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Does Medical Marijuana Availability Reduce Prescription of Anxiety Medication and Improve Mental Health?

by

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Abstract

The number of drug prescriptions has increased dramatically over the past 20 years, benzodiazepine prescriptions being a prime example with an increase of 67 percent between 1996 and 2013. Benzodiazepines are usually prescribed for anxiety; a disease marijuana has been proven to have a small yet observed effect on. Simultaneously with the increase in benzodiazepine prescriptions, mental health has emerged as one of the most expensive health issues of our time estimated to cost the world $1 billion by 2030. This study uses state-level prescription data from Medicaid (1996-2018) and individual-level survey data from the Behavioral Risk Factor Surveillance Survey (2011-2018) to estimate the effect of an introduction of a medical marijuana law on benzodiazepine prescriptions and individuals' self-reported mental health. The impact is studied with a difference-in-differences approach using the legalization of medical marijuana as the policy change. This study finds that the number of benzodiazepine prescriptions increase after the introduction of medical marijuana. This study also finds that the number of days of ill mental health decreases a medical marijuana law is introduced. Unfortunately, the results are not statistically significant at conventional levels and are therefore considered suggestive.

Keywords: Medical marijuana law, Mental health, Benzodiazepines, Difference-in-differences

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1 Introduction

The number of drug prescriptions has increased dramatically over the past 20 years, benzodiazepine prescriptions being a prime example with an increase of 67 percent between 1996 and 2013 (National Institute of Drug Abuse, 2018). This increase has contributed to a drug epidemic, which is anticipated to be as deadly as the ongoing opioid crisis (Garrison, 2018; Schumann, 2018; Szalavitz, 2018). Physicians commonly prescribe benzodiazepines for anxiety and sleep deprivation (National Institute of Drug Abuse, 2018), disorders that marijuana has a small, but observed effect on (Sarvet et al., 2018). Until now, one state has legalized medical marijuana prescribed for anxiety conditions (New Jersey Department of Health, 2019), but more might follow (Borchardt, 2019; Sholtis, 2019). However, the use of medical marijuana for anxiety is also growing in states where medical marijuana is only legal for other conditions than anxiety (Corroon et al., 2017; Lucas & Walsh, 2017). The use is increasing at the same time as medical research finds that medical marijuana can be used to treat anxiety and symptoms related to it (Bergamaschi et al., 2011; Bakas et al., 2017; Cuttler et al., 2017).

To date, 33 states, including the District of Columbia have passed medical marijuana laws (National Conference of State Legislatures, 2019), making medical marijuana more available in these states. However, not much is known of the health economic effects of medical marijuana. One side effect of marijuana often discussed in media concerns the impact on mental health (Davis, 2019; Donnelly, 2019). Still, little research using statistical tools have looked into the effects of a medical marijuana law (MML) on the population's mental health. This lack of research is although ill mental health is emerging as one of the most costly disorders of the present day as it is estimated to cost the world 16 trillion USD by 2030 (The Lancet, 2018).

Resting on the arguments above, the research question of this study is: How are mental health and benzodiazepine prescriptions affected by the introduction of a medical marijuana law? To answer how mental health is affected, I analyze how self-reported mental health changes among the adult population of the US before and after an MML introduction. I also examine in detail how the prescription rate of the most common types of benzodiazepines is affected by the introduction of an MML. This analysis may provide evidence of how some of the most common

psychiatric medications are affected by the introduction of an MML. It may also show guidance on how to battle the growing issue with deaths related to benzodiazepines and mental health overall.

In this study, I use state-level prescription data from Medicaid (1996-2018) and individual-level survey data from the Behavioral Risk Factor Surveillance Survey (BRFSS) (2011-2018) to test the effect of the introduction of an MML on benzodiazepine prescription rates and days of self-reported ill mental health. The impact is studied through a classic difference-in-differences approach, using the legalization of medical marijuana as the policy change. Previous research (Cerdá et al., 2012; Pacula et al., 2014; Powell et al., 2018) suggest that the MMLs are designed differently in the states that introduce one. Therefore, I also run some of the estimations with interaction variables representing specific characteristics that may influence how the sample is affected to test whether the effect is heterogeneous in the population of this analysis.

The state-level results of this study suggest that the number of total benzodiazepine prescriptions increases with 15,044 after the introduction of an MML, the effect is however ambiguous as one of the benzodiazepines (Clonazepam) decreases by 5,119 prescriptions. These estimates are not statistically significant at conventional levels. The results of this study then contradict the previous evidence on self-medicating anxiety with medical marijuana instead of benzodiazepines even if there are only short-term effects. Nevertheless, the effect on early adopter states (introducing MML before 2010) shows results supporting the existing research, indicating that the states are heterogeneous. The early adopters experience a decrease in total benzodiazepines by 54,628 prescriptions. However, this result is also not statistically significant.

