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Research Paper

Medical cannabis laws lower individual market health insurance premiums

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ABSTRACT

Background: To evaluate the impact of medical cannabis laws (MCLs) on health insurance premiums. We study whether cannabis legalization significantly impacts aggregate health insurer premiums in the individual market. Increases in utilization could have spillover effects to patients in the form of higher health insurance premiums.
Methods: We use 2010–2021 state-level U.S. private health insurer financial data from the National Association of Insurance Commissioners. We examined changes to individual market health insurance premiums after the implementation of medical cannabis laws. We employed a robust difference-in-differences estimator that accounted for variation in policy timing to exploit temporal and geographic variation in state-level medical cannabis legalization.
Results: Seven years after the implementation of Medical Cannabis laws, we observe lower health insurer premiums in the individual market. Starting seven years post-MCL implementation, we find a reduction of $-1662.7 (95% confidence interval [CI −2650.1, −605.7]) for states which implemented MCLs compared to the control group, a reduction of -$1541.8 (95% confidence interval [CI 2602.1, −481.4]) in year 8, and a reduction of $-1625.8, (95% confidence interval [CI −2694.2, −557.5]) in year 9. Due to the nature of insurance pooling and community rating, these savings are appreciated by cannabis users and non-users alike in states that have implemented MCLs.
Conclusions: The implementation of MCLs lowers individual-market health insurance premiums. Health insurance spending, including premiums, comprises between 16% and 34% of household budgets in the United States. As healthcare costs continue to rise, our findings suggest that households that obtain their health insurance on the individual (i.e., not employer sponsored) market in states with MCLs appreciate significantly lower premiums.

Introduction

In 2009, United States Deputy Attorney General David Ogden issued a memorandum which advised that states attorneys general "should not focus federal resources in your States on individuals whose actions are in clear and unambiguous compliance with existing state laws providing for the medical use of marijuana" (Ogden, 2009). While thirteen states had medical cannabis laws prior to 2009, this memorandum demonstrated that there was judicial freedom to implement state level medical cannabis laws (MCLs) without the logistic entanglement of having state laws in opposition with federal laws. This edict reduced barriers for states to legalize medical cannabis and, in turn, many states did implement MCLs following this memorandum.

Proponents of MCLs suggest that legalized medicinal cannabis could broaden treatment options for common ailments such as mental health disorders, chronic pain, and nausea (see e.g., Walsh et al., 2013; Boehnke et al., 2019). Medical cannabis consumption may have a positive societal impact by potentially reducing crime (see e.g., Grucza et al., 2018; Morris et al., 2014; Huber III et al., 2016), reducing the need for rehabilitative services to treat substance use disorders (Chu, 2015), decreasing hospital admission rates (Pacula et al., 2014; Shi, 2017), and/or reducing prescription drug expenditures since cannabis is a substitute for other, often more addictive, prescription drugs (see e.g., Flexon et al., 2019; Lucas and Walsh, 2017). Conversely, some research indicates that MCLs could have detrimental societal effects. The National Academies of Sciences, Engineering and Medicine (2017) review the potential negative health effects associated with cannabis use, including cancer, cardiac issues, respiratory problems, mental health, substance abuse, cognition, and pregnancy complications. Cannabis may exacerbate drug use (Gorfinkel et al., 2021), increase chronic

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medical conditions and higher rate of mental health disorders (Choi et al., 2021), worsen opioid-related mortality (Shover et al., 2019), increase traffic fatalities (Hansen et al., 2020; Santaella-Tenorio et al., 2017, 2020), or increase binge alcohol drinking (Wen et al., 2015).

All direct-purchase, individual market health insurance plans sold in the U.S., per The Patient Protection and Affordable Care Act (ACA) are subject to mandated essential health benefits, including coverage for inpatient (and outpatient) rehabilitative services for drug addiction. If cannabis serves as substitute for drugs that are more likely to require expensive inpatient treatment, then MCLs could effectively reduce healthcare costs, including health insurance premiums. Health insurance companies do not cover medical expenses associated with the direct use of medicinal cannabis (e.g., they do not cover the cost of purchasing medicinal cannabis), since medical cannabis is federally prohibited. Individuals pay out of pocket for medical cannabis.

Health insurance, which is the primary mechanism used to pay for healthcare expenditures in the U.S., operates by collecting premiums from all enrollees and paying expenses for the subset of enrollees who need medical treatment. So, by design, within the insurance pool, few individuals pay the full cost of their own health care. If health care usage decreases, then health care expenses, paid for largely by health insurance, will decrease. Insurance companies subsequently adjust premiums to reflect higher (lower) expenses. If medical cannabis reduced aggregate medical expenditures, we would expect to see lower premiums in states which had enacted MCLs, all else equal.

American households with health insurance in the individual market, where the average monthly premium was $580/month in recent years (Fehr et al., 2020) pay approximately 20% of their household budget to finance health care, including insurance premiums (Carman, Liu, & White, 2020). According to the U.S. Bureau of Labor statistics, health insurance premium payments comprise over 60% of all household healthcare expenses (Chalise, 2020). In this paper, we exploit variation in state MCLs to compare individual market health insurance premium changes between states with and without MCLs which allows us to estimate the impact of MCLs on health insurance premiums. Any reduction in premiums is welcome as healthcare expenses, including premiums, continue to rise faster than inflation and take up an increasingly sizeable portion of household budgets. By comparing premiums in and out of MCL states, we measure the financial impact of medical cannabis on the pocketbook of the average individual market enrollee. We find a statistically significant decrease in health insurance premiums starting in year seven post-MCLs and this downward trend is persistent for following years. We provide evidence that medical cannabis laws lower individual market health insurance premiums. Due to the nature of insurance pooling, in states where medical cannabis is legal, lower premiums are beneficial both to medicinal cannabis users and non-users alike.

