(0.445)	(0.340)	(0.228)	(0.042)	(0.690)	(0.401)
BorderRML	-0.090	0.080*	-0.186	0.299	0.427	0.187	0.077	-0.048	0.078
	(0.060)	(0.035)	(0.096)	(0.328)	(0.380)	(0.109)	(0.049)	(0.429)	(0.383)
RML*BorderRML	0.155	-0.062	0.637*	1.19*	0.737	0.151	0.029	-1.104	0.040
	(0.136)	(0.099)	(0.240)	(0.525)	(0.499)	(0.170)	(0.055)	(0.753)	(0.566)
N	937	937	937	937	937	937	937	1,020	1,020

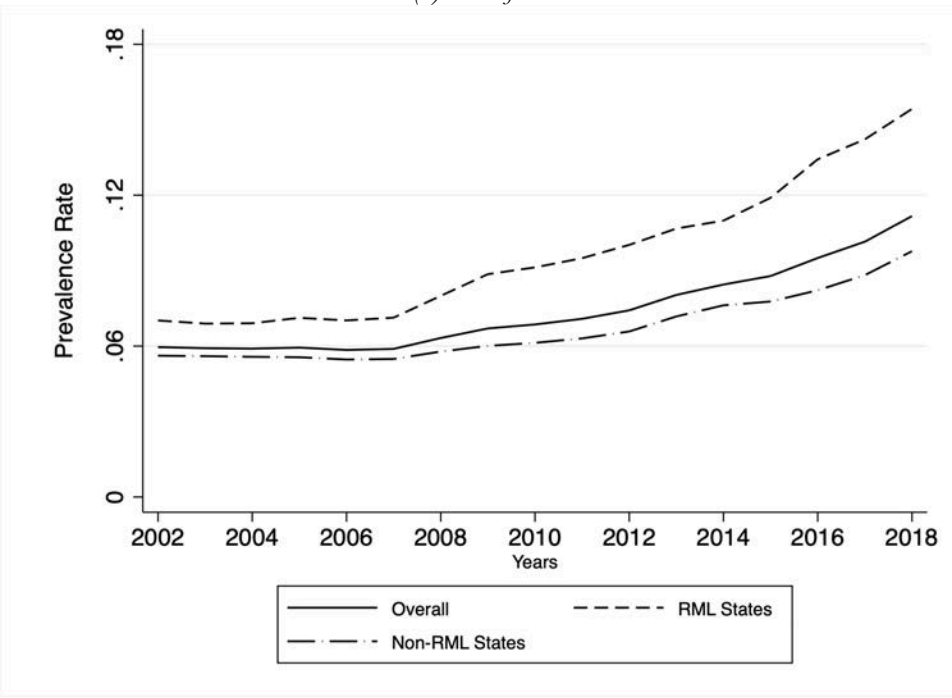
	(19)	(20)	(21)	(22)	(23)
	Heroin Deaths	*Fentanyl Deaths*	*Other Opioid Deaths*	*Alcohol Deaths*	*Suicides*
RML	-1.270	0.875	-1.173	0.841	0.011
	(0.936)	(1.679)	(0.587)	(0.486)	(0.221)
BorderRML	-1.626*	0.548	-0.833	-0.248	-0.415
	(0.784)	(1.140)	(0.757)	(0.251)	(0.222)
RML*BorderRML	1.208	-4.316	0.142	-1.135	-0.030
	(1.158)	(1.688)	(0.937)	(0.590)	(0.283)
N	1,020	1,020	1,020	1,020	1,020

***p < .001 **p < .01 *p < .05

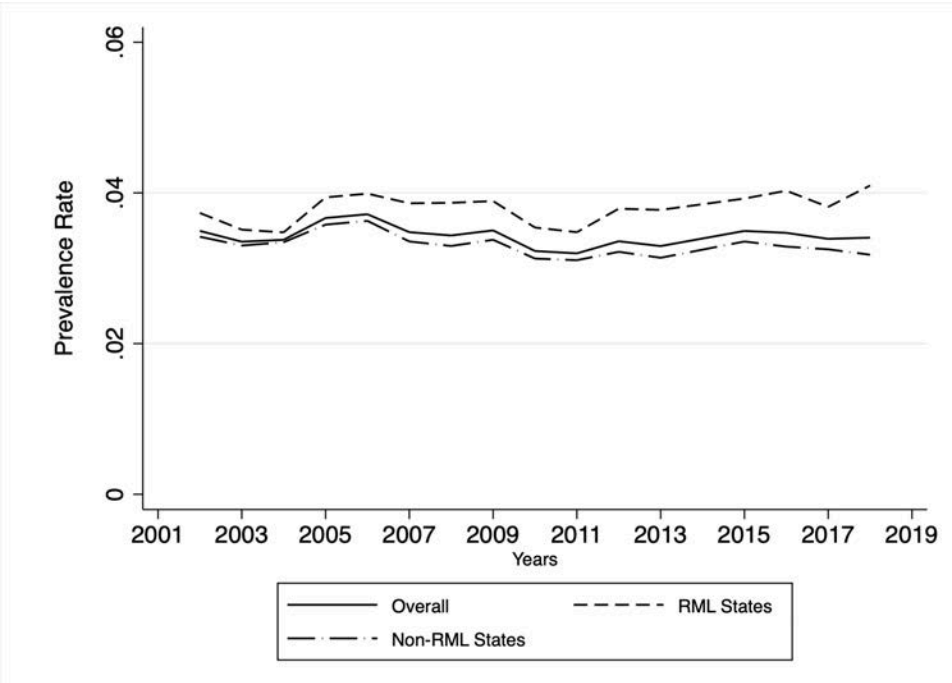
Notes: Sociodemographic and policy controls are listed in the notes to Table 1A and state-specific linear time trends. Regressions are weighted using the adult state population and standard errors are clustered at the state level.

Appendix Figure 1. Trends in Adult Substance Use Prevalence, NSUDH, 2002-2018

Panel (a): Marijuana Use

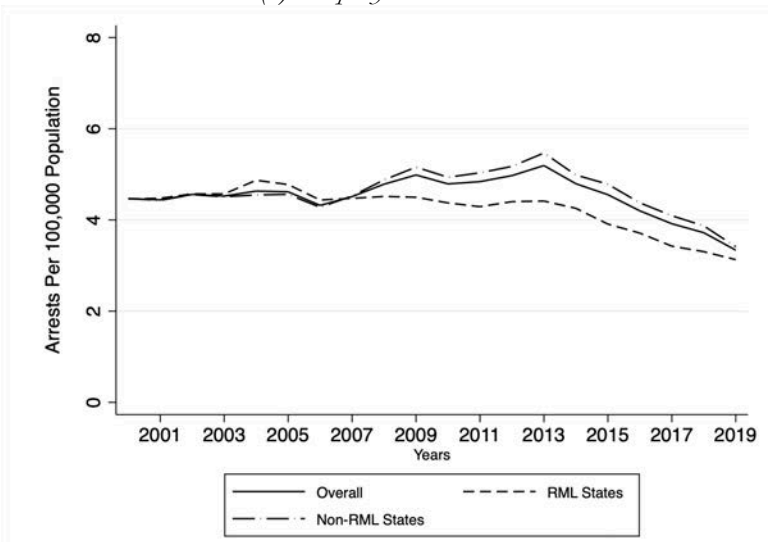


Panel (b): Illicit Drug Use Other than Marijuana

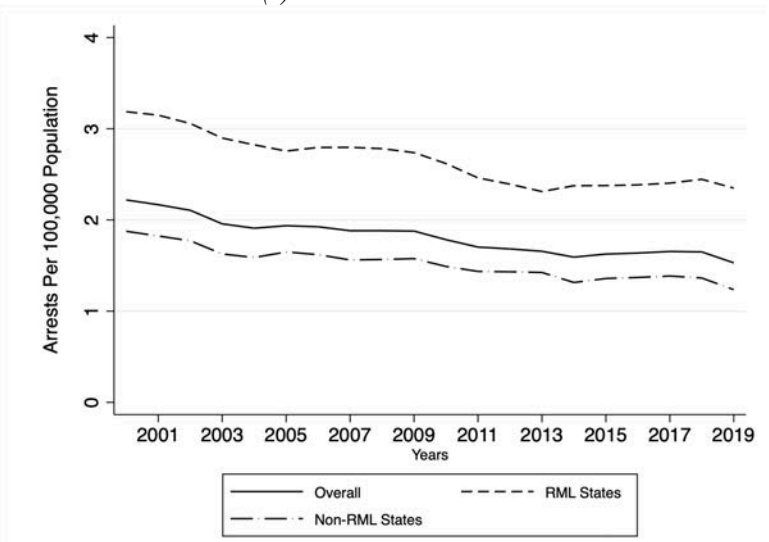


Appendix Figure 2. Trends in Adult Arrest Rate (Per 1,000 Population), UCR, 2000-2019

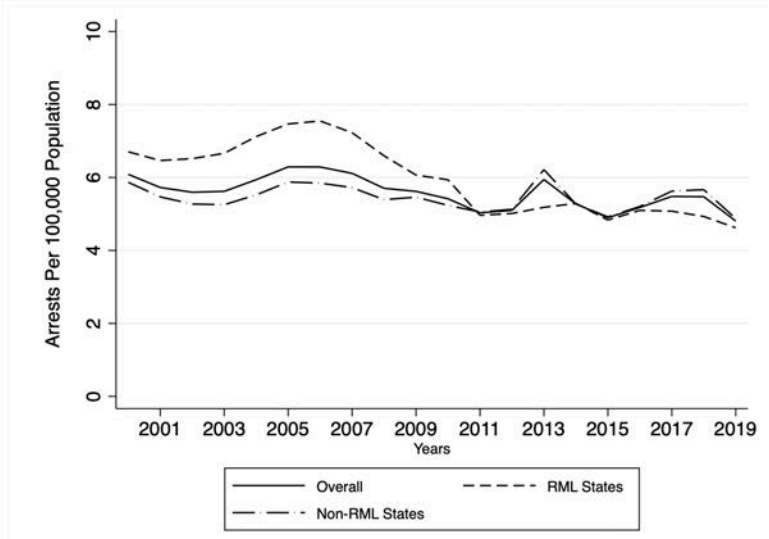
Panel (a): Property Crime Arrest Rate



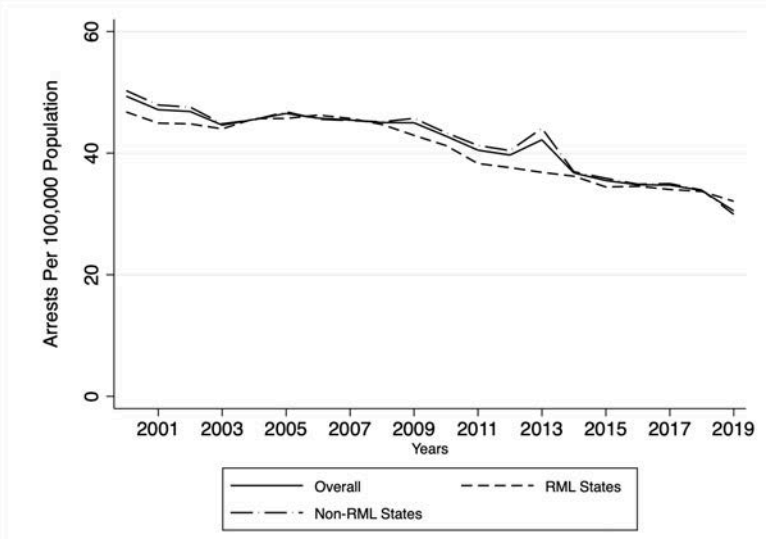
Panel (b): Violent Crime Arrest Rate



Panel (c): Drug-Related Crime Arrest Rate

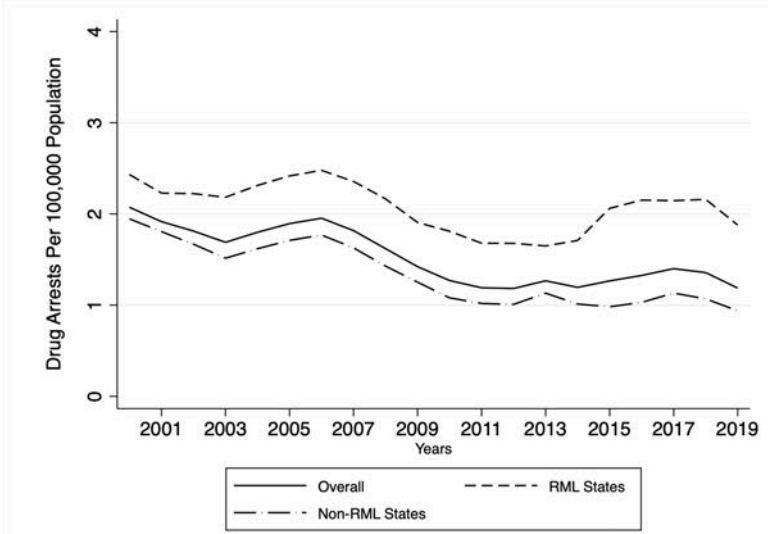


Panel (d): Total Part I Arrest Rate

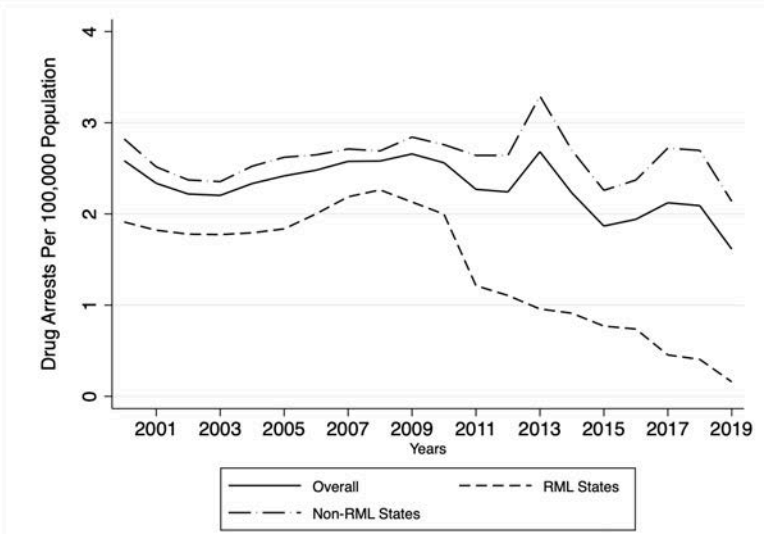


Appendix Figure 3. Trends in Adult Drug Possession Arrest Rate (Per 1,000 Population), UCR, 2000-2019

