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Medical marijuana laws and their effect on opioid related mortality

Susan Averett
Lafayette college

Emily Smith
Lafayette College

Abstract

The U.S. is currently in the midst of an opioid epidemic. In 2015, an estimated 12.5 million people misused opioid prescriptions. In 2016 alone, approximately 62,000 Americans died from an opioid overdose. The enactment of medical marijuana laws may help stem the rise in these deaths if medical marijuana can be used as a substitute for more powerful opioid pain relievers. Currently, 29 states have some form of a medical marijuana law in place, with California being the first in 1996 and West Virginia being the most recent in 2017. In this study, we use state level data from the Centers for Disease Control to test the hypothesis that medical marijuana can act as a prescribed substitute for opioid pain relievers and have the potential benefit of reducing deaths related to opioids in states with these laws. We use a difference-in-difference framework that takes advantage of variation in the timing of the enactment of these laws across states to identify whether they affect opioid-related death rates. Unlike previous work, we find little evidence that the enactment of MMLs has reduced opioid death rates. However, we do find that the presence of a legal dispensary may reduce opioid deaths. This information is useful for policymakers who are increasingly looking for policies to reduce opioid deaths.

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Contact: Susan Averett - averetts@lafayette.edu, Emily Smith - smithee@lafayette.edu.
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1. Introduction

Over the past 15 years, there has been a substantial increase in the number of opioid overdose related deaths while the number of prescription opioids sold to hospitals, pharmacies, and doctors' offices has almost quadrupled (CDC, 2017). According to the CDC, the number of deaths related to an opioid overdose has more than quadrupled since 1999 and nearly half of these opioid overdoses are related to prescription opioids (CDC, 2017). This problem has continued to grow. In 2013 alone, there were almost 250 million opioid prescriptions written, enough for every adult American to have their own bottle (CDC, 2017).

Currently, 29 out of 50 states have some sort of medical marijuana law (MML) enacted, starting with California in 1996 and most recently with West Virginia in 2017 (ProCon, 2017). MMLs are heavily debated over their perceived positive or negative impacts on a community. For example, there is a debate about whether or not adolescent marijuana use increases with MMLs (e.g. Wall et al. 2011 and Anderson et al. 2015). However, scholars have established that many individuals seek marijuana to treat chronic pain. For example, Nunberg et al. (2011) document that in California, half of all patients seeking medical marijuana did so to replace a prescription opioid medication. In this paper, we test the hypothesis that MMLs may have a positive externality by lowering opioid-related mortality rates. We find suggestive evidence that this is the case but only if the state has also opened a legal dispensary.

In the next section we review previous literature; then turn to data and methods. Following that, we discuss our findings and their implications for future research.

2. Previous literature

Given the fact that the trend in opioid deaths is positively correlated with laws that legalize marijuana use, scholars have aimed to discern if MMLs might affect opioid related deaths. To date, we are aware of two published studies that aim to uncover a potential causal link between opioid deaths and MMLs. These are by Bachhuber et al. (2014) and Powell et al. (2018). Bachhuber et al. (2014) use data from the Wide-Ranging Online Data for Epidemiologic Research (WONDER) interface of the CDC for the years 1999-2010 and a difference-in-differences strategy to estimate the effect of MMLs on opioid mortality. They report that MMLs have led to a reduction in opioid mortality.

Using the Treatment Episode Data Set (TEDS) and the National Vital Statistics System (NVSS), Powell et al. (2018) use data from 1999-2012 to examine the effect of MMLs on treatment admission for pain relievers and data from 1999-2013 to examine the effect of MMLs on opioid deaths. Importantly, they also examine the role of having a legal and active marijuana dispensary in a state on opioid deaths. They note that having access to dispensaries is associated with greater access to and use of marijuana and hence this is the relevant law to investigate. They also use a differences-in-differences method, and they find that states with legal marijuana dispensaries have a decrease in both opioid addictions and overdose deaths.