The individual-level results suggest that the days of self-reported ill mental health decrease by at least 1/10 of a day after the state introduces an MML. These results are, however, to be viewed as suggestive as they are the estimates of the states that introduced an MML between 2011 and 2018 and show rather doubtful robustness when adding control variables. The results are also not statistically significant at conventional levels. This sample also shows some signs of heterogeneity and both the male population and the high-income population show significant decreases in the number of days of ill mental health. However, as the main regression results are not stable to the inclusion of control variables the results may merely be viewed as guidelines and more research on this subject is needed to draw more definite conclusions.

The study is structured in the following way: First, the research topic and purpose of this study are presented. Section 2 introduces the institutional context surrounding MMLs and the differences between the states which have implemented it, section 2 also includes the previous research regarding the introduction of MMLs and identifies the research gap this study aims to fill. Then follows a description of the data used and the descriptive statistics of the sample. This is followed by the empirical strategy used to analyze the effect of an MML on mental health and benzodiazepine prescription. Section 5 presents the empirical results. Section 6 concludes this study.

2 Background

2.1 Institutional Background

In 1996, California became the first state to legalize marijuana for medical purposes under a physician's supervision. Since then, 32 additional states (as of January 2019) including District of Columbia have either legalized medical marijuana, decriminalized marijuana use, or legalized recreational marijuana use (Barna Bridgeman & Abazia, 2017; National Conference of State Legislatures, 2019). Medical marijuana is prescribed for several conditions and these also vary over the states. Physicians prescribe medical marijuana, for example, for chronic pain, depression, nerve diseases such as Parkinson's and epilepsy, and general anxiety disease. However, the marijuana plant is not FDA-approved, and thus, medical marijuana use is different, considering both the dosage and conditions it is prescribed for by the physicians, in the different states that have legalized it (WebMD, 2018).

Medical marijuana policies vary considerably across the states which have legalized it (Cerdá et al., 2012). All states with an MML require a licensed physician to recommend the use of medical marijuana and the recommendation only occurs if the patient suffers from one or more of the illnesses from a state-approved list (O'Keefe, 2013). In addition to the variation of the approved diseases, both the legal possession limit and its punishment differs significantly across the different states (Pacula et al., 2014). Some states have even decriminalized marijuana use or made it law enforcement's lowest priority (National Conference of State Legislatures, 2018).

There is also a difference between the states which adopted an MML before 2010 and those which adopted one after. This difference is mostly related to the variation in dispensary provisions over time that might be associated with a 2009 Obama administration policy (Smart, 2016). This policy recommended US Attorney Generals not to prioritize the federal prosecution of medical marijuana users and suppliers who complied with current state laws. This policy may have resulted in the dispensary policies designed after 2010 looking slightly different from earlier policies. Consequently, later adopters designed relatively strict policies in line with the

pharmaceutical regulation while early adopters had a more relaxed approach (Pacula & Smart, 2017). As a consequence of having more loose regulations, these states saw considerable increases in marijuana use even in the more recent time-period (Smart, 2016).

2.2 Related Literature

With the advent of MMLs, there is a growing literature in economics and medicine, which studies the impacts of medical marijuana availability. Previous studies have investigated the impacts on four broad groups of outcomes: prescriptions drugs, non-prescribed use of marijuana, deaths related to marijuana, and the mental health impacts of medical marijuana and conventional marijuana. I summarize these studies in the following four paragraphs. I then explain how my study adds to the literature on medical marijuana legalization.

Powell et al. (2018) conducted a study on how medical marijuana laws affect opioid overdose deaths from a health economic perspective. They find that there is a reduction in overdose deaths when introducing a medical marijuana law mostly connected to the relatively liberal allowance for dispensaries. Their findings suggest that access to medical marijuana may promote the substitution of marijuana for addictive opioids. Bradford and Bradford (2016; 2017) studied the effect of legalizing medical marijuana on prescription drugs filled by Medicare Part D and Medicaid. Their findings suggest that prescription drugs where marijuana might serve as the clinical alternative were significantly less used after legalization. Also, the reduction in Medicare program and enrollee were estimated to be around $165 million per year when states implemented medical marijuana laws in 2013. They also determined that if all states were to have legalized medical marijuana in 2014, this would save $1 billion for Medicaid.