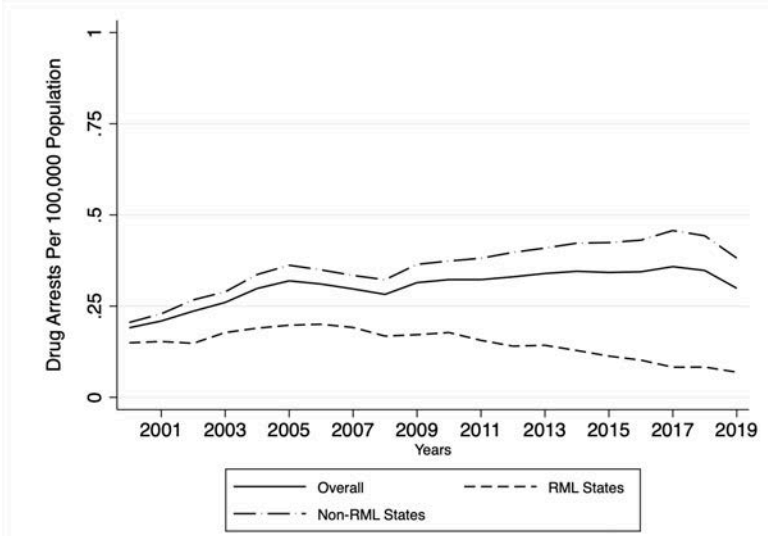
Panel (b): Cocaine/Heroin Possession Arrest Rate



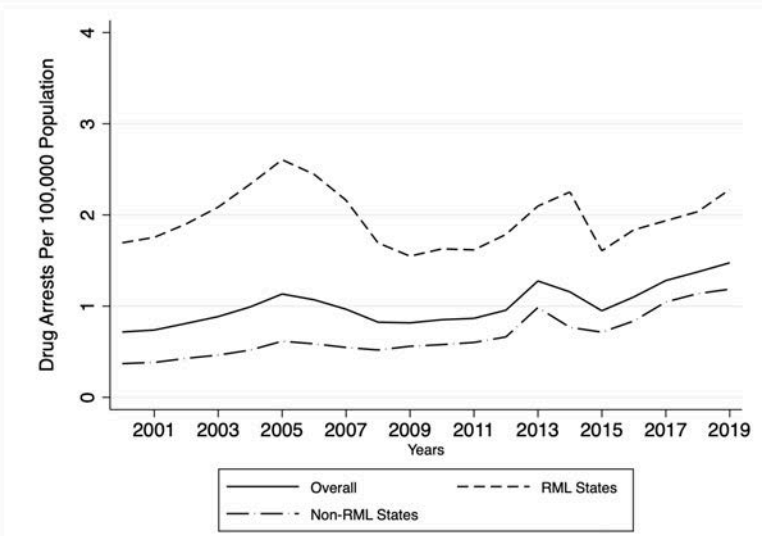
Panel (a): Marijuana Possession Arrest Rate



Panel (c): Synthetic Narcotics Possession Arrest Rate

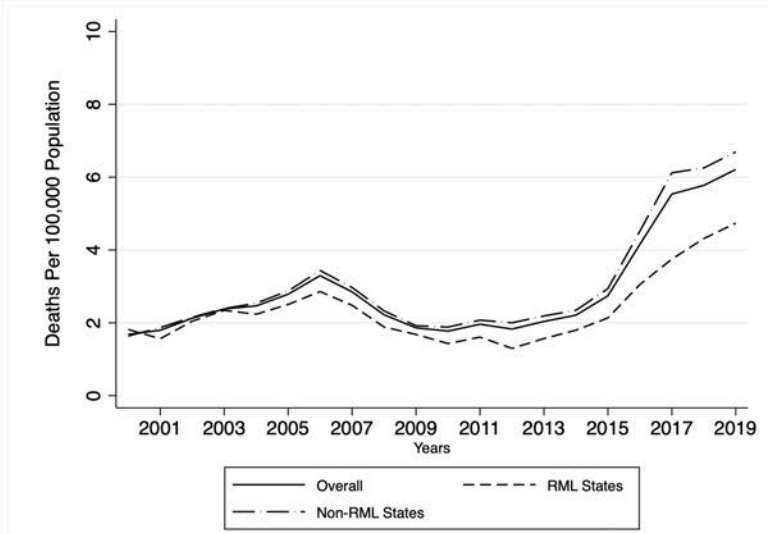


Panel (d): Other Dangerous Non-Narcotics Arrest Rate

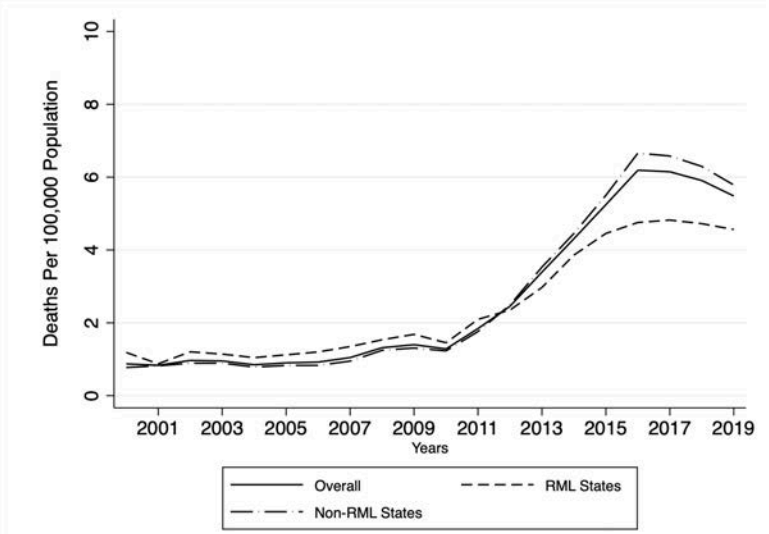


Appendix Figure 4. Trends in Substance Use-Involved Mortality Rate (Per 100,000 Population), NVSS, 2000-2019

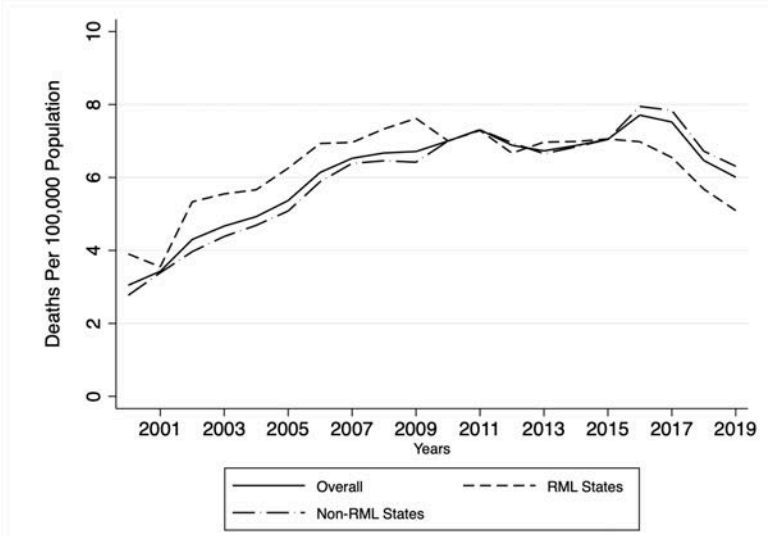
Panel (a): Cocaine-Involved Mortality Rate



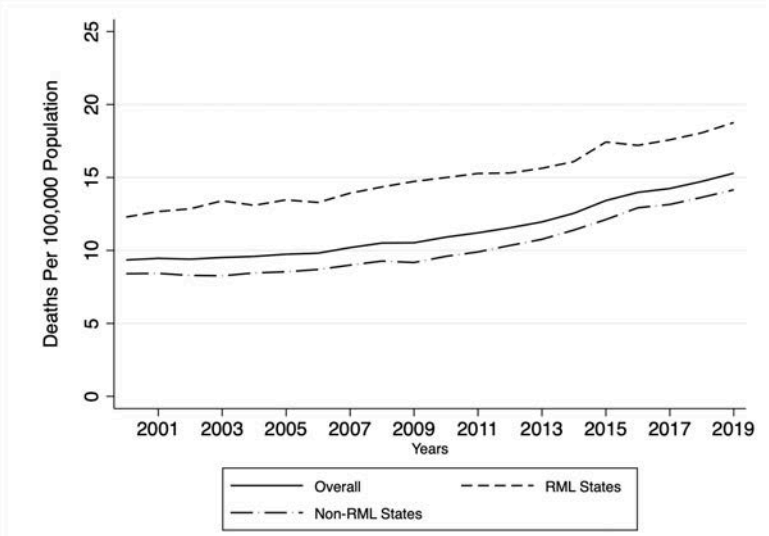
Panel (b): Heroin-Involved Mortality Rate



Panel (c): Other Opioid-Involved Mortality Rate

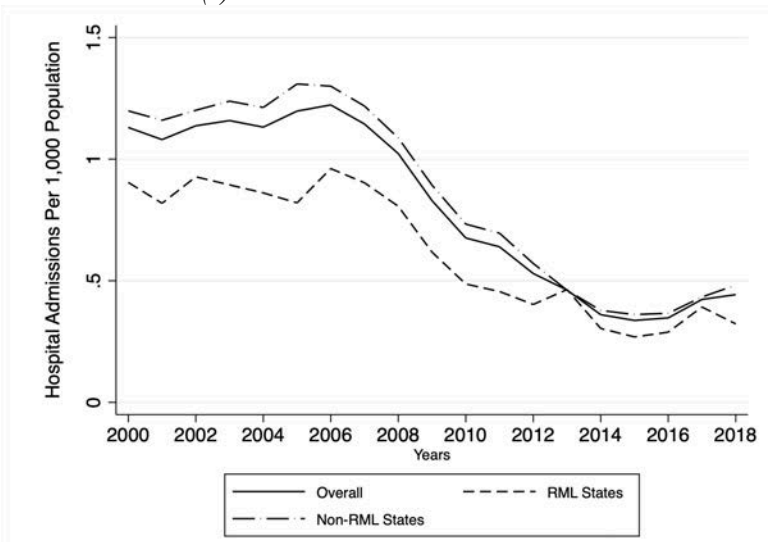


Panel (d): Alcohol-Involved Mortality Rate

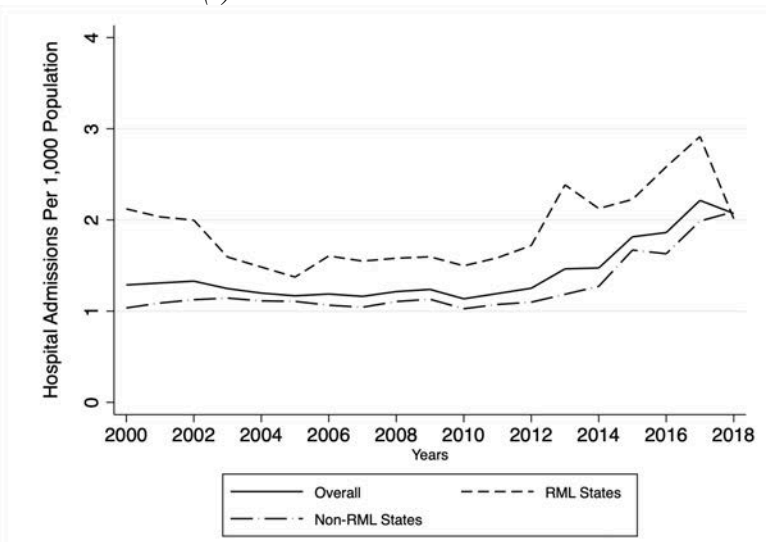


Appendix Figure 5. Trends in Substance Use Treatment Admissions Rate (Per 1,000 Population), TEDS, 2000-2018

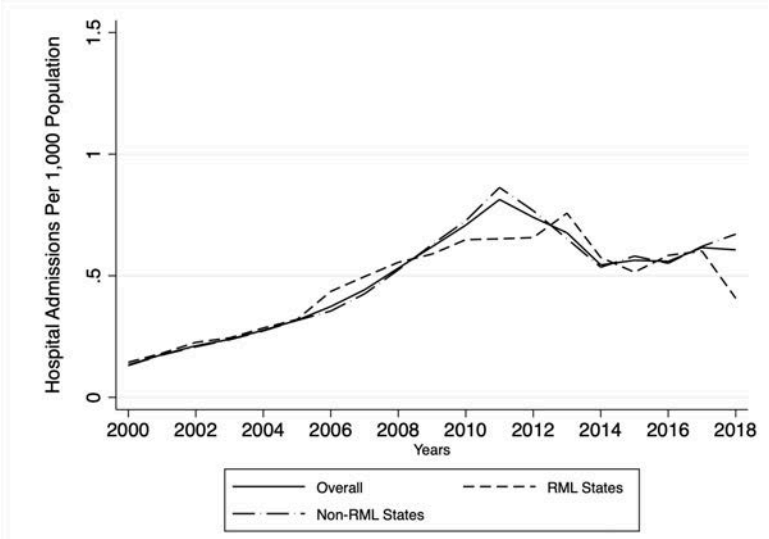
Panel (a): Cocaine-Involved Treatment Admissions



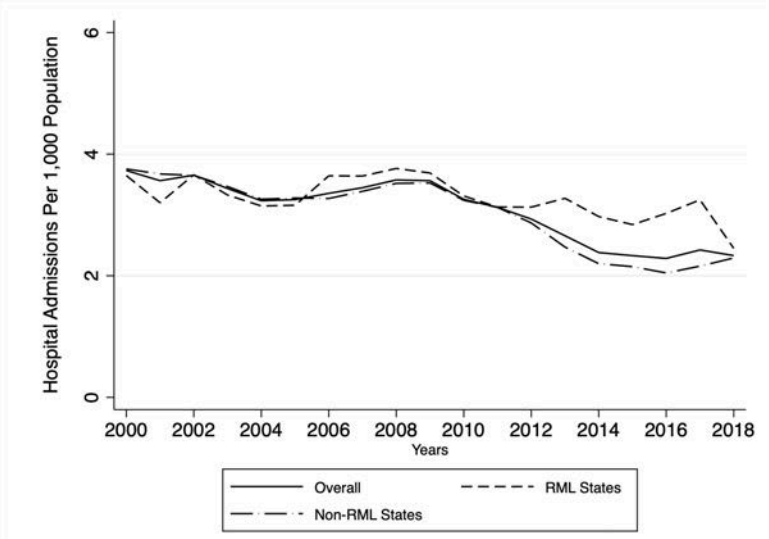
Panel (b): Heroin-Involved Treatment Admissions