Our main contribution to this literature is the use of more recent data. Given that after the above papers were published, opioid deaths have continued to rise and Maryland, Minnesota and New York have all enacted MMLs further investigation is warranted. In addition, a number of states have legalized dispensaries increasing access to marijuana in those states. Thus, with more data and additional laws passed, we may find a change in the relationship between MMLs and opioid deaths. A second contribution is that in some specifications, we allow estimates of the effect of MMLs to vary by demographic characteristics of the state, namely the percent population white and the percent population male. We discuss this further below.

3. Data and Methods

The state-level data for the rate of opioid-related mortality for this study is collected from the CDC WONDER. We follow the coding used by the CDC to categorize deaths into those related to opioids. In particular, we use the ICD-10 codes to identify overdose deaths. These include codes X40-X44, X60-64, X85, or Y10-Y14. We then use the CDC drug identification codes to limit our measure to overdose deaths related to opioids which are codes T40.2-T40.4. These are the same codes as reported by Powell et al. (2018). Bachuber et al. (2014) use similar coding. Our data spans the years 1999 to 2015 and is collected information from the death certificates from all U.S. states and the underlying cause of death as well as the mortality and population count for each U.S. state.

As shown in Table I, Oregon, Washington, California, and Alaska all enacted MMLs prior to 1999, with California being the first in 1996. Between 1999 and 2010, twelve states in total enacted MMLs with Maine in 1999 and Arizona, Washington D.C. and New Jersey in 2010. Between 2010 and 2017, fourteen states have enacted MMLs with West Virginia being the most recent in 2017 (ProCon, 2017). In column 2 of Table I, we present the year that the state had an active legal dispensary up and running if it did so. The dispensary years refer to the first full year that the dispensary became legal in the state so that we are sure to capture legal and hence easier access to medical marijuana.

Using a difference-in-differences framework, we take advantage of variation in the implementation of MMLs over time and across states and use state level data to estimate equation (1) below:

$$\ln(mortality_{st}) = \beta_0 + \beta_1(MML_{st}) + \beta_2(X_{st}) + V_s + W_t + \varepsilon_{st} \qquad (1)$$

The logarithm of the age-adjusted mortality rate for each state is the dependent variable with the MML dummy variable representing the presence or absence of an enacted MML in a particular state and year. X_{st} represents a set of control variables in state *s* at year *t* in the model. We control for the unemployment rate, the percentage of the population that is white as well as the percentage of the population that is male, as the CDC indicated these to be influential demographic factors associated with prescription drug abuse. Along with these economic and demographic controls, we also control for whether or not a state has a prescription drug-monitoring program in place. We include the state alcohol tax as a control variable since alcohol may act as a potential substitute for marijuana and may affect opioid use and abuse as shown in previous literature. We also control for the political party of the state's governor. We include state and year fixed effects, V_s *and* W_t. The state fixed effects account for the influence of time-invariant factors at the state level such as state sentiment towards marijuana use and ensure that estimates of the association between MMLs and opioid fatalities are identified using only within-state variation over time. The year fixed effects are included to account for year-to-year changes in opioid fatalities that were common across all 50 states and the District of Columbia. As is customary in this literature, we cluster our standard errors by state.

Table I. Enactment of Medical Marijuana Laws and Legally Protected Dispensary Laws by State.

State	Year of Enacted MML	Year of Enacted Legally Protected Dispensary Law
Alaska	1998	
Arizona	2010	2013
Arkansas	2016	
California	1996	2004
Colorado	2000	2011
Connecticut	2012	2015
Delaware	2011	
Florida	2016	
Hawaii	2000	
Illinois	2013	
Maine	1999	2012
Maryland	2014	
Massachusetts	2012	
Michigan	2008	
Minnesota	2014	2014
Montana	2004	2014
Nevada	2000	2014
New Hampshire	2013	
New Jersey	2010	2013
New Mexico	2007	2010
New York	2014	
North Dakota	2016	
Ohio	2016	
Oregon	1998	2014
Pennsylvania	2016	
Rhode Island	2006	2014
Vermont	2004	2014
Washington	1998	2014
Washington DC	2010	2014
West Virginia	2017	

Sources: Column 2, Procon.org. Column 3, adapted from Powell et al. (2018) and updated with various sources.