Background

From the literature, we describe three broad mechanisms through which MCLs could impact health insurance claims which could, in turn, change premiums in subsequent periods. We highlight some of the literature related to potential mechanisms through which average utilization and, thus, premiums may decline. Anderson and Rees (2023) provide an in-depth review of the literature on medical cannabis laws and public health. The first mechanism is a substitution from prescription medications to medicinal cannabis. Bradford and Bradford (2017; 2018) study Medicare and Medicaid beneficiaries and find that after MCL enactment fewer prescriptions are written and that there are cost savings on prescription drugs in MCL states. Wen and Hockenberry (2018), find a 6% reduction for Medicaid enrollees. McMichael et al. (2020) find legalizing medicinal cannabis is associated with a four percent decline in the prescription of opioids. Cheon et al. (2021) examine claims data from a private health insurance company and find that there are fewer opioid prescriptions, fewer total days supplied, and a lower total dosage of opioids prescribed after states implement a medical marijuana law. A reduction in prescription drug expenditures due to a decrease in prescription intensity after implementation of an MCL is consistent with a decrease in insurance premiums following MCL implementation.

The second potential mechanism is associated with behavioral changes in the presence of medical cannabis. After the implementation of MCLs, the rates and quantities of alcohol consumption and tobacco use may change. Anderson et al. (2013) find that MCLs are associated with a decrease in the purchase of beer, a decrease in self-reported alcohol use, and a decrease in alcohol-related traffic deaths. Choi et al. (2019) find that MCLs are associated with a reduction in both the number of tobacco cigarettes smoked by adults and the number of adults smoking. Reduced rates of cigarette smoking and reduced intensity among smokers could lead to a decrease in medical expenditures directly through fewer smoking-related illnesses and indirectly through less exposure to secondhand smoke. More broadly, MCLs are associated with lower rates of fatal traffic accidents (Anderson et al., 2013; Cook et al., 2020), reduced rates of work-absenteeism (Ullman, 2017), lower rates of workers' compensations claims (Ghimire & Maclean, 2020), and increased work hours for older adults (Nicholas & Maclean, 2019). Collectively, behavioral changes relating to reduced consumption of tobacco and alcohol, in addition to improvements in workplace safety and motor vehicle operation in the presence of MCLs, should reduce healthcare expenditures which may pass through to the policyholders in the form of reduced premiums.

A third mechanism through which MCLs may reduce premiums relates to changes in mental health and substance-abuse treatment. For example, McMichael et al. (2020) examine aggregate opioid prescriptions and find a decrease in opioid prescriptions in states with MCLs. This reduction in opioid prescriptions could lead to a decrease in insurance-covered medical expenditures both directly due to a decrease in covered prescriptions and indirectly, as documented by Powell et al. (2018), due to a decrease in health conditions associated with opioid use/misuse (e.g., rehabilitative services for substance use disorder). Chu (2015) finds a decrease in treatment for heroin addiction following MCL implementation. Jayawadhana and Fernandez (2021) find hospitalization and emergency department visits related to opioids increase with home cultivation but decrease in states with dispensaries. MCLs are also associated with reductions in the rates of death by suicide generally (Anderson et al. (2013) and, specifically, death by suicide involving a firearm (Bartos et al., 2020). Decreasing the demand for rehabilitation services, decreasing opioid prescriptions, and/or decreasing emergency room visits and hospitalization for opioids all reduce medical expenditures for insurance companies which should eventually result in lower premiums, all else equal.

We now discuss several mechanisms through which MCLs may increase health insurance premiums. Olfson et al. (2018) found in a nationally representative sample of non-institutionalized adults in the U.S., that cannabis use increased both nonmedical opioid use and opioid use disorder. Gorfinkel et al. (2021) find that, among 211 participants with known problem substance use, the odds of opioid use appear to be approximately doubled on days when cannabis was used. The treatment associated with illegal opioid use could cause increases in health insurance claims such as hospitalizations and rehabilitative services. More generally, Secades-Villa et al. (2015) find that nearly 45% of individuals with lifetime cannabis use progressed to other illicit drug use. Whether cannabis exacerbates opioid use disorder or increases the likelihood of partaking in other illicit drugs, if increased need for treatment arises from these issues, health insurance premiums could increase.

MCLs could also increase health insurance premiums through comorbidities such as increased psychiatric comorbidities brought on by cannabis use. Hasin (2018)) finds a correlation between cannabis use disorder and other substance and psychiatric disorders such as alcohol and nicotine use disorders, mood disorders, anxiety, personal disorders, post-traumatic stress disorder, and positive psychotic symptoms.

Beyond increased need for psychiatric care, the use of cannabis, particularly when inhaled, could expose users to carcinogenic cannabis smoke. Bowles et al. (2012) discuss the carcinogenic properties of cannabis smoke, including that cannabis smoke contains several of the same carcinogens as tobacco smoke but at a 50% higher concentration and three times the tar. Thus, the long-term effects of repeated cannabis use could include an increased potential for smoking-related cancers. If cannabis increases comorbidities, this could lead to higher health insurance claims, particularly if cannabis increases the complexities between various health issues, which could increase health insurance premiums in subsequent policy periods. Health insurance premiums are a useful metric to study both because of their saliency in household budgets, and because of the nature of pooling in insurance. Insurance premiums decrease (increase) when the amount of average expenditure per insurance enrollee decreases (increases). If medical cannabis, which individuals pay for completely out of pocket, is substituting for other types of care that are paid for by insurance, medical expenditures will decrease (increase). To this end, lower premiums in states which enacted MCLs compared to states which did not enact MCLs is consistent with other literature.