Panel (c): Other Opioid-Involved Treatment Admissions

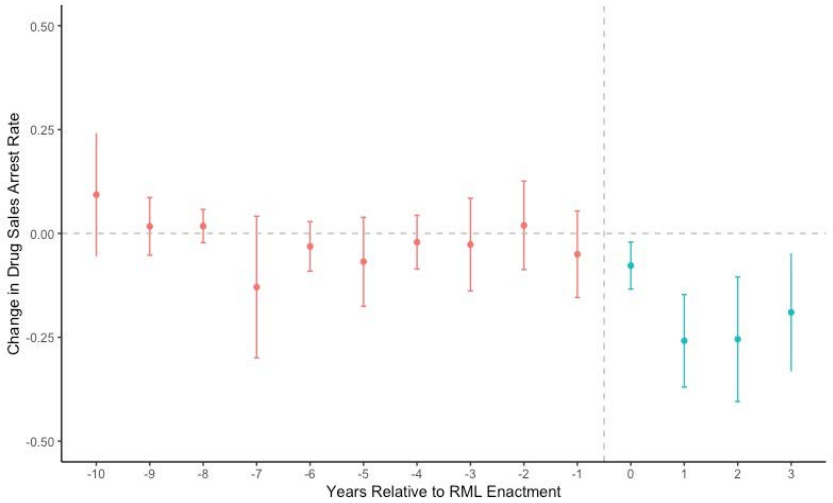


Panel (d): Alcohol-Involved Admissions

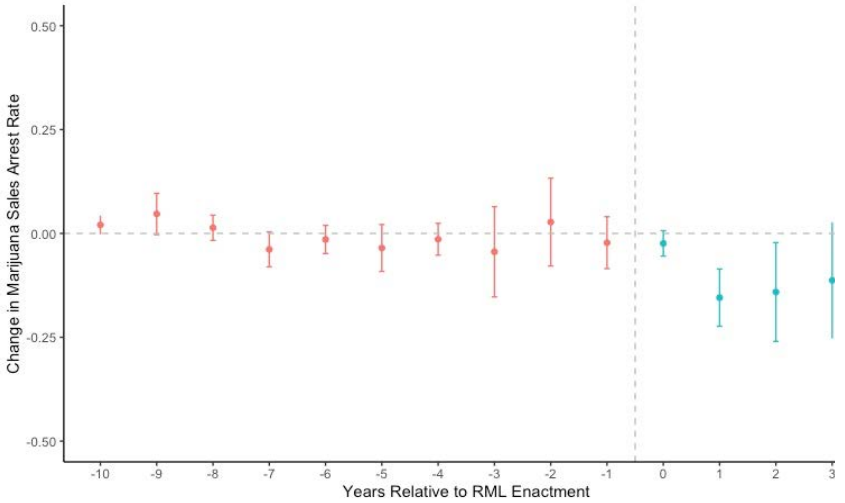


Appendix Figure 6. Callaway-Sant'Anna (2021) Event-Study Analyses of Adult Drug Sales Arrest Rates

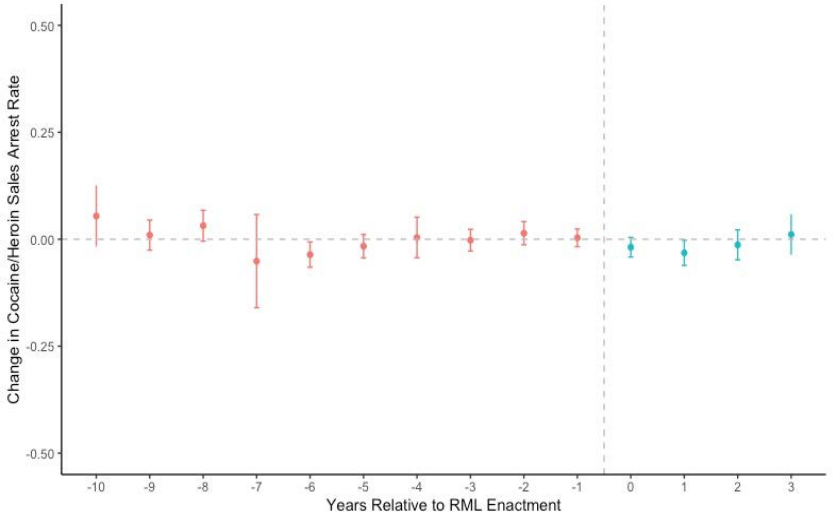
Panel (a): Drug Sales Arrests



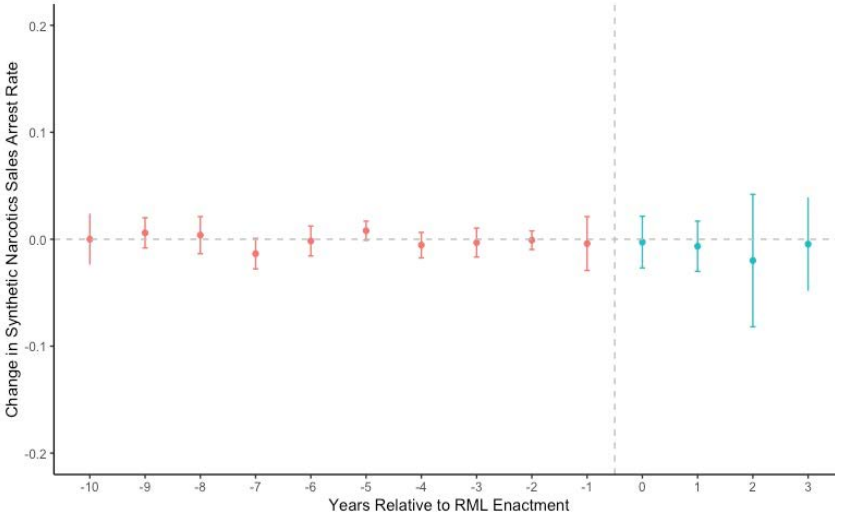
Panel (b): Marijuana Sales Arrests



Panel (c): Cocaine/Heroin Sales Arrests

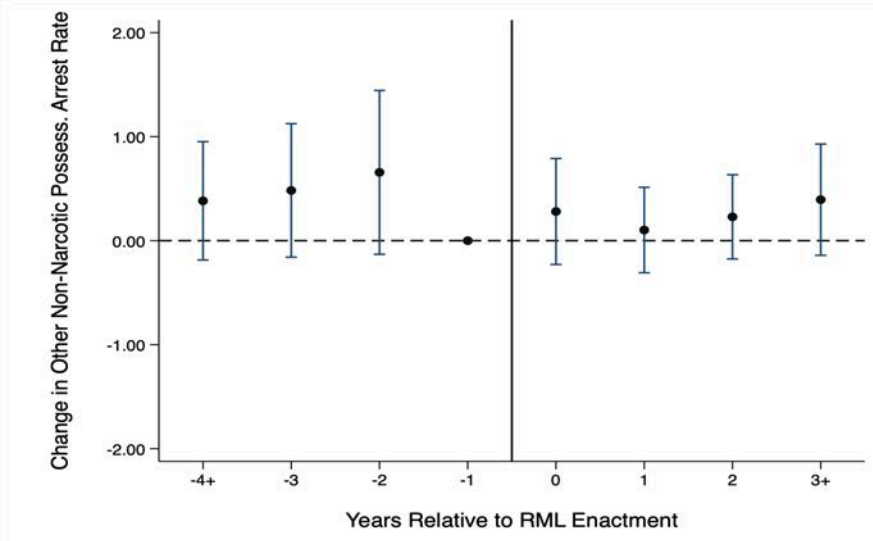


Panel (d): Synthetic Narcotics Sales Arrests

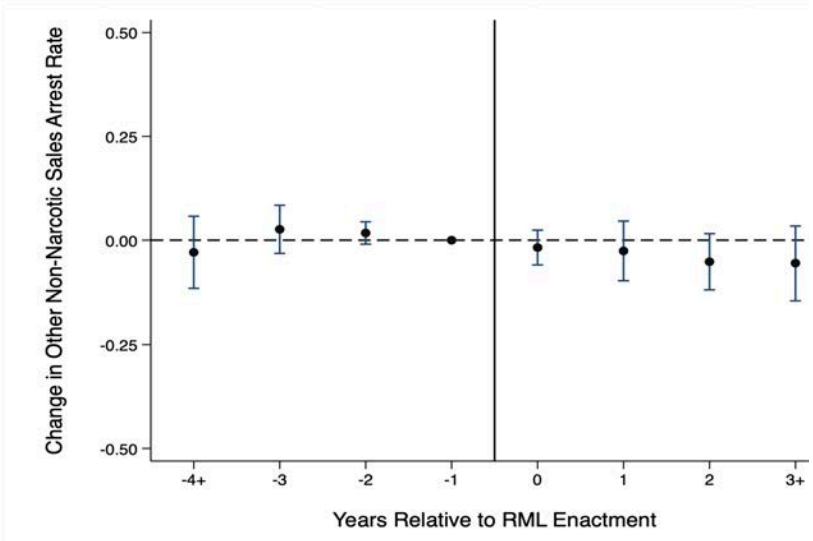


Appendix Figure 7. Event-Study Analyses of Arrests Due to Other Dangerous Non-Narcotics

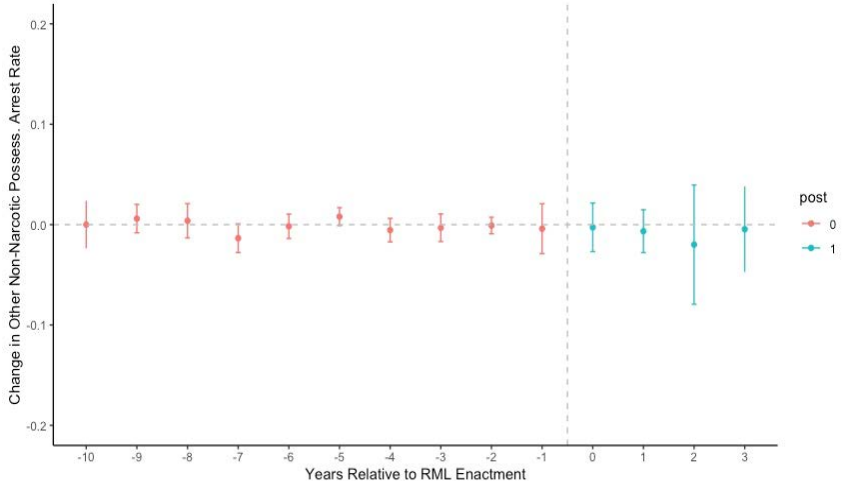
Panel (a): TWFE, Other Non-Narcotic Possession Arrests



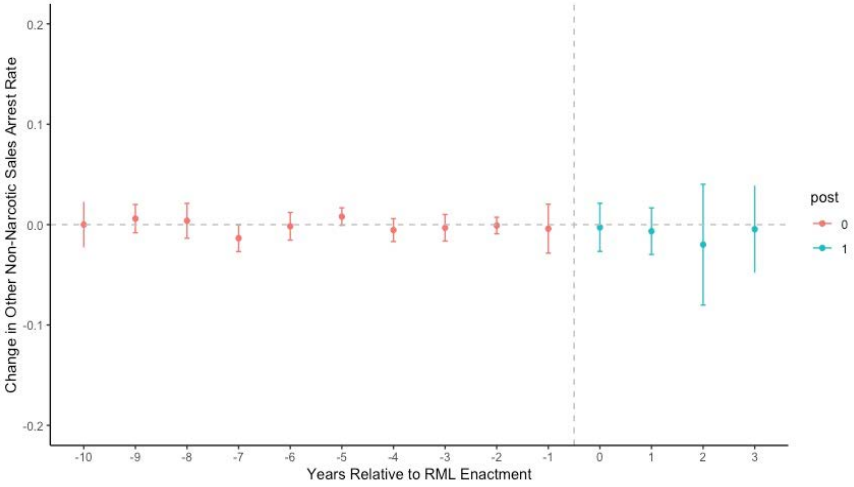
Panel (b): TWFE, Other Non-Narcotic Sales Arrests



Panel (c): CS, Other Non-Narcotic Possession Arrests

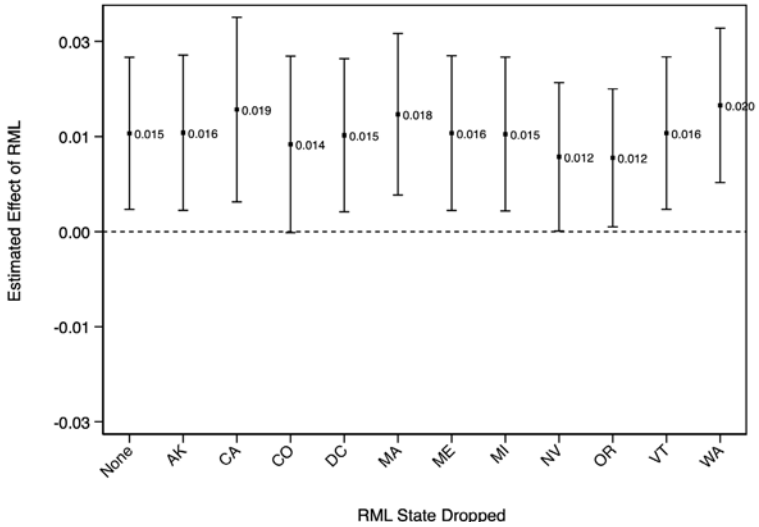


Panel (d): CS, Other Non-Narcotic Sales Arrests

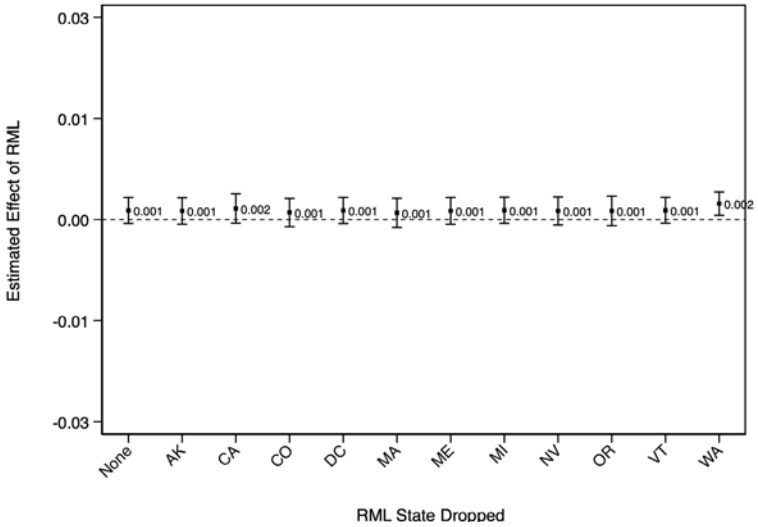


Appendix Figure 8: Sensitivity of Estimated Effects of RML by One-at-a-Time Exclusion of Each Treatment State

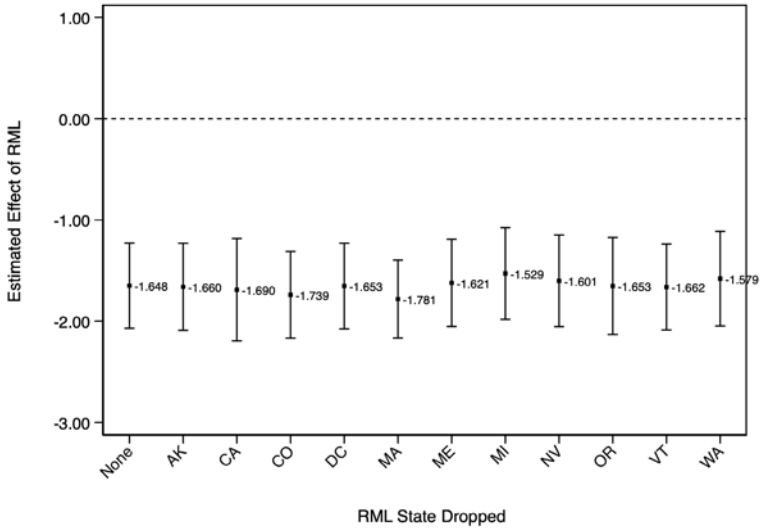
Panel (a): Marijuana Use, NSUDH



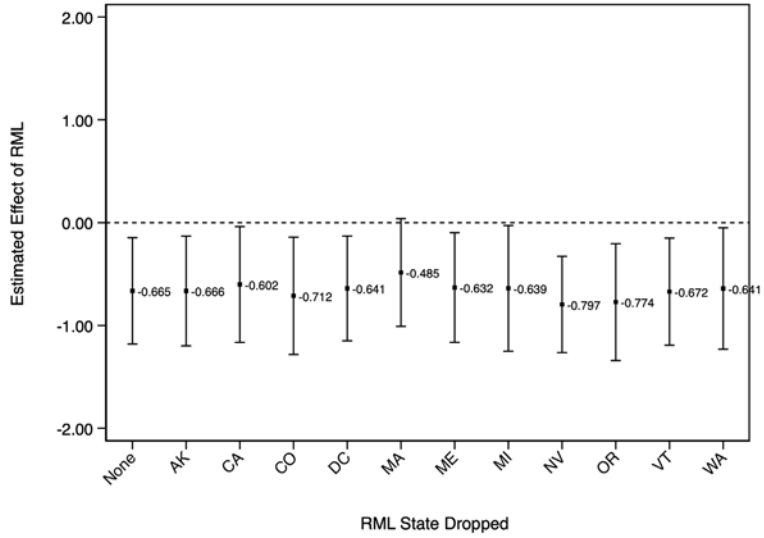
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH



Panel (c): Marijuana Arrests, UCR

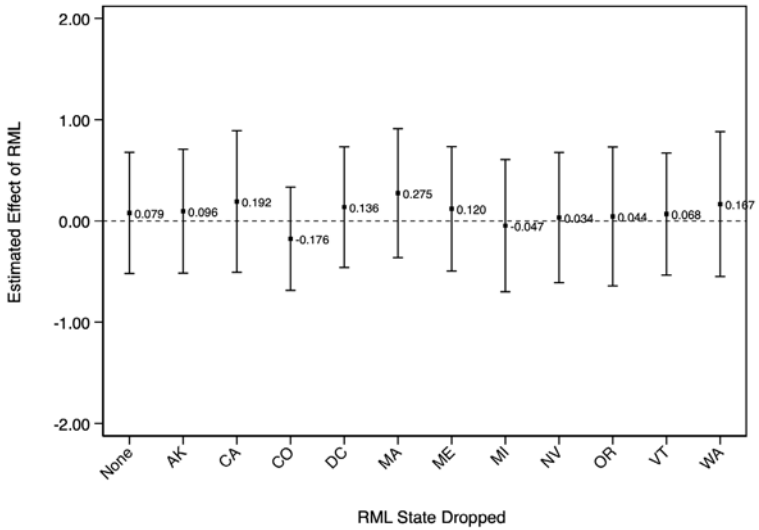


Panel (d): Non-Marijuana Drug Arrests, UCR

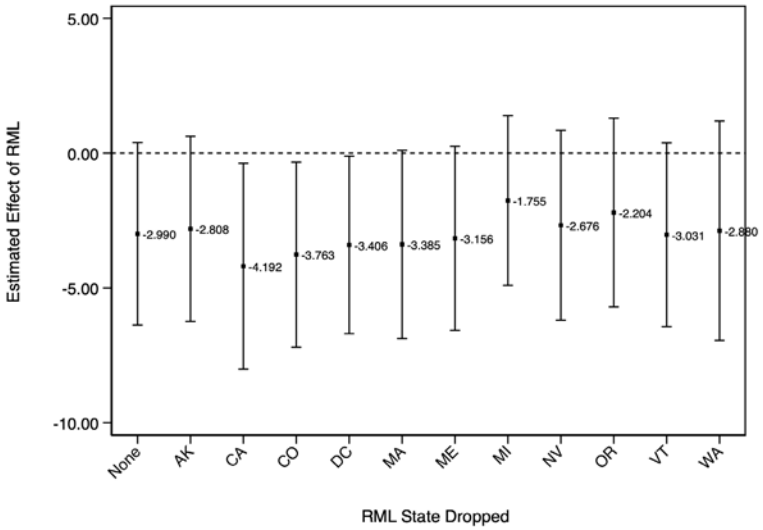


Appendix Figure 8, Continued

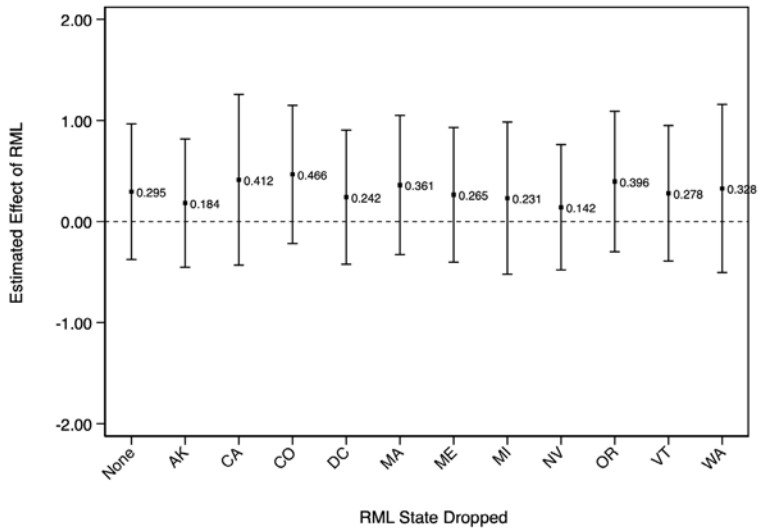
Panel (e): Part I Offense Arrests, UCR



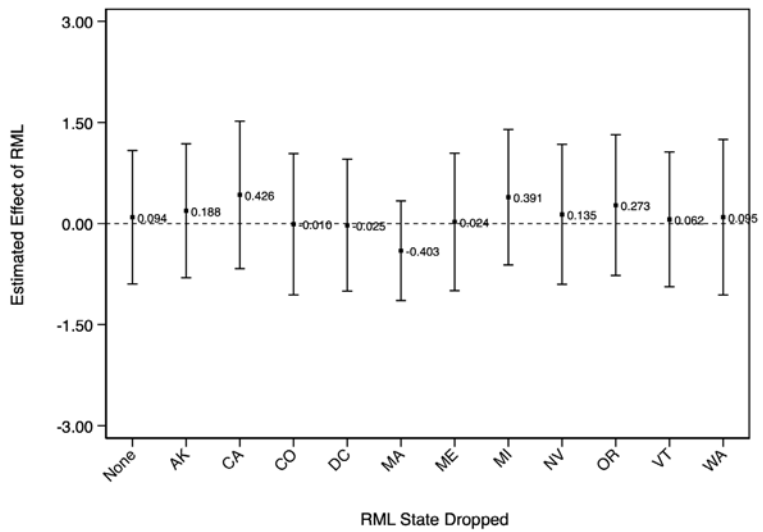
Panel (f): Opioid-Related Deaths, NVSS



Panel (g): Alcohol-Related Deaths, NVSS

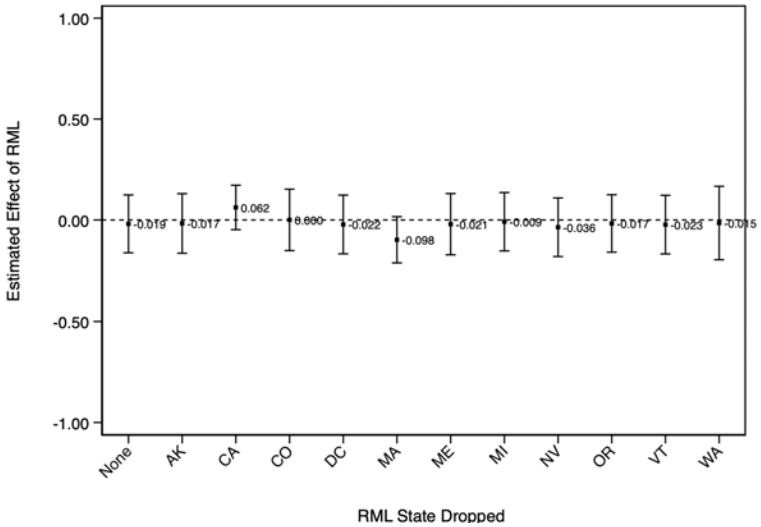


Panel (h): Cocaine-Related Deaths, NVSS

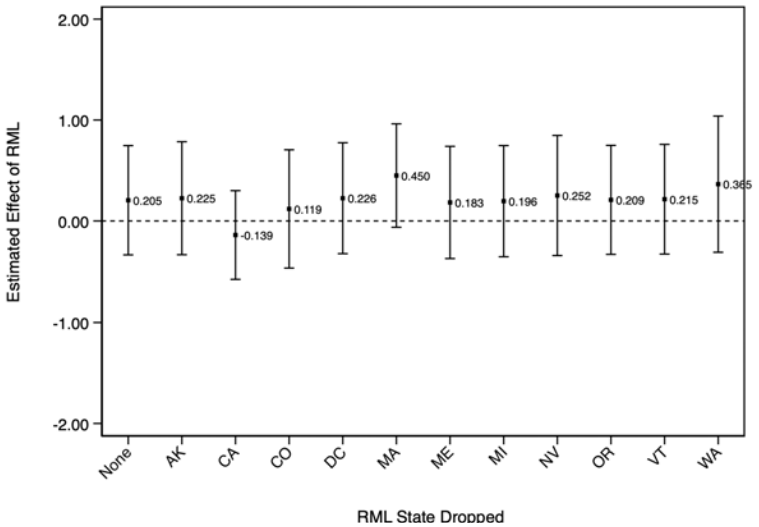


Appendix Figure 8, Continued

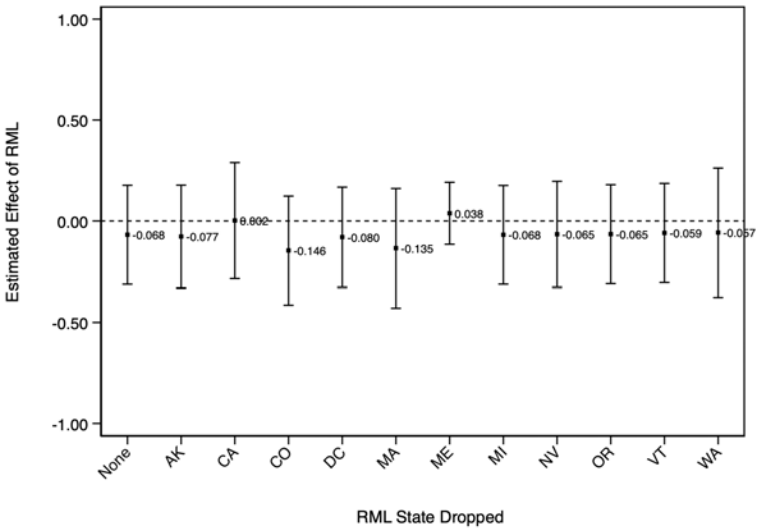
Panel (i): Cocaine Admissions, TEDS



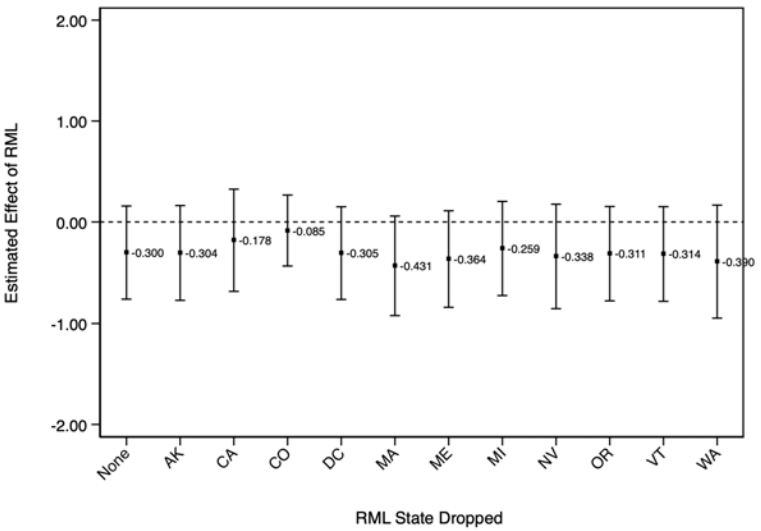
Panel (j): Heroin Admissions, TEDS



Panel (k): Other Opioid Admissions, TEDS

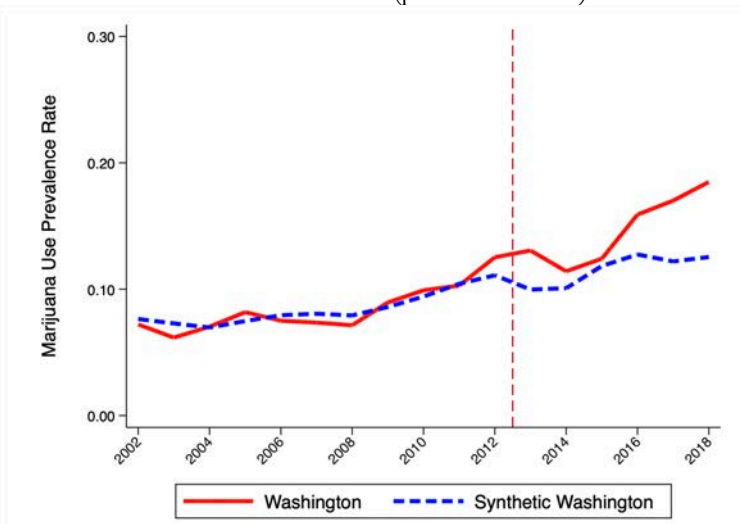


Panel (l): Alcohol Admissions, TEDS

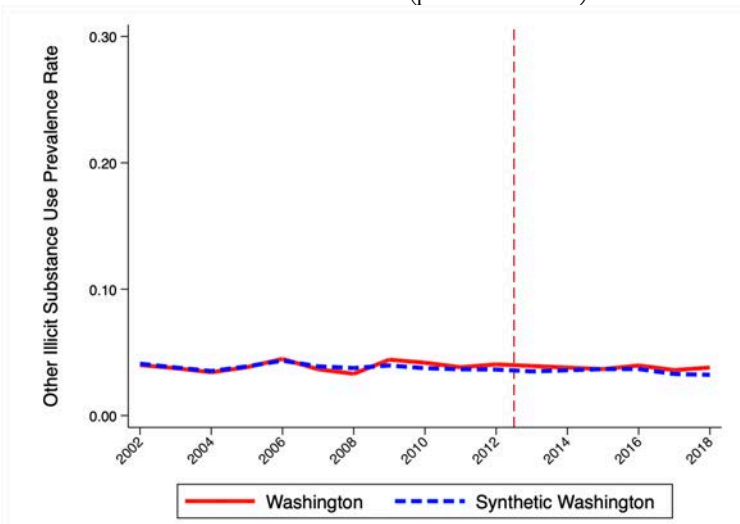


Appendix Figure 9. Synthetic Control Estimates for Washington

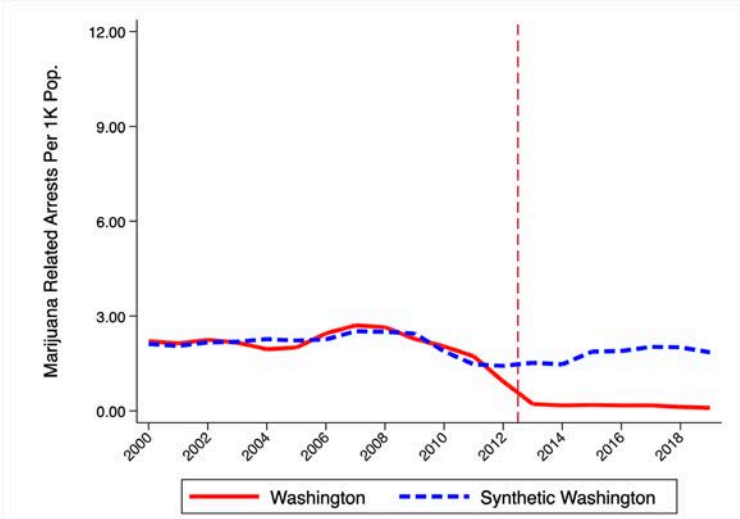
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.032 (p-value = 0.192)