When states introduce MMLs, the self-medication with medical marijuana increases as the therapeutic value of marijuana spreads. A study (Sarvet et al., 2018) concluded that self-medication with drugs was significantly higher in states with MMLs. The self-medication may be a possible effect of the legalization itself as it changes the perception of medical marijuana, making people believe that it has more general therapeutic uses. A likely unwanted secondary effect of the self-medication among adults is that marijuana use among adults in states where medical marijuana is legalized increases disproportionately compared to adults in states that have not legalized it. The increase in marijuana use may cause marijuana use disorders and that

illegal marijuana use increase as it is easier accessible from dispensaries. Studies (Hasin et al., 2017; Chu, 2014; Wen et al., 2015) show that medical marijuana laws seem to be partly responsible for the increased occurrence of illicit marijuana use and marijuana use disorders. This result may be a sign of marijuana being more accessible to the public as the state introduce medical marijuana, even without a physician's recommendation.

Several studies have looked into how MMLs impact mortality. Some (Anderson et al., 2013; Santaella-Tenorio et al., 2017; Hartman et al., 2016) have looked into the connection between traffic fatalities and medical marijuana. These studies found that legalization correlates with a decrease in fatal accidents during the first year after implementation. Another link between deaths and MMLs is the deaths caused by opioid overdoses. A study concluded that states with a medical marijuana law were associated with a lower rate of annual opioid overdose mortality (Bachhuber et al., 2014). Nearly 30 % of all opioid overdoses also include benzodiazepines as patients frequently use the drugs together. When co-prescribing the two drugs, the risk of death increases significantly compared to just having an opioid prescription. However, patients still use them together (Sun et al. 2017).

Despite the growing literature on the introduction of an MML, little research has shown how mental health is affected. One medical study found that marijuana use increased the risk of developing schizophrenia. However, the authors found no clear causality between marijuana use and psychosis, which is a commonly thought side-effect of marijuana use (Arseneault et al., 2004). Another possible mental health consequence of marijuana use is an effect on the number of suicides. A study found that suicides among men decreased after a state passed an MML (Anderson et al., 2013). One hypothesis for this negative relationship is that people may use marijuana as a coping mechanism against stressful life events. However, it remains clear that there is a research gap in the relationship between mental health and medical marijuana.

This study aims to provide some insight on this topic to further close this gap by analyzing the impact the introduction of an MML has on the self-reported mental health. Considering the previous research, I expect to find that self-reported health improves as marijuana appears to be used to deal with events that worsen mental health. I also aim to answer whether patients use medical marijuana as a substitute for benzodiazepines, an anti-anxiety medication. This is to link the research on declining prescription rates after the introduction of an MML and the research on self-medication with medical marijuana. Taking the previous research by Bradford

and Bradford (2016;2017), and Sarvet et al. (2018) in mind, I expect to find a decline in the number of benzodiazepine prescriptions after the introduction of an MML.

3 Data

In this study, I employ data at the state level and at the individual level from a variety of sources. I describe each of these in turn below.

3.1 State-Level Data on Benzodiazepine Prescriptions

I use data on the number of prescriptions of the benzodiazepine medicines Alprazolam, Clonazepam, and Diazepam on the state-level over the years 1996-2018 from the Medicaid State Drug Utilization Data (Medicaid, 2018). These three benzodiazepines are according to the National Institute of Drug Abuse (2018), three of the most commonly prescribed benzodiazepines in the USA. The State Drug Utilization Data on FDA-approved prescription medicine has been collected since the start of the Medicaid Drug Rebate Program in 1990. Some of the prescription rates of some of the states were suppressed due to confidentiality, therefore the number of observations available varied from state to state, especially in the earlier years. I decided, therefore, to analyze data from 1996 to 2018. However, as the timespan is adequately long, the sample is considered representable. Medicaid is the largest source of health coverage in the USA and can cover almost all low-income citizens under age 65 (Medicaid, 2019). The low-income of the sample might be a limitation, and future research is needed to understand the prescription drug responses of the higher income population.

Table 1 State-Level Descriptive Statistics

VARIABLES	(1) N	(2) Mean	(3) SD	(4) Min	(5) Max
Number of Benzodiazepine prescriptions:					
Alprazolam	1,149	87,701	105,401	14	602,276
Clonazepam	1,147	82,072	149,756	40	4,064,000
Diazepam	1,152	37,304	39,336	75	283,329
Total	1,177	202,105	249,721	0	4,118,000

Table 1 shows the descriptive statistics of the state-level sample. Here, the mean and standard derivation of the three most commonly prescribed benzodiazepines and the total of these three are visible. Table 1 displays the benzodiazepine drugs in order of the number of prescriptions. The number of observations is 51 states, including District of Columbia, over 23 years and varies slightly due to the availability of data from Medicaid.