Insurance companies selling ACA compliant plans on the individual market cannot set premiums based on individual health status or medical claims history. Under mandated community rating rules in the Patient Protection and Affordable Care Act (ACA), the premium established for all enrollees in the pool varies only by family/household size, geographic location, age, and tobacco smoking status. Sec. 2701. Fair Health Insurance Premiums of the Patient Protection and Affordable Care Act (2010) states "with respect to the premium rate charged by a health insurance issuer for health insurance coverage offered in the individual and small group market – such a rate shall vary with respect to the particular plan or coverage involved only by (i) whether such plan or coverage covers an individual or family; (ii) rating area, (iii) age; (iv) tobacco use." Since premiums cannot vary by cannabis consumption, if individuals need less (more) insurance-covered healthcare due to medical cannabis consumption, then we expect to see decreases (increases) overall healthcare expenses. These decreased (increased) expenses will be spread over all enrollees in the form of lower (higher) premiums. Therefore, if medical cannabis usage is decreasing health care expenses, the savings will be shared across all enrollees in the insurance pool in the form of lower premiums.

We examine the effect of state MCLs on health insurance premiums in the individual health insurance market, which includes plans directly purchased from health insurance companies and plans purchased on the ACA exchanges. Households with the lowest income (bottom 20%) pay an average of 34% of their income toward healthcare. Households with the highest income (top 20%) pay 16% of their income toward healthcare (Carman et al., 2020). In 2019, the average monthly premium in the individual market was $580/ month (Fehr et al., 2020). Therefore, we expect that households are sensitive to changes in health insurance premiums. Other work that considers state-level regulations and the impact on insurance premiums includes Park and Coe (2022) where the authors find that state-specific Medigap regulations are strongly predictive of Medigap premiums. While Park and Coe consider state-level changes to regulation in the Medigap market, their work highlights that policy makers should consider the impact of state-specific regulation on insurance coverage and premiums.

Previous literature has explored the role of medical cannabis in treating a multitude of conditions including cancer, chronic pain, epilepsy, and mental health disorders such as post-traumatic stress disorder. Medical cannabis legalization expands treatment options, which may increase or decrease health care utilization. Health insurance is priced to reflect average utilization, so changes to utilization will be borne by all enrollees. In this study, we consider how potential decreases in utilization could have spillover effects to patients in the form of lower health insurance premiums.

Table 1
Summary statistics of annual adjusted premium per Enrollee.

	Mean	Std. Dev.	N
Full Sample	4519.48	2030.08	115,185,735
Medical Cannabis Laws	4576.86	1996.304	69,726,485
No Medical Cannabis Laws	4431.48	2077.74	45,459,250

Data and methods

Data on individual market health insurance premiums were drawn from the Supplemental Health Care Exhibit – Part 1 (SHCE) using the S&P Capital IQ Pro-database for insurers with individual market business from 2010 to 2021. The SHCE is an exhibit on the annual statutory insurance company filing required by state insurance regulators and compiled by the National Association of Insurance Commissioners (NAIC). The SHCE is used to track annual financial and enrollment data for all insurers that have health insurance business. Data on MCL 'effective' dates is drawn from Anderson and Rees (2023). The SHCE was filed starting in 2010. The unit of observation in our sample is an insurer-state-year, e.g., Aetna Health in Illinois in 2019. When referencing SHCE line numbers and columns, we refer to an NAIC Statement Blank.

The period between 2010 and 2021 was one of substantial change both in cannabis legalization and in the individual market for health insurance. When the 2009 Ogden Memorandum was issued, thirteen states had legalized medical cannabis. The Ogden Memorandum dictated that (with some exceptions) federal prosecutors would not use resources to bring criminal charges against people using medicinal cannabis in states that had legalized (Patton, 2020). During our sample period, twenty-one states legalized cannabis increasing the total number of states with legalized medicinal cannabis to thirty-four. In 2010, the Patient Protection and Affordable Care Act (ACA) was passed with a goal of increasing the number of insured either through state-level Medicaid expansion or the mandated formation of state-level individual market online exchanges which streamline health insurance purchasing in the direct purchase (i.e., individual) market. Medicaid expansion and individual market exchanges were both implemented in 2014 to much success (Frean et al., 2017).

The outcome variable of interest in our study is annual premiums per enrollee. This variable is constructed from adjusted premiums earned (SHCE line 1.8, column 1), which are the premiums earned by the health insurer net of federal and state taxes and regulatory fees. We exclude insurers with fewer than 1000 enrollees as well as insurers that report negative premiums. Broadly speaking, negative premiums are indicative that an insurer is no longer offering that type of plan. Summary statistics for premiums per enrollee are in Table 1.

We use difference in differences (DiD) estimation to determine the effect of medicinal cannabis on per-enrollee premiums. Broadly, DiD compares treated groups (those with the implemented policy) and control groups (no policy change) over time. For valid comparisons, the treated group and the control group must have similar outcomes prior to policy implementation. Therefore, DiD relies on parallel trends in outcomes for the treated and control groups pre-policy, with the assumption that - in the absence of treatment- the treated and control groups would change in the same way over time.

To infer causation from a traditional DiD estimator, the policy must be implemented in a single time period, and the impact of the policy must be homogenous across time. However, when there is variation in the timing of policy implementation, such as in our case where states do not all legalize medicinal cannabis in the same year, the traditional DiD estimator may be biased and may misstate the sign or significance of the estimate (Goodman-Bacon, 2021).