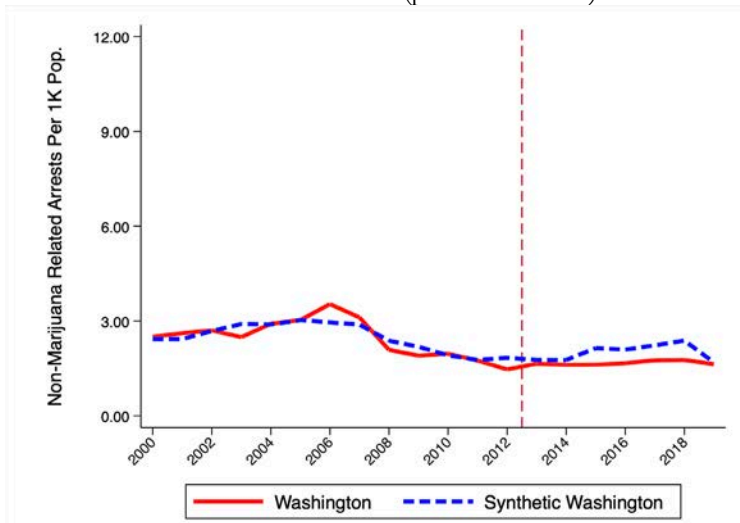
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.0001 (p-value = .654)



Panel (c): Marijuana Arrests, UCR
RML Effect = -1.643 (p-value = 0.231)

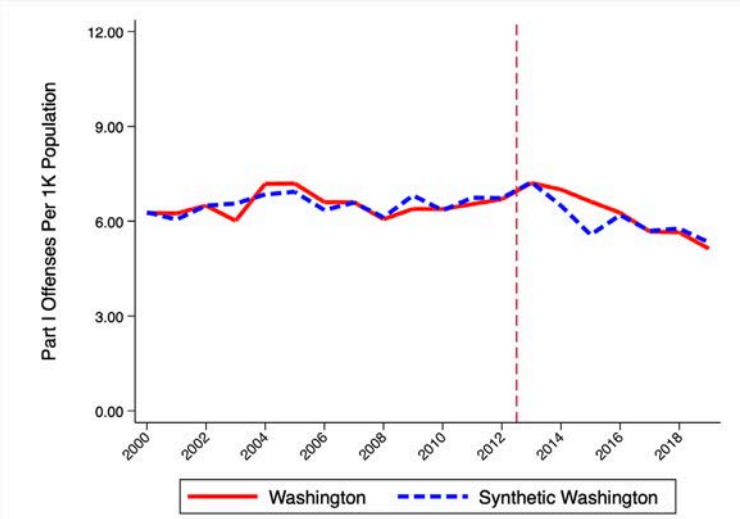


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = -0.339 (p-value = 0.800)

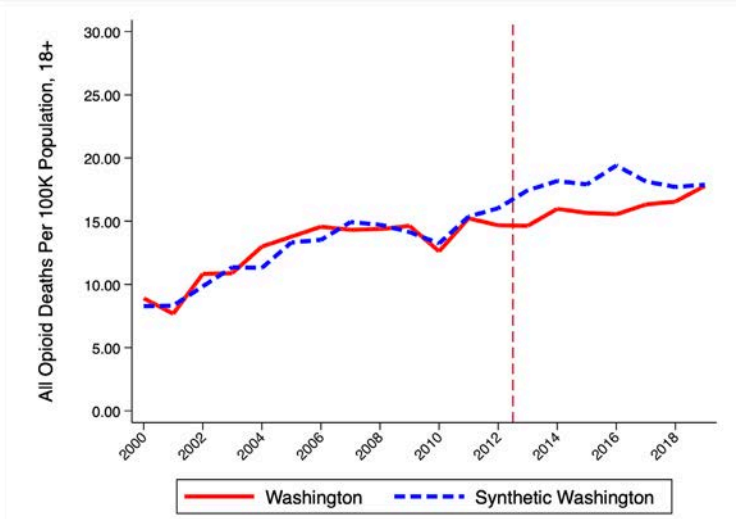


Appendix Figure 9, Continued

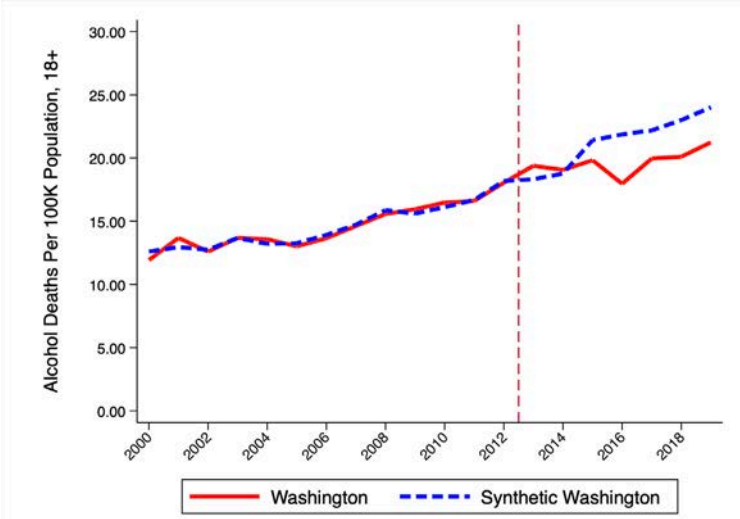
Panel (e): Part I Offense Arrests, UCR
RML Effect = 0.182 (p-value = 0.680)



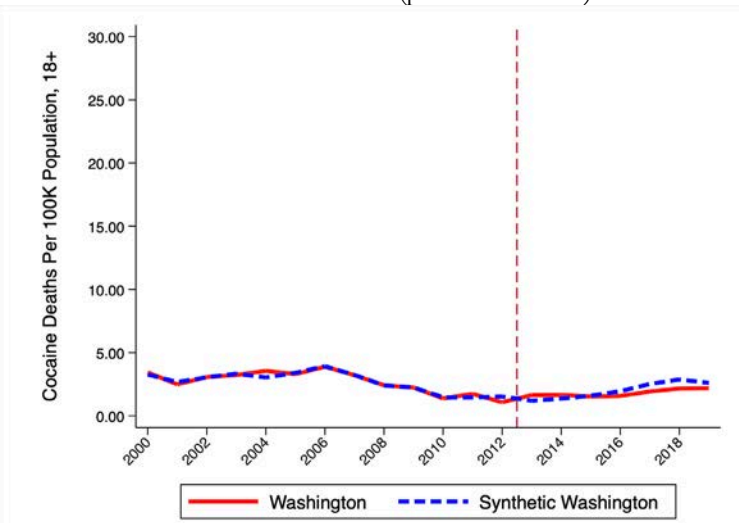
Panel (f): Opioid-Involved Deaths, NVSS
RML Effect = -2.031 (p-value = 0.846)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = -1.721 (p-value = 0.038)

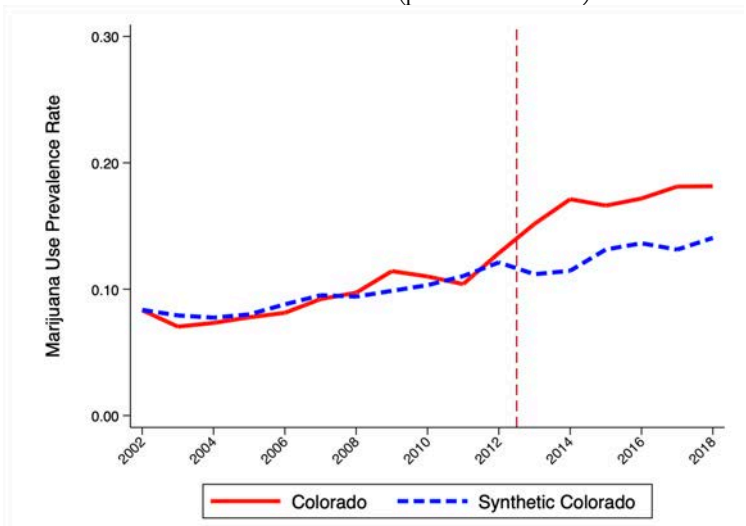


Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = -0.201 (p-value = 0.769)

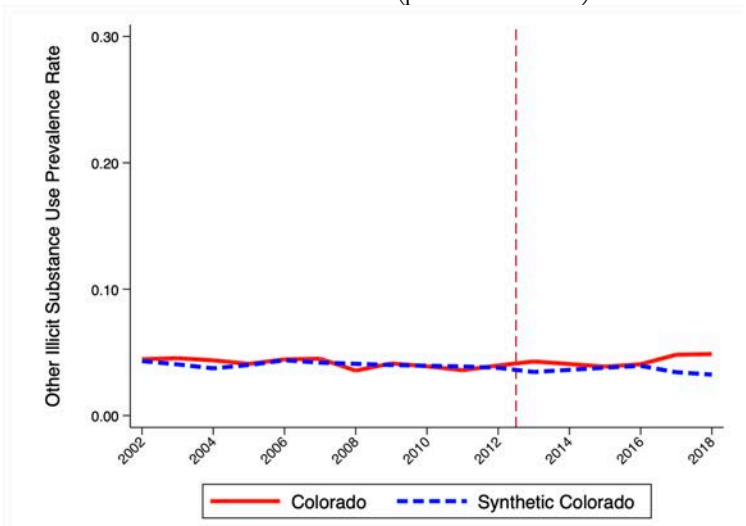


Appendix Figure 10. Synthetic Control Estimates for Colorado

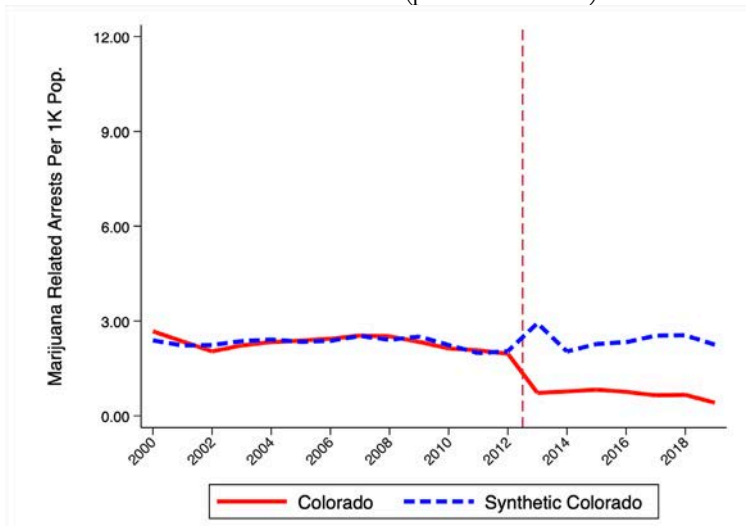
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.043 (p-value = 0.077)



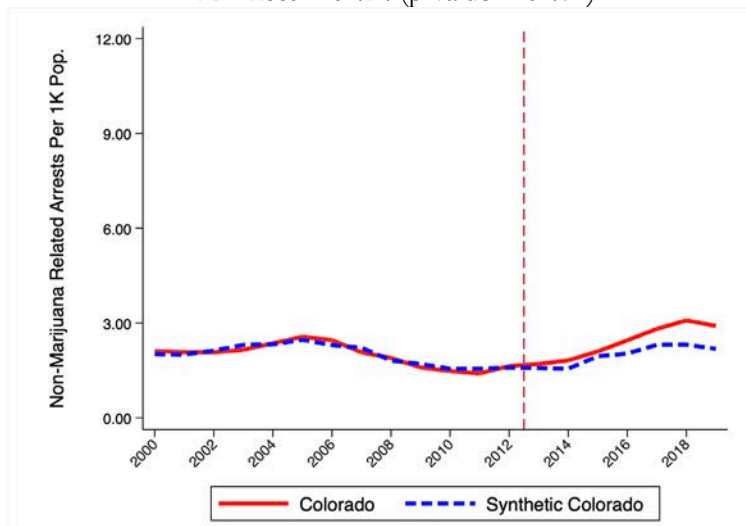
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.008 (p-value = 0.192)



Panel (c): Marijuana Arrests, UCR
RML Effect = -1.728 (p-value = 0.200)

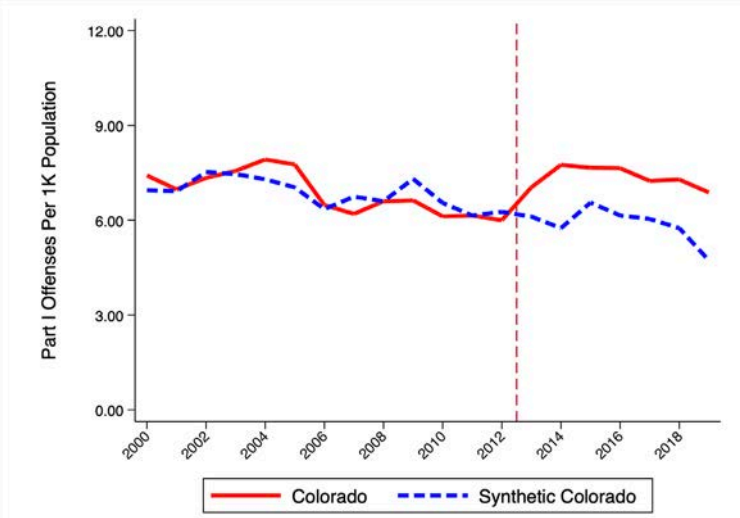


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = 0.424 (p-value = 0.471)