The variable of whether a state has an MML or not and at what time the state introduced the MML was constructed using data from the National Conference of State Legislatures (2019). Here, all states (including District of Columbia) that have passed a medical marijuana law was considered to have introduced it. The dataset does not include states where only cannabidiol (CBD) is legal.

3.2 Individual-Level Data on Mental Health

I use self-reported mental health data on the individual-level from the Behavioral Risk Factor Surveillance System (BRFSS) over the years 2011-2018. The BRFSS collects data on US residents concerning their health-related risk behaviors, chronic health conditions, and use of preventive services (CDC, 2019). Unfortunately, the weighting scheme of the BRFSS changed in 2011, so the years leading up to 2011 are not comparable to 2011 and later data (CDC, 2018). The question of interest in the survey was asked as "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?". The BRFSS dataset is a combined landline and cell phone dataset submitted each year and it includes data for individuals from the 50 states, the District of Columbia, Guam and Puerto Rico (CDC, 2019). I have included the 50 states and District of Columbia in my analysis. The survey consists of over 400,000 interviews each year, making it the most extensive continuous health survey system of the world (CDC, 2019). Hence, although the timespan is limited, it is the largest available data source and provides estimates that contribute to the current research gap on mental health responses of the introduction of an MML.

Table 2 State-Level Descriptive Statistics

VARIABLES	(1) Fraction	(2) Mean	(3) SD
Number of Days Mental Health Not Good		3.424	7.749
Gender			
Male	41.65 %	1	0
Female	58.35 %	2	0
Income Level (Annual Household)			
Less Than $10,000	5.55 %	1	0
$10,000 - $15,000	5.92 %	2	0
$15,000 - $20,000	7.89 %	3	0
$20,000 - $25,000	9.58 %	4	0
$25,000 - $35,000	11.27 %	5	0
$35,000 - $50,000	14.54 %	6	0
$50,000 - $75,000	15,79 %	7	0
More Than $75,000	29,47 %	8	0
Race/Ethnicity Category			
White, Non-Hispanic	77.51 %	1	0
Black, Non-Hispanic	8.11 %	2	0
Other Race Only, Non-Hispanic	4.50 %	3	0
Multiracial, Non-Hispanic	1.93 %	4	0
Hispanic	7.96 %	5	0
Age in six groups			
18 to 24	5.32 %	1	0
25 to 34	9.94 %	2	0
35 to 44	12.01 %	3	0
45 to 54	16.77 %	4	0
55 to 64	22.29 %	5	0
65 or older	33.66 %	6	0

Table 2 above shows the descriptive statistics of the individual-level data. More specifically, the number of days when mental health was not good (in the past 30 days). As we can see, with an average of 3.4 and a standard deviation of 7.7, the number of days of ill mental health is on average random. Table 2 above also shows the descriptive statistics of the categorical variables. The classifications used to describe the categories are those used by the BRFSS in the survey. The different categories are displayed in fractions to show that the sample is on average random. The descriptives suggest that the sample is a bit older, mostly white, and has a slight majority of females. However, considering this, the sample is still reasonably representative for the US and is therefore used in this analysis.

4 Empirical Strategy

In order to estimate the causal effect of the introduction of MMLs on benzodiazepine prescriptions and mental health, I estimate a series of difference-in-differences models. In particular, for the state-level analysis, I estimate:

$$Y_{st} = \alpha + \beta MML_{st} + \lambda_t + \mu_s + \epsilon_{st}$$

The Y-variable in the state-level study is the number of benzodiazepines prescriptions. The Y-variable is the number of prescriptions of the three most common benzodiazepines and the total of these, and thereby of three of the most commonly prescribed medications for anxiety in the US (National Institute of Mental Health, 2016). The subscript *s* denotes state and the subscript *t* denotes years. MML_{st} is an indicator variable that takes value 1 if state *s* has passed an MML at time *t* and 0 otherwise. As the legalization of medical marijuana occurs at different times for different states, the estimation equation does not include a time variable. Instead, year fixed effects λ_t are included to control for the unobserved factors that are invariant over time are not independent of the value of MML_{st} for all time periods. Also, all estimations include μ_s, a vector of state fixed effects, to allow for level differences between the different treated states.