Fundamentally, a DiD estimator is a weighted sum of the difference in outcomes between treated units and control units after treatment. In studies in which there is variation in treatment timing, there can be two

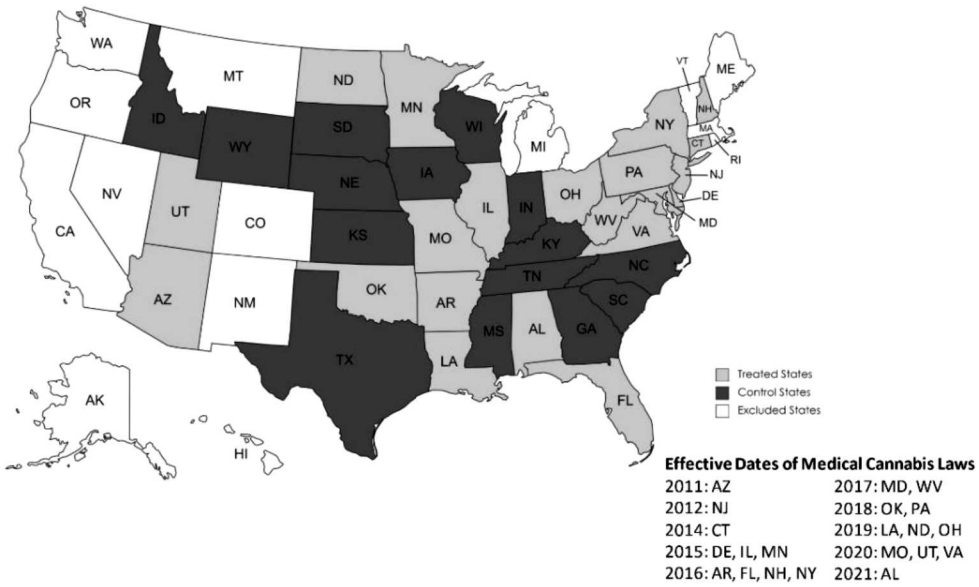

Fig. 1. States with Effective Cannabis Laws between 2010 and 2021.

erroneous comparisons which lead to bias in estimated effects. There can be an incorrect comparison between units treated early in the study period being compared to units treated later in the study, prior to the late unit treatment. Thus, the units treated later were acting as a control group when they should not have been. Another error comes from comparing units treated later in the study period with units treated early, after both have been treated. These incorrect comparisons get aggregated into the basic DiD estimator and can lead to incorrect inference in both the sign and significance of the average effect on the treated (ATT). For a more complete discussion see Goodman-Bacon (2021).

Because states legalized medicinal cannabis in different years, we require a robust estimation strategy that accounts for the variation in the timing of state MCLs and produces causal estimates of the policy's effect. We utilize a DiD framework, but we employ the robust Sun and Abraham (2021) (SA) estimator which overcomes the potential bias in a traditional event study two-way fixed effect (TWFE) model. The SA estimator provides unbiased and causal lead and lag (event study) estimates. The SA estimator is designed to eliminate two sources of bias: the first source of bias is induced by heterogeneous treatment effects which "spillover" from other time periods and can create the appearance of non-parallel pre trends or mis-specified post estimates when none are present. Without the 'correction' in the SA estimator, an estimate from one period after policy implementation could contaminate the estimates from the pre-policy period, and vice versa. The SA estimator also corrects a second source of bias that arises from variation in timing of policy implementation, as we see in state-level cannabis legislation. SA estimates the "cohort specific average treatment effects on the treated" or CATT. By analyzing each annual "cohort" of states enacting MCL policies, we utilize the robust SA estimator to estimate a causal impact of medicinal cannabis legalization on premiums each year after implementation.

It is worth noting that medicinal cannabis laws are created because of political will within a state. States which elect to implement MCLs may have different characteristics than those that do not. Some of those characteristics may be unobservable (in the data). To address these potential differences in underlying characteristics, in our analysis of the impact of MCLs on premiums, we utilize the SA estimator with two distinct control groups. The first control group is comprised of states that never receive treatment (never implement a medicinal cannabis law). These "never treated" states are a natural control group as they are "untreated" by MCLs and the subsequent impact on health care expenditure. However, one might be concerned that states which have not implemented MCLs would have similar trajectories of premiums per enrollee to those that elected to implement an MCLs. Thus, we also consider a different group of control states: those states which legalize medicinal cannabis in the last year of the study period. The basis of comparison, then, is states that have legalized medicinal cannabis between 2010 and 2020 to states that legalized cannabis in 2021. The advantage of using the "not yet" treated group as the basis of comparison is that unobservable factors, such as attitudes towards medicinal cannabis and local politics regarding cannabis consumption, may be more similar to those in which MCLs have been implemented. The SA estimator is designed to support both of these different control groups.

We estimate the following equation using an event-study DiD ordinary least squares (OLS) framework in addition to our main model which utilizes the SA estimator with two control groups, the not yet treated and never treated:

$$Premiums\ per\ enrollee_{isy} = \beta_0 + \beta_t * MCL_{st} + \gamma_{is} + \rho_y + \varepsilon_{isy} \quad (1)$$

Where the dependent variable, $Premiums\ per\ enrollee_{isy}$, is the per-enrollee premium for insurer i in state s in year y. MCL_{st} is an indicator variable equal to 1 if state s enacts an MCL in our sample period. Time t represents the number of years since MCL implementation. We utilize event time. For example, $t = 1$ represents the first full year after MCL implementation regardless of the chronological year in which the MCL began. Similarly, $t=-1$ represents the year before MCL implementation. Values of $t<0$ represent years prior to implementation. For $t<0$, we expect no impact of MCLs (β_t not distinguishable from 0). For $t>0$, β_t represents the impact of MCLs t years after implementation. Insurer-state and year fixed effects are represented by γ_{is} and ρ_y, respectively. We cluster our standard errors at the insurer-state level.