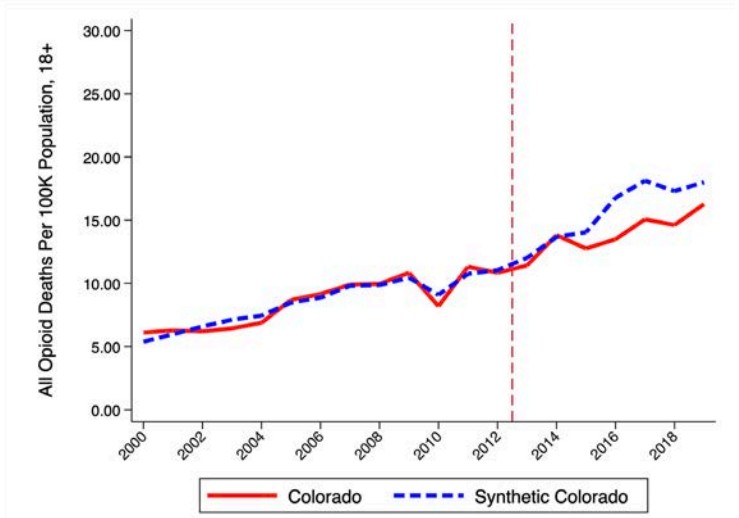


Appendix Figure 10, Continued

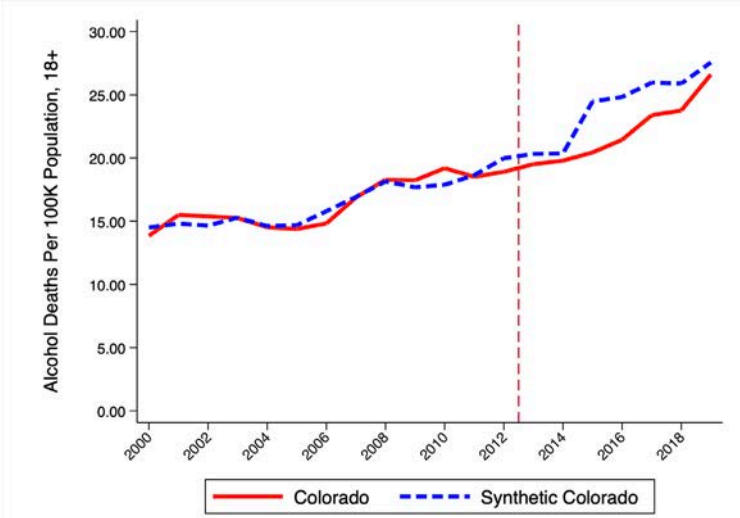
Panel (e): Part I Offense Arrests, UCR
RML Effect = 1.489 (p-value = 0.471)



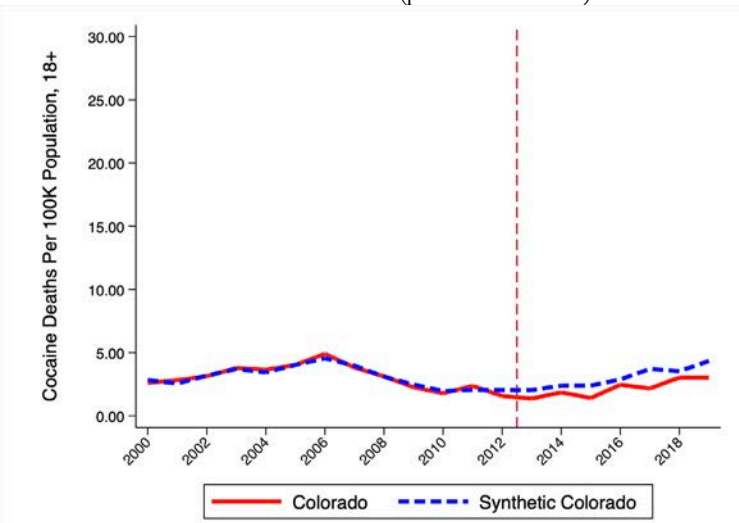
Panel (f): Opioid-Involved Deaths, NVSS
RML Effect = -1.783 (p-value = 0.769)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = -2.067 (p-value = 0.269)

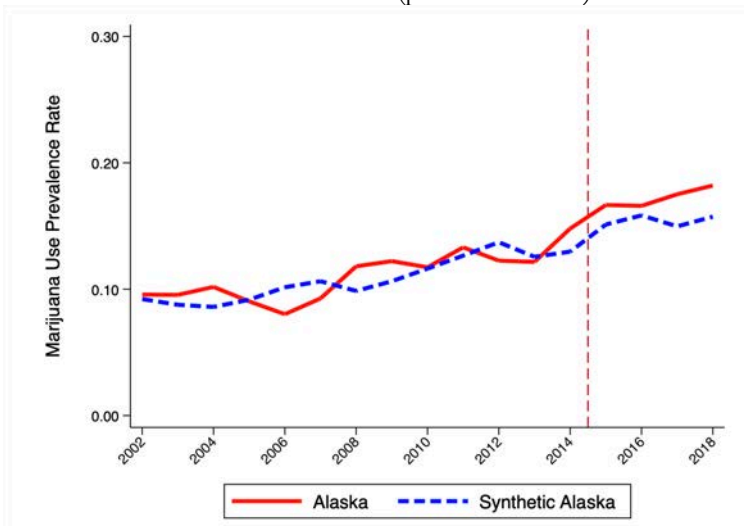


Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = -0.852 (p-value = 0.615)

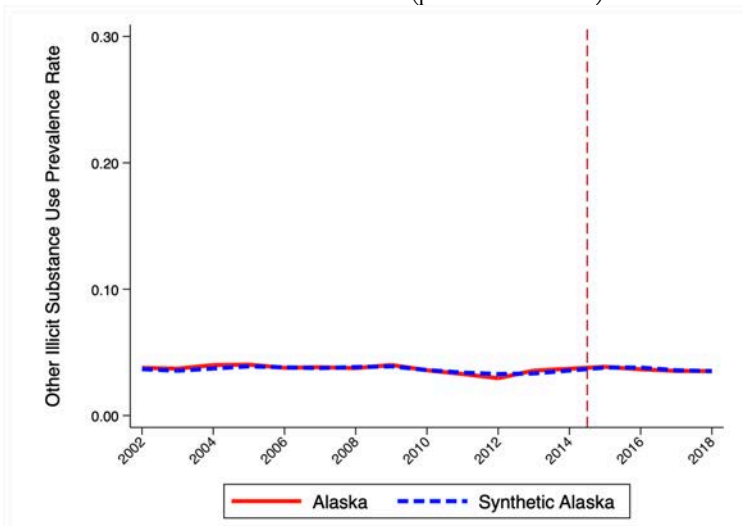


Appendix Figure 11. Synthetic Control Estimates for Alaska

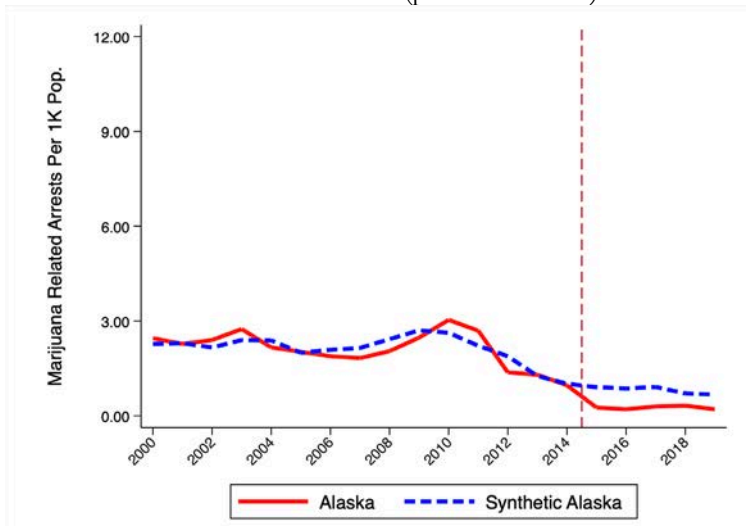
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.018 (p-value = 0.852)



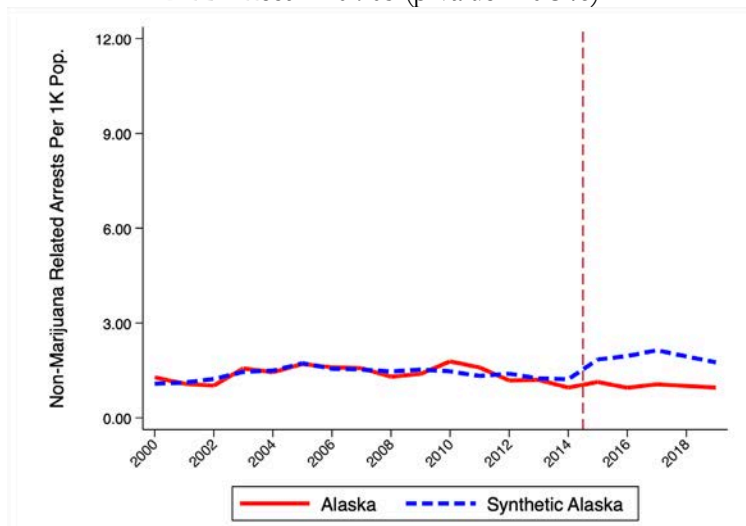
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.00001 (p-value = 0.963)



Panel (c): Marijuana Arrests, UCR
RML Effect = -0.554 (p-value = 0.462)

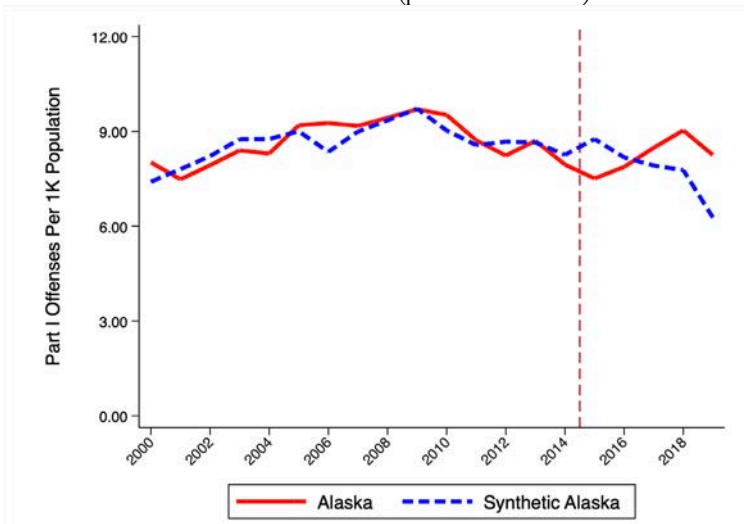


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = -0.905 (p-value = 0.346)

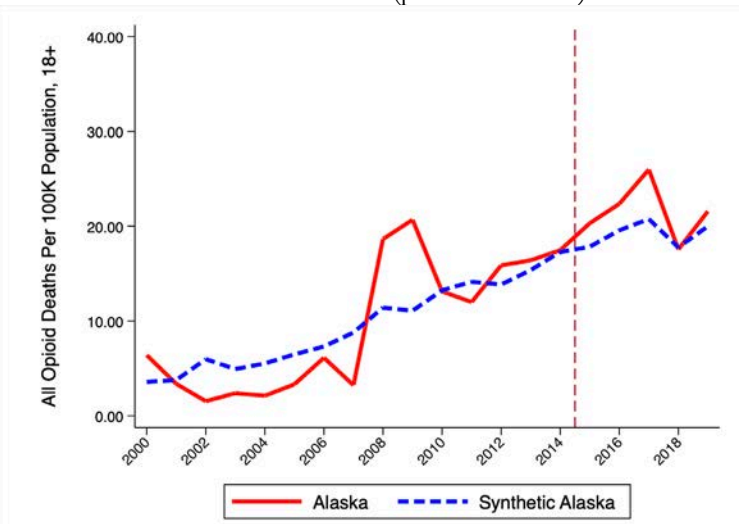


Appendix Figure 11, Continued

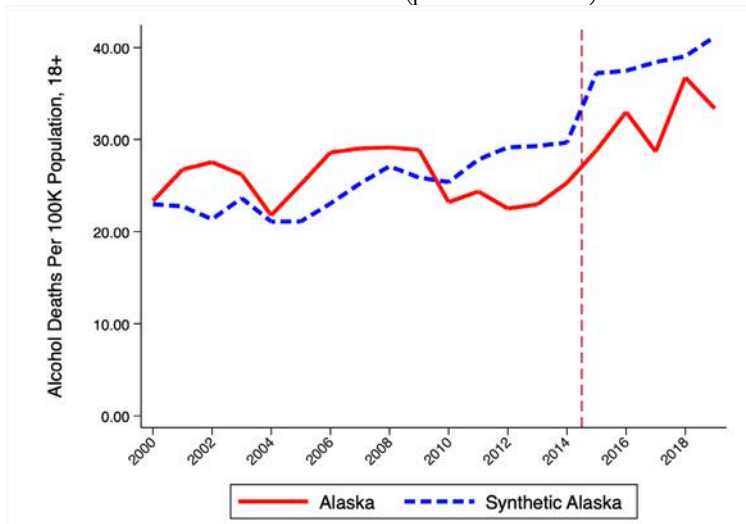
Panel (e): Part I Offense Arrests, UCR
RML Effect = 0.449 (p-value = 0.462)



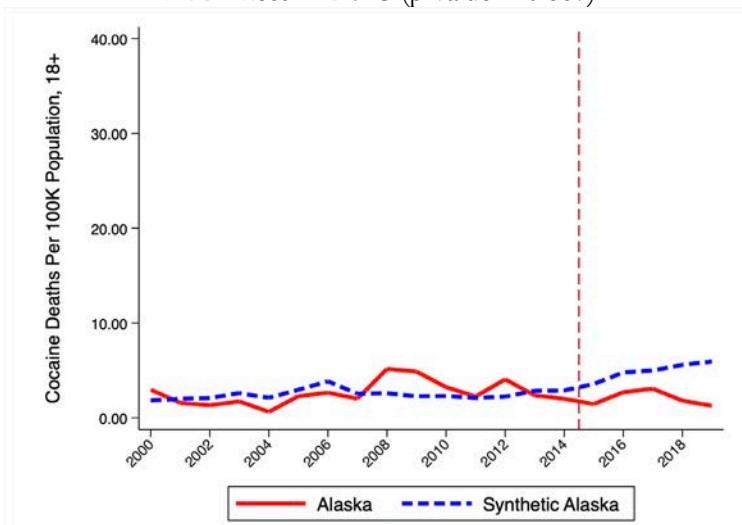
Panel (f): Opioid Involved Deaths, NVSS
RML Effect = 2.373 (p-value = 1.000)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = -6.541 (p-value = 0.741)

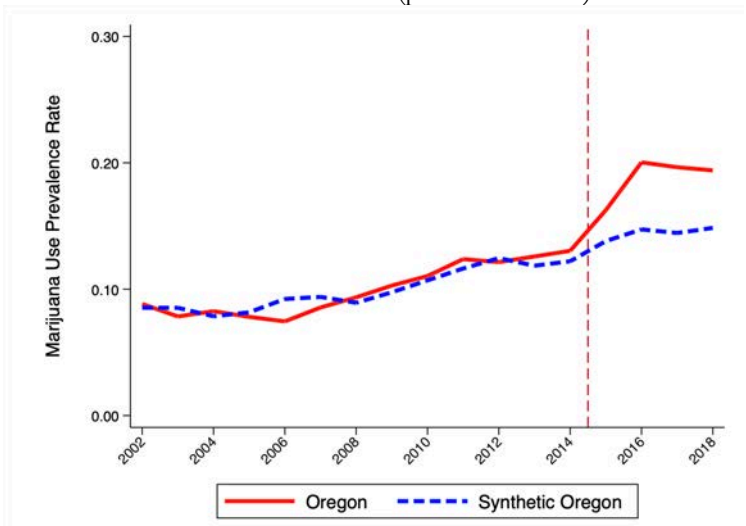


Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = -2.913 (p-value = 0.667)