The MML-variable (the difference-in-differences-variable) takes value 1 when the legalization occurs in a state. Hence, the parameter of interest is β. In all specifications, standard errors are clustered on the state-level to correct for the serial correlation. The clustered standard errors allow for arbitrary within-state correlation in error terms but assume independence across the states (Bertrand et al., 2004). The 33 states (including District of Columbia) where medical marijuana legal within the timespan are the treatment group and the remaining states are the control group. Some estimations include control variables as the number of prescriptions and the usage of marijuana might not be random. These are the unemployment rate and whether marijuana was decriminalized in a state in a given year. These variables control for economic downturns and legal repercussions of using marijuana as both of these may affect both the use of anxiety medication and the use of marijuana.

For difference-in-differences to have a causal effect, the assumption of parallel trends has to be fulfilled. Otherwise, the estimator is biased, this means that the control group and the treatment

group have parallel trends, and if there would be no policy change, I assume that the trends would have continued to be parallel (Meyer, 1995). A placebo check with leads of the years (1 and 2 years) leading up to the introduction of the MML was performed to determine that the data in the study did not violate this assumption. The placebo check controls for an effect in the years where there is not supposed to be an effect and thereby conclude strict exogeneity of the introduction of the MML (Freyaldenhoven et al., 2018). If the leads are insignificant, I conclude that there was no effect before the introduction of the MML. No effect before the MML supports the assumption of parallel trends between the control group and the treatment group and can, therefore, interpret the difference-in-differences estimates as causal effects.

To control for heterogeneity among states, I added an interaction variable between early adopters and the MML-variable to the estimation. One key difference between early and late adopters of MMLs (late adopters introduced an MML in 2010 or later) is that the late adopters more tightly regulated the dispensaries and decreased the access to medical marijuana (Pacula & Smart, 2017; Smart, 2016). The estimation includes an interaction variable between high unemployment states and the MML-variable to control for the heterogeneity in unemployment among states as this greatly affects the likelihood of suffering from anxiety and also using marijuana (Lynskey et al., 2002).

The individual-level analysis I estimate with an equivalent regression:

$$Y_{ist} = \alpha + \beta MML_{ist} + \lambda_t + \mu_s + X_{ist} + \epsilon_{ist}$$

The difference in this analysis compared to the state-level analysis is the Y-variable, which the number of days of ill mental health in the past 30 days measured on the individual-level. I also control for X_{ist}, a vector of individual-level controls. These control variables are gender, age, and income level are included to control for different characteristics among the individuals. The estimation also includes state-level control variables as the introduction of an MML might not be random. To control for heterogeneity in the individual sample, I include interaction variables between gender, whether the individual lived in a high unemployment state, and the income level of the individual and the MML-variable. All of these characteristics might influence the likelihood of suffering from ill mental health as well as the likelihood of using marijuana (Lynskey et al., 2002; Galea et al., 2007; Anderson et al., 2013). The individual-level sample was not divided based on being early or late adopters as the timespan started in 2011, and therefore, all states that introduce an MML are late adopters.

5 Results and Discussion

In this section, the results of this study are presented. First, I present the results of the aggregated state-level analysis and then follows the results of the individual-level analysis.

5.1 State-Level Results

Table 3 Main Results State-Level

VARIABLES	(1) Alprazolam	(2) Clonazepam	(3) Diazepam	(4) Total
MML	8,340	-5,119	4,194	15,044
	(17,620)	(9,017)	(5,860)	(30,178)
Observations	1,149	1,147	1,152	1,177
R-squared	0.709	0.347	0.693	0.601
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 above shows the results when regressing the introduction of an MML on three of the most prescribed benzodiazepines and the total of these three. Although all estimates are insignificant, the results indicate that legalizing medical marijuana increases the number of prescriptions of benzodiazepine drugs. The increase is especially visible for the total of the three most prescribed benzodiazepines. Even though I find a negative effect on Clonazepam, the other coefficients show a positive effect on the amount of prescriptions. The coefficients suggest that the number of benzodiazepine prescriptions increases with a total of 15,044 prescriptions per year and state. This is a noticeable increase as the mean total prescriptions per state and year is 202,000 (see Table 1 for descriptives). For all the different types of benzodiazepines except for Clonazepam in this analysis, the same interpretation can be made, that the introduction of an MML leads to a relatively large increase in prescription rates for

benzodiazepines medications. However, as there are signs of some ambiguity, controls are added to the estimations in Table 4 below to show robustness.