There exists some tension in the literature as to how one classifies an 'effective' MCL date. Anderson and Rees (2023) define an 'effective' date when, pragmatically, patients may be able to access medical cannabis while Pacula et al. (2014) classify an 'effective' MCL date as a combination of law enactment and legally protected dispensaries even in states with significant limitations for medical cannabis access. A salient example is the case of New Jersey which passed an MCL in 2010, but the law only permitted marijuana in the case of debilitating illness; thus, potential uptake was limited. Using Pacula et al. (2014) classification, New Jersey is effective in 2010 whereas in the Anderson and Rees (2023) data, New Jersey is assigned an 'effective' date of 2012. This study focuses on MCL dates which reflect easier access to medicinal

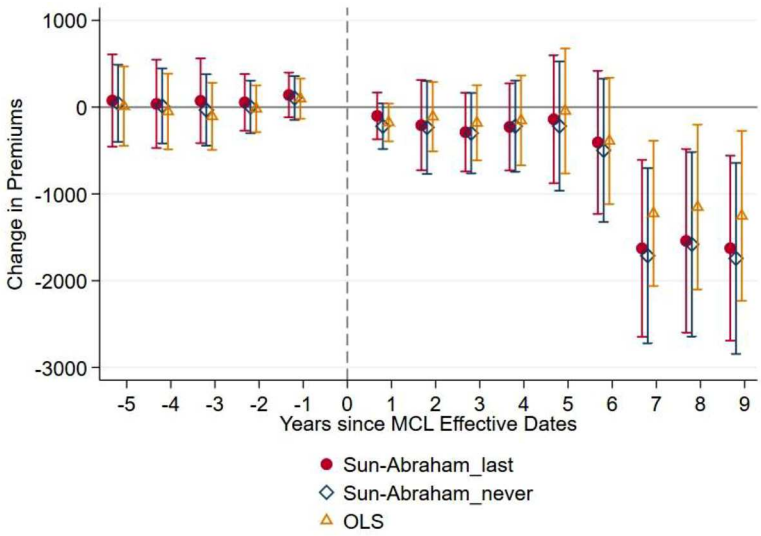

Fig. 2. Changes in Annual Individual Market Premiums per Enrollee before and after Medical Cannabis Legalization Notes: Fig. 2 shows the point estimates for the impact of medicinal cannabis laws on individual market health insurance premiums from the estimation of Eq. (1). Time 0 is implementation of the medical cannabis law. We show three estimators: the Sun-Abraham estimator using as a control group the states that implemented laws late in the sample period (Sun-Abraham_last), the Sun- Abraham estimator using a control group of states that have never had MCLs (Sun-Abraham_never), and a traditional OLS event-study estimator for comparison. Standard errors are clustered at the insurer-state level and estimation includes both year and insurer-state fixed effects.

cannabis. Using MCL dates from Anderson and Rees (2023), then, treated states are those with effective MCL dates between 2010 and 2021.

We consider two different groups of control states: "never treated" states which did not enact a MCL prior to 2021 and "not yet treated" states which enacted a law later in 2021. In this paper, we evaluate the impact of medicinal cannabis exclusively, even though some states have recently enacted recreational cannabis laws following earlier enactment of MCLs. For example, Massachusetts enacted recreational cannabis with dispensaries opening in 2018. To cleanly identify the impact of medical cannabis only, we exclude Massachusetts from our sample. Additionally, Arizona and Illinois adopted recreational cannabis in 2020, which could pose a problem when we include them in our sample. However, open enrollment for 2020 plans began in 2019 and premiums for those plans were set well before the open enrollment period, and thus the legalization of recreational cannabis in these states should not have an impact on health insurance premiums. An additional concern with the sample ending in 2021 is the potential confounding impact of the COVID-19 pandemic which notably impacted the U.S. starting in March 2020. However, since premiums are set prior to the start of the year (i.e., 2020 premiums would have been set before the start of 2020), the likelihood of interference of COVID-19 on premium data from that year is less likely. In Fig. 1, we illustrate the twenty-one treated states and their effective implementation dates as well as the fifteen "never treated" control states.

Additionally, we separately estimate Eq. (1) with states that enacted medicinal cannabis early, mid, and late in our sample period. A full discussion and associated results are available from this exercise in the Appendix.

Finally, we conduct a falsification test. In this falsification test, we utilize a random number generator to assign placebo treatment dates to each of the states which enacted medical cannabis laws in our sample. In this way, we create a "placebo treatment", in which we would not expect to observe any statistically significant results. We then re-estimate Eq. (1) with both sets of control states. Results of this exercise are discussed in the Results section below.

Results

We consider that the impacts of MCLs may not be consistent across time and may take time to manifest. To investigate if there are short- or long-term effects of MCLs on health insurance premiums, we conduct an event study utilizing a traditional OLS DiD estimator (represented on the figure as OLS), the SA 'never treated' estimator (represented on the figure by Sun-Abraham_never) and the SA 'not yet treated' estimator (represented on the figure by Sun-Abraham_last) by estimating Eq. (1). In Fig. 2, we present the yearly point estimates of the effect of medical cannabis legalization on per-enrollee-premiums. Extending from our point estimates are 95% confidence intervals. Statistically significant point estimates do not include zero (the X axis) within their confidence bars. On the X axis, $t = 0$ indicates the year that medical cannabis legalization was implemented. Negative years on the X axis identify the impact of MCLs on premiums prior to legalization. In the years leading up to policy implementation, all point estimates of the impact of MCLs on premiums are near zero, suggesting our treated and control states had few differences in premiums prior to MCL implementation. All confidence intervals for periods $t<0$ include zero, which is expected as the policy is not yet in place. This suggests parallel trends between the treated and control group prior to MCL implementation.