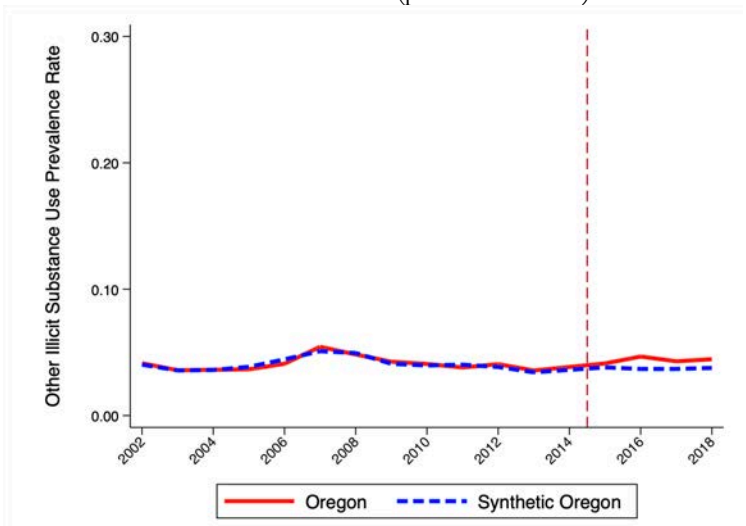


Appendix Figure 12. Synthetic Control Estimates for Oregon

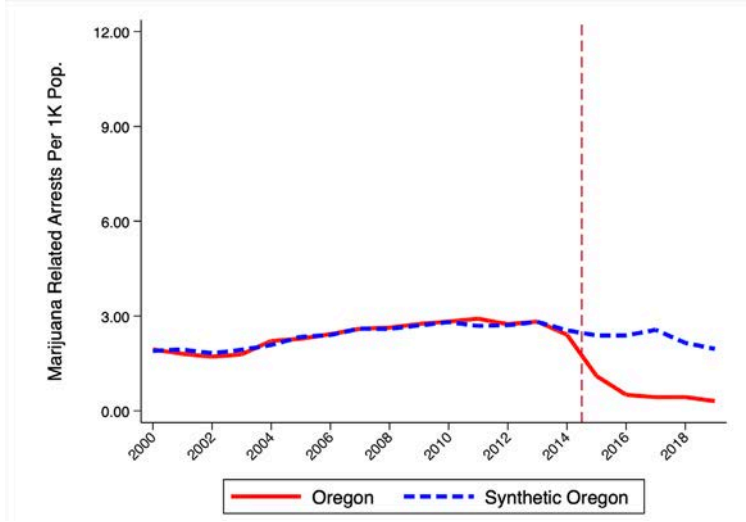
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.044 (p-value = 0.037)



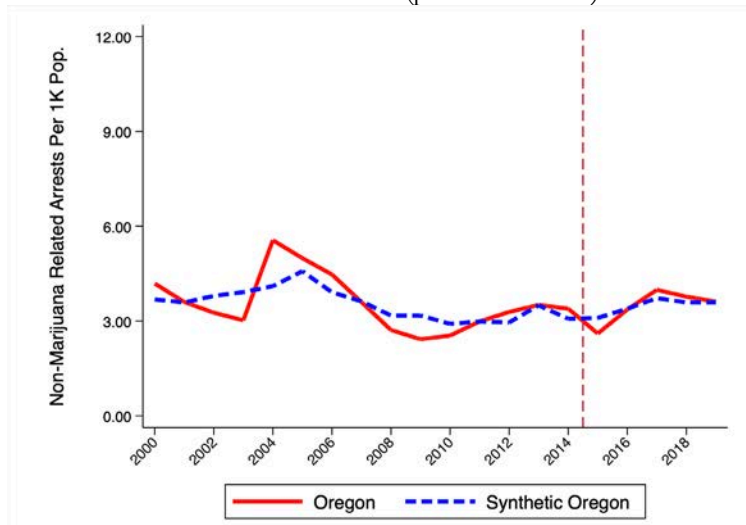
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.006 (p-value = 0.222)



Panel (c): Marijuana Arrests, UCR
RML Effect = -1.732 (p-value = 0.077)

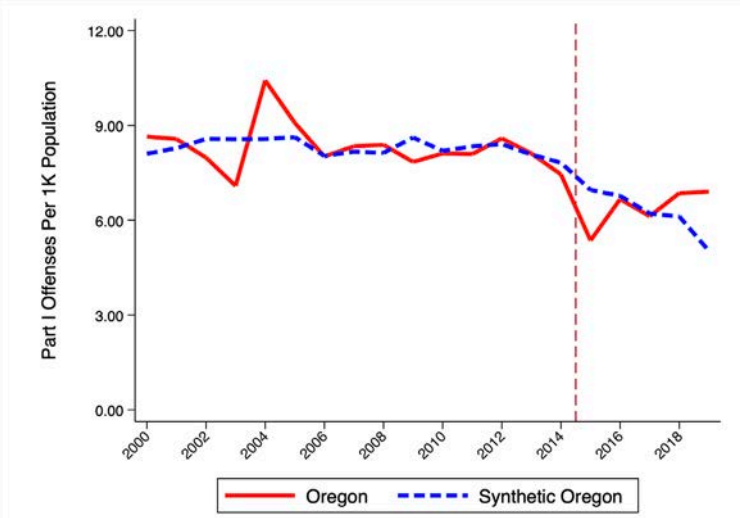


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = -0.001 (p-value = 0.962)

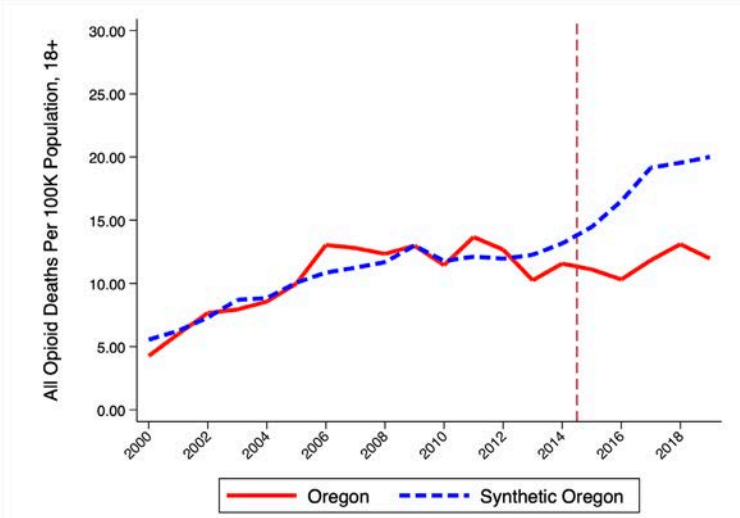


Appendix Figure 12, Continued

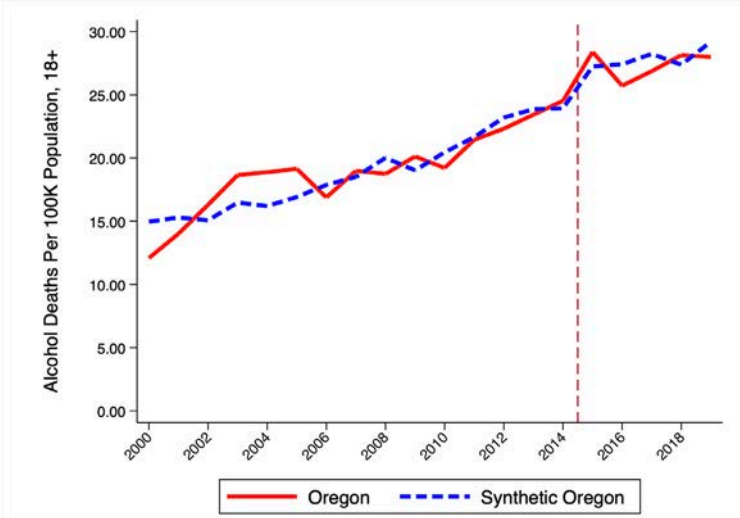
Panel (e): Part I Offense Arrests, UCR
RML Effect = 0.165 (p-value = 0.615)



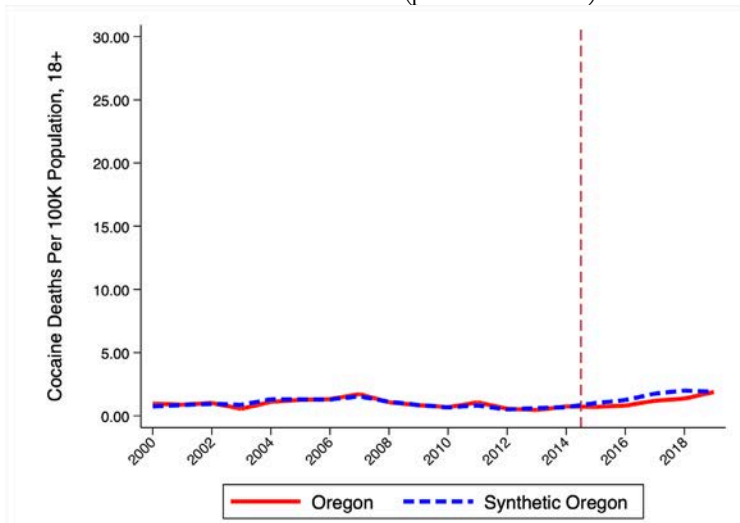
Panel (f): Opioid-Involved Deaths, NVSS
RML Effect = -6.275 (p-value = 0.481)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = -0.472 (p-value = 0.889)

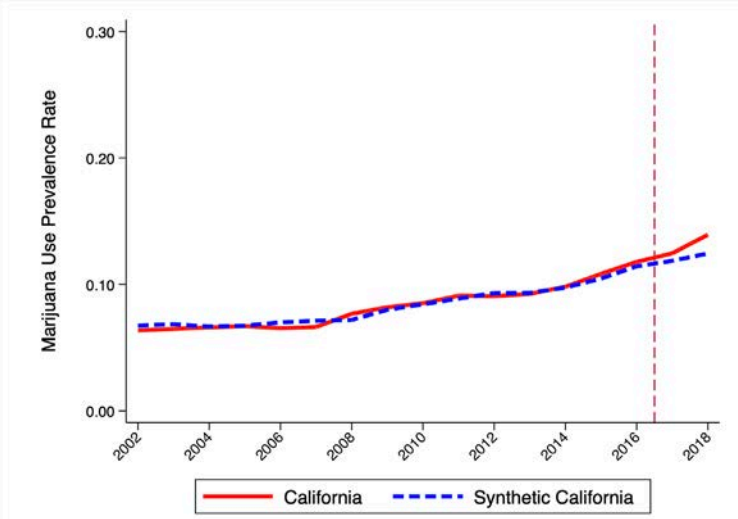


Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = -0.395 (p-value = 0.593)

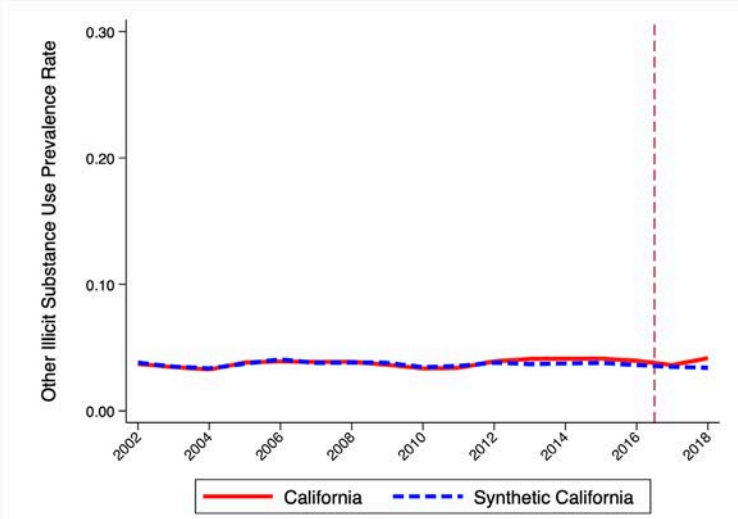


Appendix Figure 13. Synthetic Control Estimates for California

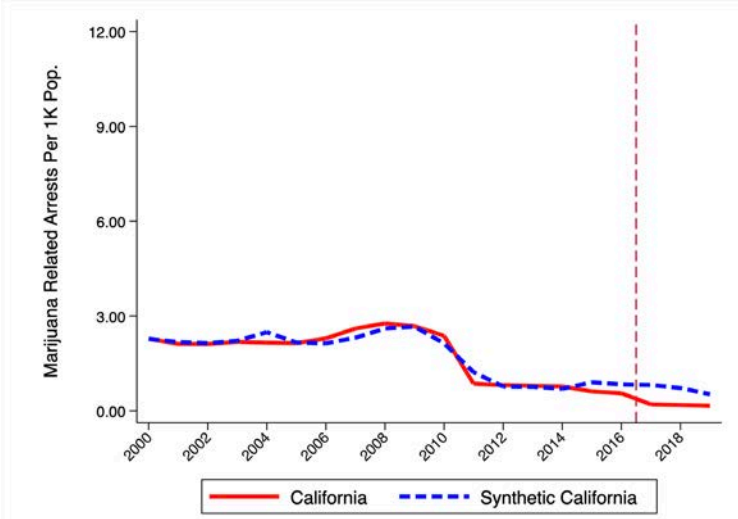
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.001 (p-value = 0.206)



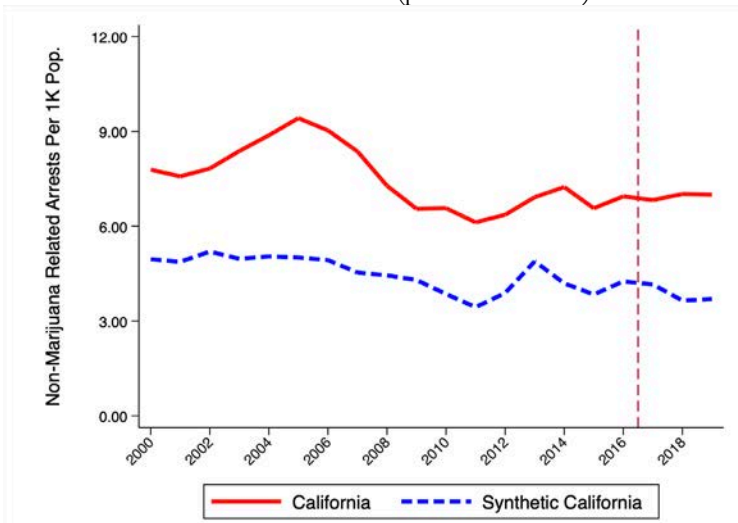
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.005 (p-value = 0.206)



Panel (c): Marijuana Arrests, UCR
RML Effect = -0.507 (p-value = 0.371)