The main results on the number of benzodiazepine prescriptions contradict the current research on prescription rates (Bradford & Bradford, 2016; Bradford & Bradford, 2017). The reason for this contradiction could be that this study has a larger time-span, as the studies by Bradford and Bradford use limited time spans over about four years. The increase in the number of prescriptions may be a result of a still on-going upward trend for benzodiazepines. This trend is evident in the mortality rates connected to benzodiazepines, which are continuously growing (National Institute of Drug Abuse, 2018). It may also be that there is some heterogeneity between the different states, for example, due to the economic crisis hitting states differently and thereby influencing anxiety among the population. Another explanation is that there are differences between early adopter states and later ones, as the availability of medical marijuana varies with the laws on dispensaries. Therefore, I later introduce interaction variables to the regression to test for possible heterogeneity in the sample (see Table 7 below).

Table 4 Adding controls to the state-level regression of total benzodiazepines

VARIABLES	(1) Alprazolam and Controls	(2) Clonazepam and Controls	(3) Diazepam and Controls	(4) Total and Controls
MML	6,302	-5,849	3,098	12,436
	(17,277)	(9,369)	(5,770)	(29,892)
Unemployment Rate	9,788**	-328.9	2,253	12,408
	(4,578)	(7,939)	(1,756)	(11,217)
Decriminalized	2,296	4,725	4,319	798.9
	(15,198)	(9,830)	(4,127)	(25,887)
Observations	1,149	1,147	1,152	1,177
R-squared	0.714	0.347	0.695	0.603
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 above shows the results when the control variables unemployment rate and if the state has decriminalized marijuana are added to the baseline regressions of the different types of benzodiazepines and also to the total number of prescribed benzodiazepines. It is clear that the

results remain stable to the inclusion of both state-level controls as neither the magnitude nor the significance of the MML variable change after the inclusion.

Table 5 State-level robustness checks with of placebo leads of one and two years

VARIABLES	(1) Alprazolam 1 Year	(2) Clonazepam 1 Year	(3) Diazepam 1 Year	(4) Total 1 Year	(5) Alprazolam 1 & 2 Year	(6) Clonazepam 1 & 2 Year	(7) Diazepam 1 & 2 Year	(8) Total 1 & 2 Year
MML	10,228	-3,527	4,551	16,148	12,836	-2,551	5,094	19,513
	(19,613)	(9,967)	(6,510)	(33,516)	(21,603)	(11,826)	(7,247)	(36,862)
1 Year Lead	10,659	9,107	2,066	6,278	12,528	9,816	2,462	8,686
	(14,418)	(11,263)	(4,207)	(29,443)	(16,160)	(12,904)	(4,769)	(32,495)
2 Year Lead					14,102	5,197	2,941	18,347
					(14,119)	(17,937)	(4,536)	(28,946)
Observations	1,149	1,147	1,152	1,177	1,149	1,147	1,152	1,177
R-squared	0.709	0.347	0.693	0.601	0.709	0.347	0.693	0.601
State FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 above shows the placebo checks with one and two years leads. All of the placebo leads are non-significant, supporting the assumption of parallel trend and no effect in the years leading up to the introduction of an MML. However, for Alprazolam and Diazepam, the assumption might not hold as the coefficients on the leads are almost as large as the main regression coefficients. This result means that only the results for Clonazepam and the total number of prescriptions in the main regression can be interpreted as causal. However, as seen in Table 3, the causal effect goes in different directions as the number of prescriptions decrease for Clonazepam and increase for the total number of benzodiazepine prescriptions. The one-year lead coefficient of total benzodiazepines is relatively small compared to the real effect after the state introduces the MML. This small coefficient implies no signs of an anticipatory effect right on the total number of prescriptions before the MML introduction. The absence of an anticipatory effect yields even more support to the assumption of parallel trend for the total number of benzodiazepines.

Table 6 Heterogeneity checks on state-level, dividing the states on different characteristics