Positive years on the X axis identify the impact of MCLs on premiums after medical cannabis legalization. After medical cannabis legalization, we see a small (but not statistically significant) reduction in premiums in the first five years following MCL enactment, followed by a (not statistically significant) reduction in year 6 of about $500. The sluggish impact on per-enrollee premiums is not surprising given a few factors: first, the uptake of medicinal cannabis is far from instantaneous. Individuals must consult with a provider and shift from their current treatment plan to medicinal cannabis. Then, behavioral changes regarding alcohol and tobacco use as well as driving behavior and workplace safety will take time to fully manifest. The insurers must then observe the changes in utilization that arise from these changed treatment and behavioral patterns that reduce health insurance claims. Once the insurer has observed sufficient claims data to identify if the impact of medicinal cannabis on claims is a momentary shock or a persistent change in utilization, only then would insurers update premiums to reflect the new (lower) utilization.

Starting seven years after MCL implementation, we estimate a sizeable and statistically significant reduction in annual per- enrollee premiums of about $1600. In 2021, the last year in our sample, average premiums per enrollee were nearly $6500. A $1600 reduction in per enrollee health insurance premiums represents a twenty-five percent decrease in MCL states in years 7, 8, and 9. Comparing the two different SA estimators (using the never treated group represented on the figure as Sun-Abraham_never and not-yet treated states as a control group represented on the figure as Sun-Abraham_late), point estimates of the impact of MCL on premiums are similar. In the SA estimation using the "not-yet" group as a control, we find a reduction of $−1662.7 (95% confidence interval [CI −2650.1, −605.7]) for states which

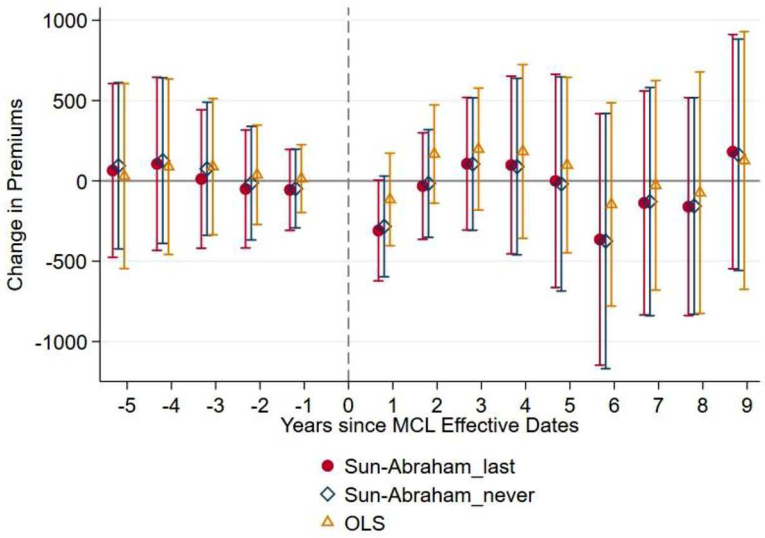

Fig. 3. The impact on individual market premiums for the placebo treatment years assigned to states that underwent MCL between 2010 and 2021. Notes: Fig. 3 shows the point estimates for the impact of medicinal cannabis laws on individual market health insurance premiums from the estimation of Eq. (1) using a 'placebo treatment' assignment falsification test. Time 0 is implementation of the medical cannabis law. We show three estimators: the Sun-Abraham estimator using as a control group the states that implemented laws late in the sample period (Sun-Abraham_last), the Sun- Abraham estimator using a control group of states that have never had MCLs (Sun-Abraham_never), and a traditional OLS event-study estimator for comparison. Standard errors are clustered at the insurer-state level and estimation includes both year and insurer-state fixed effects.

implemented MCLs compared to control in year 7, a reduction of -$1541.8 (95% confidence interval [CI 2602.1, −481.4]) in year 8, and a reduction of $−1625.8, (95% confidence interval [CI −2694.2, −557.5]) in year 9. Using the never treated states as a control group, SA estimates a $−1712.3 (95% confidence interval [CI= −2724.1, −700.6]) reduction in year 7, a $−1581.8 (95% confidence interval [CI= −2647.5, −516.0]) reduction in year 8, and a $−1743.6 (95% confidence interval [CI= −2847.2, −640.1]) reduction in year 9 to individual market premiums after effective MCL dates.

In Fig. 3, we present the results of our falsification test. Here, we randomly assigned placebo treatment years to the states which underwent enactment of medicinal cannabis laws within our sample. We note that, prior to the (randomly assigned) placebo treatment date, point estimates for the impact of placebo medicinal cannabis are all near zero, with large confidence intervals. Additionally, after the placebo treatment, there are no statistically significant estimates for any of the post periods from either the Sun-Abraham_never or Sun-Abraham_late estimates. Estimates are noisy, and there is no clear pattern to them. The results of this exercise provide evidence that the results we find using the true MCL dates and discuss in Fig. 2 are not spurious, but, in fact, a statistically significant impact of a policy change.

Discussion

In this study, we provide evidence of a statistically significant reduction in individual market premiums starting seven years after the implementation of medicinal cannabis laws. Because of the pooled nature of insurance, the lower premiums benefit cannabis users and non-users alike in medical cannabis states. Our results are important as health care expenses, including health insurance premiums, have been growing faster than inflation and comprise an increasing share of a household's budget.

To understand the future financial benefit of medical cannabis, we provide a conservative estimate of premium savings for the individual health insurance market. Eighteen states that enacted MCLs between 2010 and 2021 are not yet seven full years post implementation. Assuming these states have a similar experience to states with seven or more years of post-implementation data, (Arizona, Connecticut, and New Jersey), we provide a back of the envelope calculation to quantify a lower bound of savings based on estimates reported in Fig. 2. Using the number of enrollees in our sample in the individual market in 2021, we estimate the premium savings soon to be realized by the eighteen states when they reach seven years post-implementation. The conservative SA estimate predicts a reduction in annual per enrollee premiums of $1663 scaled by the 5783,587 individual health insurance market enrollees in these eighteen states in our data. The resulting estimate in annual health insurance premium savings is approximately $9.6 billion. These savings accrue to medical cannabis users and non-users in the individual health insurance market due to the nature of insurance pooling and community rating. If MCLs were enacted nationally, conservatively, we expect to see a savings of at least $16.8 billion (10,115,334 enrollees * $1663).