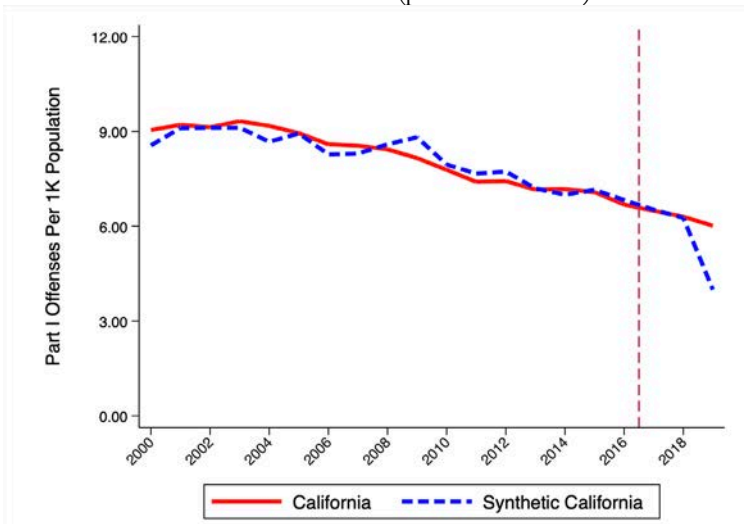


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = 3.115 (p-value = 0.719)

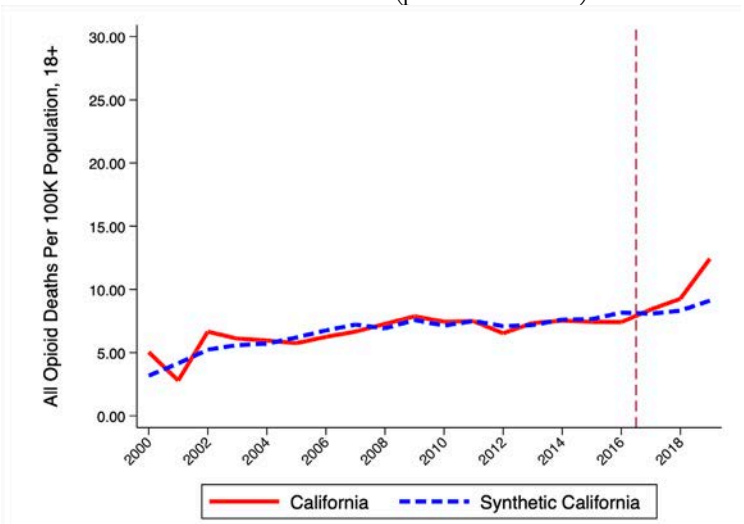


Appendix Figure 13, Continued

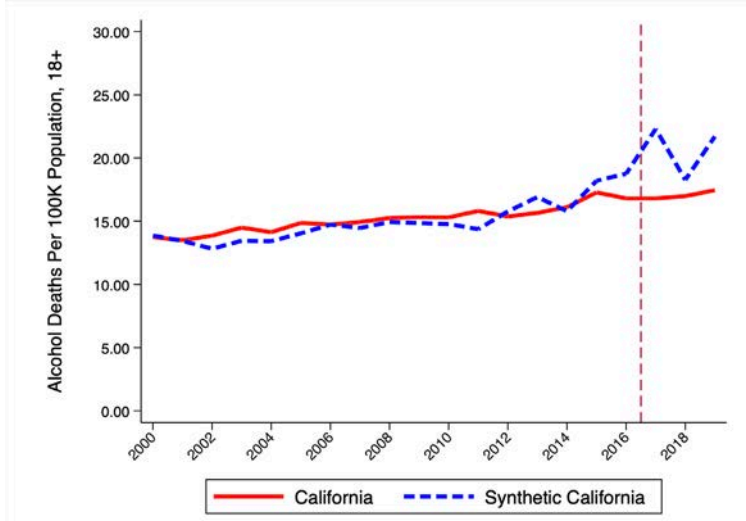
Panel (e): Part I Offense Arrests, UCR
RML Effect = 0.675 (p-value = 0.094)



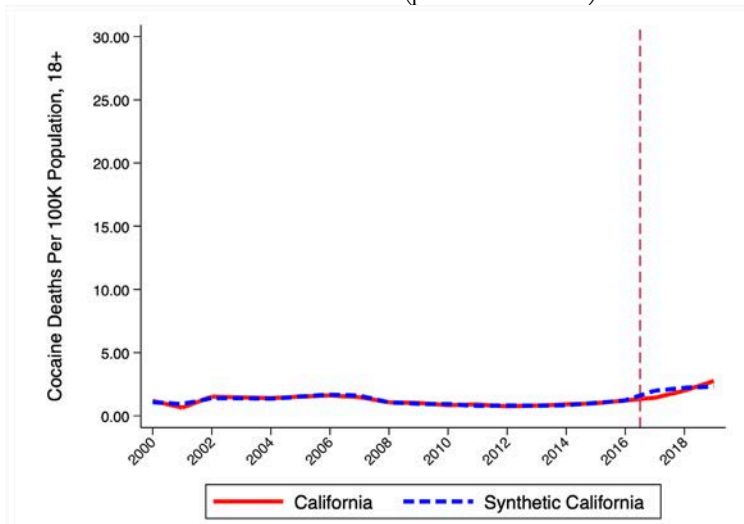
Panel (f): Opioid-Involved Deaths, NVSS
RML Effect = 1.531 (p-value = 0.647)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = -3.677 (p-value = 0.118)

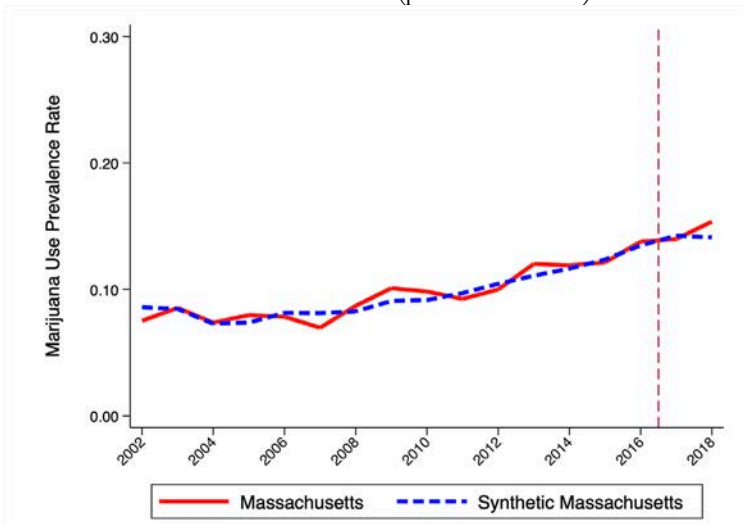


Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = -0.117 (p-value = 0.500)

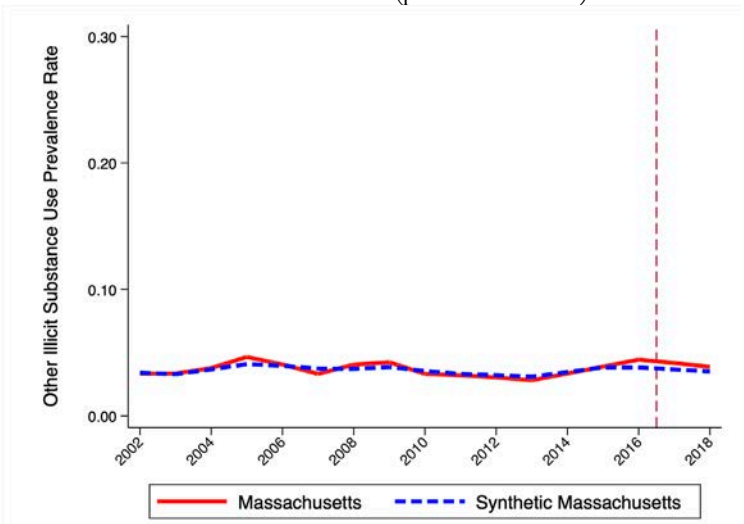


Appendix Figure 14. Synthetic Controls for Massachusetts

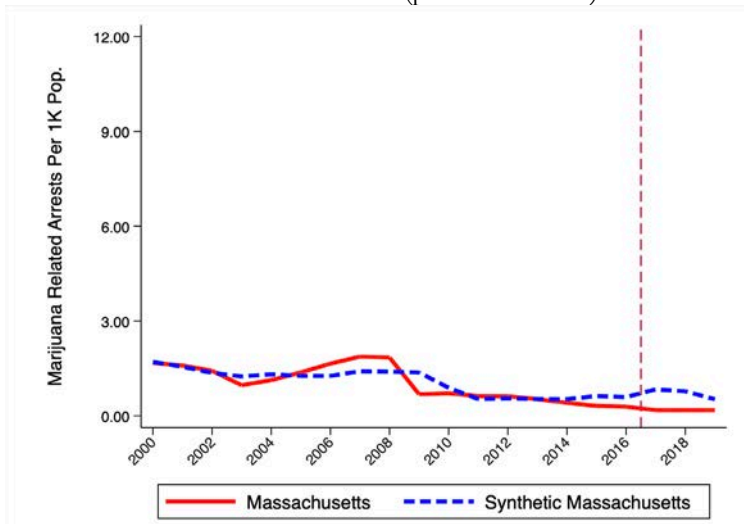
Panel (a): Marijuana Use, NSUDH
RML Effect = 0.005 (p-value = 0.771)



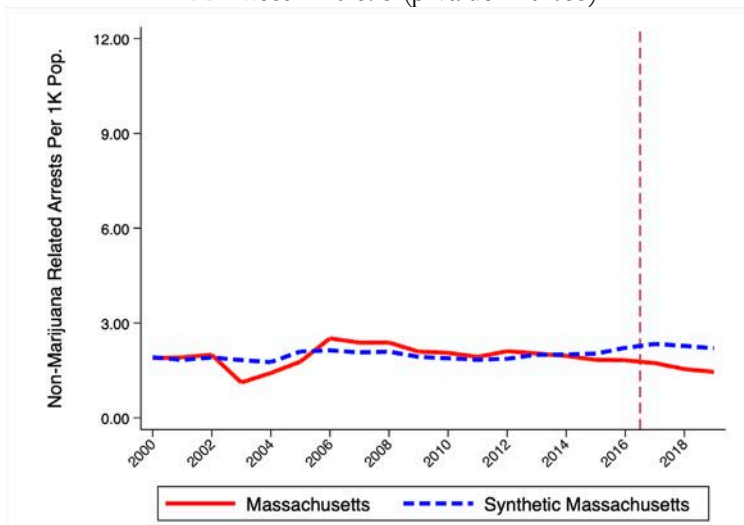
Panel (b): Illicit Drug Use Other than Marijuana, NSUDH
RML Effect = 0.004 (p-value = 0.486)



Panel (c): Marijuana Arrests, UCR
RML Effect = -0.532 (p-value = 0.515)

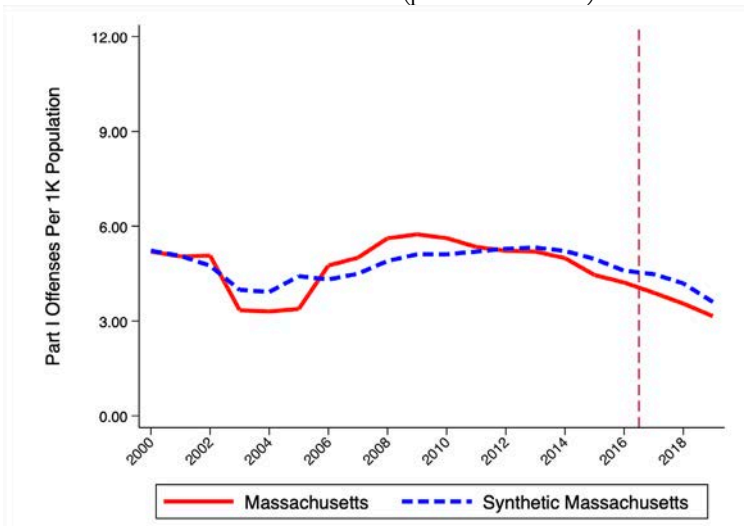


Panel (d): Non-Marijuana Arrests, UCR
RML Effect = -0.695 (p-value = 0.485)

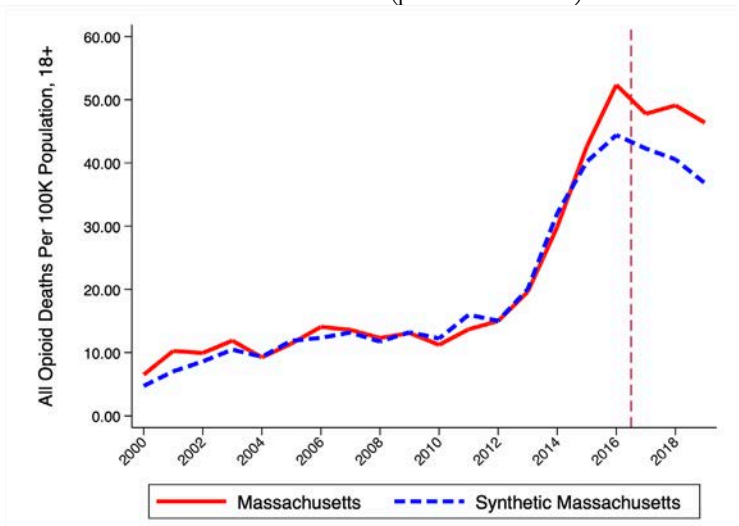


Appendix Figure 14, Continued

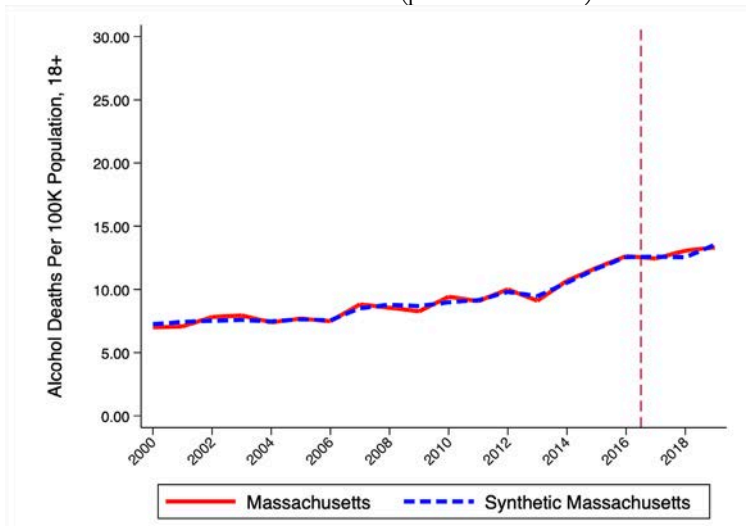
Panel (e): Part I Offense Arrests, UCR
RML Effect = -0.560 (p-value = 0.727)



Panel (f): Opioid-Involved Deaths, NVSS
RML Effect = 7.872 (p-value = 0.514)



Panel (g): Alcohol-Involved Deaths, NVSS
RML Effect = 0.051 (p-value = 0.714)



Panel (h): Cocaine-Involved Deaths, NVSS
RML Effect = 2.371 (p-value = 0.486)