VARIABLES	(1) Alprazolam	(2) Clonazepam	(3) Diazepam	(4) Total	(5) Alprazolam	(6) Clonazepam	(7) Diazepam	(8) Total
MML	4,704	-16,761	5,305	-11,516	13,227	11,169	1,829	37,425
	(27,928)	(12,346)	(8,318)	(45,966)	(16,375)	(10,234)	(5,342)	(31,591)
MML x High Unemployment	7,414	23,801	-2,270	51,718				
	(28,447)	(15,141)	(7,176)	(49,850)				
MML x Early Adopter					-11,450	-39,262**	5,612	-54,628
					(34,535)	(17,940)	(8,855)	(58,544)
Observations	1,149	1,147	1,152	1,177	1,149	1,147	1,152	1,177
R-squared	0.709	0.347	0.693	0.602	0.709	0.348	0.693	0.602
State FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 above shows the results when introducing indicator variables to the regression based on high unemployment and whether the state was an early adopter or not. This indicator variable was introduced to test for heterogeneity in the sample. Early adopters introduced an MML in 2009 or earlier, as later adopters introduced stricter laws on dispensaries in 2010. Here, it is visible that the states with high unemployment, as a matter of fact, encounter an increase in the number of benzodiazepine prescriptions. This increase is especially evident for the total number of benzodiazepines which experienced an increase of 51,718 prescriptions after the introduction of the MML. There is, however, some ambiguity in these results as well, the number of Diazepam prescriptions decreased by 2,270, making the link between high unemployment state, MMLs, and benzodiazepine prescriptions less clear. Nevertheless, the increase is even more substantial than the main results, implying that the high unemployment states experience a stronger effect from introducing an MML on benzodiazepine prescription rates. It may also be a consequence of the higher prevalence of anxiety in high unemployment states (Tefft, 2011), as the number of benzodiazepine prescriptions has to correlate with the prevalence of anxiety.

Table 6 above also shows that the states that are early adopters, hence with less strict laws on dispensaries, see a decrease in the number of prescribed benzodiazepines after the introduction of the MML. The decrease is only significant for Clonazepam with a decrease of 39,262 prescriptions. For the total number of benzodiazepine prescriptions, the decrease is 54,628 prescriptions. These results also show some ambiguity as Diazepam increases with 5,612 prescriptions. The results in Table 6 confirm the theory introduced by among others Powell et

al. (2018) that there is a vast difference between states introducing the MML early and the states that introduced the MML after 2010. This result could mean that in the availability of medical marijuana has an impact on the number of benzodiazepine prescriptions. This result contradicts the main results but supports the results found by Bradford and Bradford (2016; 2017) on the relationship between medical marijuana and prescription medicine. Interestingly, as mentioned before, the Bradford studies (2016; 2017) cover the timespan after the introduction of stricter laws on dispensaries. Meanwhile, my results find that the decrease in prescriptions is only evident among early adopters, hence before 2010. Hence, there seems to be conflicting results and further research is needed to definitively conclude the relationship between MMLs and prescription drugs.

5.2 Individual-Level Results

Table 7 Individual-level main results and robustness checks in with individual control variables, state control variables, and Placebo leads of one and two years

VARIABLES	(1) Days Of Ill Mental Health	(2) Days Of Ill Mental Health Individual Controls	(3) Days Of Ill Mental Health State Controls	(4) Days of Ill Mental Health Leads
MML	-0.0971	-0.0577	-0.102*	-0.0298
	(0.0858)	(0.0677)	(0.0555)	(0.0695)
Male		-0.988***	-0.988***	-0.824***
		(0.0272)	(0.0274)	(0.0221)
Age		-0.328***	-0.329***	-0.499***
		(0.0236)	(0.0233)	(0.0199)
Income Level		-0.684***	-0.684***	-0.736***
		(0.0310)	(0.0309)	(0.0189)
Unemployment Rate			0.0797***	0.0315*
			(0.0257)	(0.0164)
Decriminalized State			0.0402	0.0195
			(0.0561)	(0.0361)
1 Year Lead				0.00510
				(0.0517)
2 Year Lead				0.00938
				(0.0581)
Observations	2,759,180	2,759,180	2,759,180	2,759,180
R-squared	0.169	0.207	0.207	0.120
State FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7 column (1) shows that self-reported ill mental health decreases by a 1/10 of a day after introducing an MML. This result is a reasonably large decrease as the maximum number of days to report is 30, and the average number of days reported is 3.4. However, this result is insignificant and is therefore only suggestive. Table 7 column (2) shows the results when adding control variables of individuals' characteristics. The coefficient of MML is unfortunately unstable to the addition of individual-level controls. Table 7 column (3) shows the results when adding state-level control variables. Here, the MML coefficient is approximately of the same magnitude as in the main regression. However, the significance changes, and it is no longer

possible to establish that the MML coefficient is stable to the addition of state-level controls. This lack of stability when adding controls make the results less convincing and causality is difficult to infer.

Table 7 column (4) shows the results when including leads for one and two years before the introduction of the MML. The estimations with leads for 1 and 2 years show that the effect is non-significant in the years leading up to the reform and that the point estimates show that the self-reported days of ill mental health was increasing leading up to the reform. These estimates may be the signs of a trend breakage at the time of the MML introduction, causing mental health to increase. Also, the point estimates of the leads are small compared to the main results, implying that there is no effect before the introduction of the MML. The results in Table 7 column (4) thereby support the assumption of a parallel trend. However, as mentioned above, the MML coefficient is not stable when adding controls, and causality is still hard to infer.