There are some limitations to our study. Because of the design of our study, we exclude states that legalized medicinal cannabis prior to 2010, including California, Washington, Oregon, and Colorado, which are all key states in the movement to legalize cannabis. Thus, we note that our results reflect the aggregate impact of MCL adoption after the Ogden Memo of 2009. We also acknowledge that MCLs differ by state; all allow individuals with qualifying conditions to use cannabis related products for treatment but states differ on the health conditions that qualify for medical cannabis treatment. There is also variation in state level policies regarding how patients obtain medical cannabis, as documented by Pacula et al. (2014).

Due to the aggregate nature of our data, while we can comment on changes in health insurance premiums, we cannot speak to differences in health care utilization overall or differences across demographic groups. When considering all states which implemented MCLs between 2010 and 2021, we find a statistically significant decrease in premiums that emerges in year seven and is sustained through years eight and nine. However, the coefficients and confidence intervals for years 7, 8, and 9 are estimated from insurers in Arizona, Connecticut, and New Jersey, as these are the only states with seven or more years of post-implementation data. The impact of medical cannabis on states that adopted MCLs shortly after the Ogden memorandum may not be equivalent to the experience of states which adopted MCLs later. To examine potential heterogeneity in the impact of MCLs, illustrated in Fig. A1 in the Appendix, we separately run the analysis for early, mid, and late MCL adopters. It is possible that the states that enacted MCLs earlier in our sample are not representative of states that enacted later. We leave to future work a more nuanced examination of variation in MCL policy, law, and implementation.

The individual market for health insurance, in 2021, represented 6% of the non-elderly insured market. Thus, results from this study should be generalized with caution to enrollees in other insurance markets such as the group (i.e., employer-sponsored) market. Individual market enrollees are likely more sensitive to changes in premiums, because their premiums are not subsidized by their employer, and healthcare expenses are a sizeable part of household budgets. Moreover, there is likely more demographic overlap between medical cannabis users and those who are

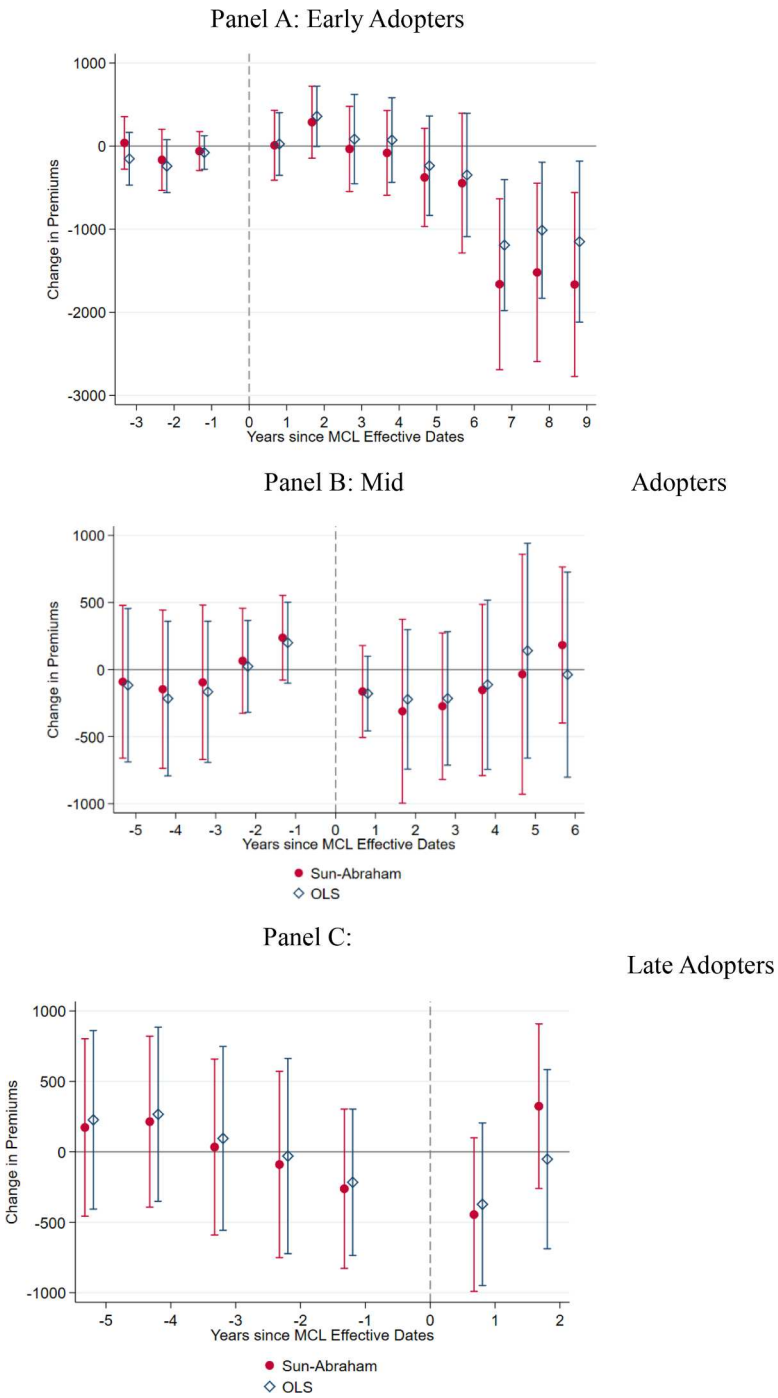

Fig. A1. Changes in Annual Individual Market Premium per Enrollee before and after Medical Cannabis Legalization: Subsample of Early, Mid, and Late MCL adopters. Panel A: Early Adopters Panel B: Mid Adopters Panel C: Late Adopters Notes: Fig. A1 shows the point estimates for the impact of medicinal cannabis laws on individual market health insurance premiums from the estimation of Eq. (1). We show three different time periods (early, mid, and late adopters). Time 0 is implementation of the medical cannabis law. We show two estimators: the Sun-Abraham estimator using as a control group the states that implemented laws late in the sample period (Sun-Abraham_last), and the Sun- Abraham estimator using a control group of states that have never had MCLs (Sun-Abraham_never). Standard errors are clustered at the insurer-state level and estimation includes both year and insurer-state fixed effects. Treatment 0 is aligned for all three panels to aid in comparison in the variation of estimates for pre and post periods for states with early, medium, and late adoption of MCLs.

insured through the individual market (see e.g., Goulet-Stock et al., 2017; Dai & Richter, 2019; Keisler-Starkey & Bunch, 2020). Collectively, the individual health insurance market is the most likely to see a direct benefit from MCLs in the form of lower insurance premiums.

Finally, we acknowledge that because we are only estimating changes in health insurance premiums, we are not capturing improved health, such as through older individuals being able to work more hours and having fewer workplace fatalities or better self-reported health as other cannabis-related studies have evaluated. Additionally, we do not capture the improved mental health benefits presumed by lower suicide rates. Thus, this is not a complete cost-benefit analysis as we are only evaluating direct expenditures on premiums and not benefits that are indirect and/or non-pecuniary such as lower pain or less nausea.

Conclusion

In this paper, we evaluate changes to U.S. individual market health insurance premiums following the legalization of cannabis for medicinal purposes. Since states have legalized cannabis over time (i.e., not uniformly) in the last few decades, we employ a difference-in-differences approach designed for variation in treatment timing. We provide evidence that although the effect does not begin until seven years post-medical cannabis law implementation, there is a significant and sizeable reduction in health insurance premiums. The individual market for health insurance has been long considered the market of last resort as most Americans receive subsidized health insurance coverage either through their employer or by the needs-based Medicaid program. When

we consider aggregate health insurance premiums in the individual market, positive externalities from medical cannabis legalization led to significantly lower premiums for all enrollees. The long-term impacts of cannabis legalization on health insurance premiums are not well-studied, and it is not clear how increased cannabis usage among teens and young adults may impact their future medical costs and utilization. However, initial concerns about medical cannabis legalization leading to increases in medical care costs, which would be reflected in higher insurance premiums, appear to be unfounded.

Author Contributions

The authors certify that we did not use AI in writing this paper.

Ethics approval

The authors declare that they have obtained ethics approval from an appropriately constituted ethics committee/institutional review board where the research entailed animal or human participation.

CRediT authorship contribution statement

Amanda C. Cook: Conceptualization, Methodology, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **E. Tice Sirmans:** Visualization, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization, Writing – original draft, Writing – review & editing. **Amanda Stype:** Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Appendix 1

We consider that there may be differential impacts of MCLs on health insurance premiums for states that were early, middle, or late adopters of MCLs, as the decision to legalize is not exogenous. To determine if states which legalized early (mid or late) have a more pronounced (muted) effect on premiums, we define three treatments related to timing of MCLs. First, we split our sample into states which adopted prior to 2016. These early adopters are Arizona, New Jersey, Connecticut, Delaware, Minnesota, and Illinois. Next, the mid-sample adopters are states which adopted between 2016 and 2018 (Arkansas, Florida, Maryland, West Virginia, New Hampshire, New York, Oklahoma, and Pennsylvania,). Finally, the late adopters include states which adopted MCLS between 2019 and 2021 (Louisiana, Missouri, Utah, North Dakota, Virginia, Ohio, and Alabama). Comparing estimates between the early, mid, and late adopters will provide evidence of whether MCL implementation timing was an important factor in the magnitude and direction of the impact of MCLs on individual market health insurance premiums. Results are shown in Fig. A1.

In Fig. A1 the three panels are aligned to compare estimates for the years before and after medical cannabis legalization. In panel A, we see point estimates and confidence intervals of the impact of MCLs on individual market health insurance premiums for the early adopters; states that legalized medicinal cannabis between 2010- 2015. In panel B, we see estimate for the impact on premiums for states that enacted MCLs between 2016 and 2018. Similarly, in panel C, we present results for states that adopted MCLs between 2019 and 2021.

In panel A of Fig. A1, we see that for early-adopter states, point estimates rise briefly, then consistently fall from years 3–9 after MCL enactment. This means that states which enacted medical cannabis laws had lower premiums relative to states without MCLs. The magnitude of the difference between premiums in early adopter MCL states (vs non-MCL states) increased each year after the second year of MCL enactment, becoming statistically significant in years 7, 8, and 9.

However, for the states which implement MCLs between 2015 and 2017, which are depicted in panel B, premiums decline for two years, but then return to being largely in line with non-MCL states by year 5, with none of the effects being statistically significant at the 5% level. In panel C, we see non-statistically significant reductions in the point estimates in the first two years after MCL enactment. Thus, for early, mid, or late adopting states, there seems to be a small increase in premium in the second full years after enactment. However, early moving states continue to see a decline in premiums for years 3 through 9, whereas mid-adopting states see an attenuated impact on premiums after year 3. Further work should investigate if these trends are in fact disparate as more years of data are available for more post implementation years for mid and late adopting states.

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