The lack of stability may be a result of the relatively short time-span of the individual-level sample. A shorter sample yields fewer states going from untreated to treated and it also gives the states a rather short post treatment time. Hence, the long-term effects may be more stable, but these are impossible to estimate using this sample. It may also be that there exists a systematic relationship between the MML variable and the individual and state control variables. This systematic relationship may show that the ones who use medical marijuana and/or are affected by ill mental health are not random. Therefore, heterogeneity in the sample is tested in the results displayed in Table 8 below. The heterogeneity tests are based on the some of the individual and state control variables in Table 7 above to see whether it there is a large difference within the sample.

Table 8 Individual-level heterogeneity checks, dividing up the sample based on characteristics

VARIABLES	(1) Days Of Ill Mental Health	(2) Days Of Ill Mental Health	(3) Days Of Ill Mental Health
MML	0.460***	1.929***	-0.0156
	(0.0960)	(0.142)	(0.0718)
MML x Male	-1.160***		
	(0.0483)		
MML x High Income		-2.786***	
		(0.151)	
MML x High Unemployment			-0.113
			(0.130)
Observations	2,759,180	2,759,180	2,759,180
R-squared	0.171	0.178	0.169
State FE	YES	YES	YES
Year FE	YES	YES	YES

Robust standard errors clustered on the state-level in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8 above shows the results when introducing interaction variables. Column (1) shows the results when introducing an MML on the male population, here the self-reported days of ill mental health decrease by more than one day. The result is significant on a 1 %-level. As the sample is 40 percent male, the average of the MML coefficient and the MML x Male coefficient is not equal to the main regression estimate in Table 7 column (1). Column (2) shows the results when introducing an MML on the high-income population, here the self-reported days of ill mental health decrease by more than two and a half days. This result is also significant on a 1 %-level. Column (3) shows the result when introducing an MML on the high unemployment state population, here the self-reported days of ill mental health decrease by almost 1/5 of a day. However, this result is not statistically significant. The sample was not divided on whether the state was an early adopter or not as the time-period of the sample starts in 2011, which is after the change in the dispensaries took place.

The individual-level analysis provides supporting evidence to the study by Anderson et al. (2013), which found that suicides among men declined in states with an MML introduction. The findings of this study also support the hypothesis of especially men using marijuana to cope with stressful life events. This hypothesis is coherent as mental health improves for the entire population with 1/10 of a day while the male population endures a decrease of more than a day

of ill mental health. Another interesting factor from the heterogeneity results is that the population with an income higher than the average experiences a larger decrease in ill mental health days. This increase might be due to the evidence showing that people with higher income are more likely to consult a doctor than those with a lower income (Devaux, 2015). The higher likelihood of consulting a doctor may result in a more extensive availability of medical marijuana for the high-income population. However, as the number of years in the individual-level study is limited, the results are suggestive and more research is needed to draw any definite conclusions.

6 Conclusion

The state-level results of this study show that the introduction of an MML affects the number of prescribed benzodiazepines in a mostly positive direction. This causality can only be inferred on Clonazepam and the total number of benzodiazepine prescriptions. However, the effect is ambiguous as the Clonazepam prescriptions decrease by 5,119 prescriptions while the total number of prescriptions increase by 15,044 prescriptions. The state-level results also show that states with high unemployment encounter a large increase compared to the main results. On the contrary, the states who were early adopters experienced a decrease in prescriptions. This decrease could be due to the different laws on dispensaries, as the availability of medical marijuana might vary with this factor.

The individual-level results show at least a decrease in the days of self-reported ill mental health of 1/10 of a day, and this was especially evident for the male population and the high-income population. Previous research supports the results showing an improvement in mental health for the men, as suicides also have been shown to decline with the introduction of an MML. The reasoning behind the increase for the high-income population is less explored but may be due to more knowledge of the health system and thereby making medical marijuana more available. It is, however, difficult to infer causality in the individual-level results and the results are not robust to the inclusion of control variables, so these results should be interpreted with caution.

To conclude, the introduction of an MML could cause the prescription rates of benzodiazepines, an anti-anxiety medication, to increase and individuals' ill mental health days to decrease. This connection is, however, still a rather unexplored field and more research is required to be able to draw policy implications. This future research should focus on the mechanism that drives the effect of medical marijuana on mental health. For this, the sample would require a larger time-span which unfortunately was not easily accessible for this study.

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