In some specifications we add interactions between MML and percent white and MML and percent male to equation (1). Finally, as noted earlier, because what may be more important is the ability to obtain medical marijuana from a legal dispensary, in an additional specification, we also estimate equation (1) adding in a control for whether there is a legal and active marijuana dispensary in the state.

We also perform a complementary event study analysis to estimate lagged effects while also testing for pre-existing trends For this approach, we estimate equation (1) while allowing for differential effects based on the time relative to adoption. We include indicators representing 5 or more years prior to adoption, 4 year prior to adoption, 3 years prior to adoption, 2 years prior to adoption, year of adoption, 1 year after adoption, 2 years after adoption, and 4 or more years after adoption. Our reference category is the year prior to the adoption. We estimate the event studies for MMLs and dispensaries jointly as suggested by Powell et al. (2018).

4. Results

4.1. Descriptive results

In figure 1, we show the trends in opioid-related mortality rates between 1999 and 2015 for each state. It is clear that states are trending very differently over time in opioid death rates and that the rate of increase for many states has accelerated in recent years. Due to small cell sizes, death rates are not reported for some states in some years.

Figure 1. Trends in opioid overdose mortality rates by state from 1999-2015.

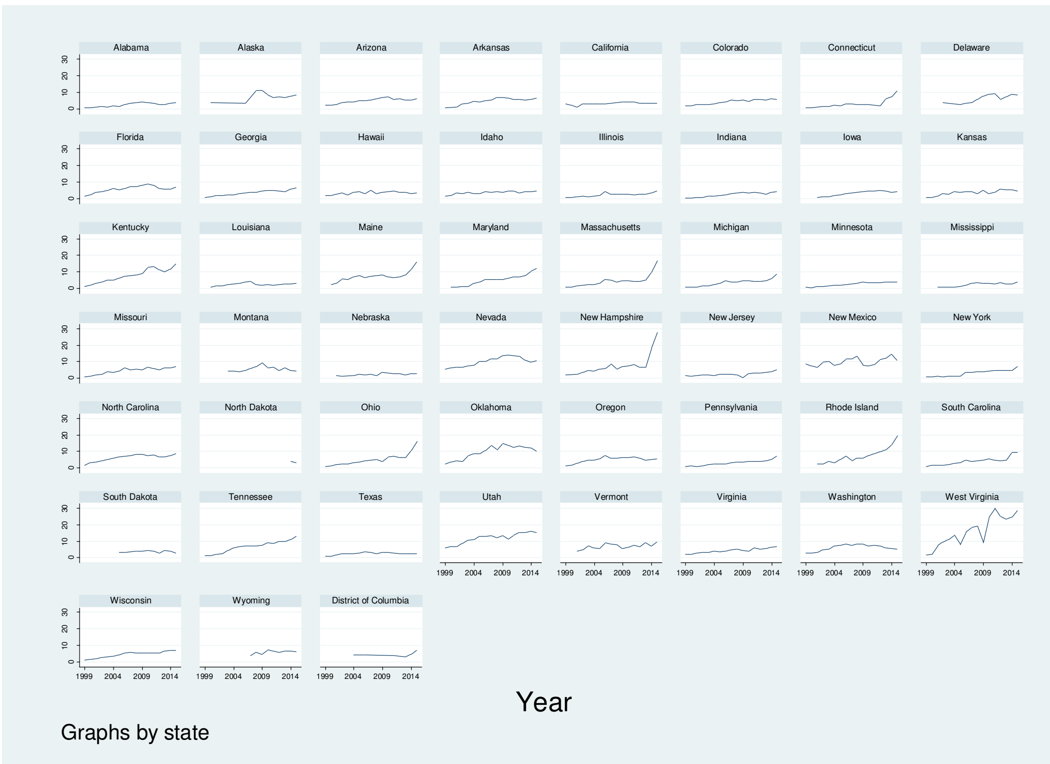


Table II presents the summary statistics of the variables included in the model. The dependent variable of interest, age-adjusted opioid overdose mortality rate, ranges from .3 to 30 deaths per 100,000 population over the sample period with an average rate of 5.17 deaths per 100,000. Over our sample period, 26 percent of our states have passed a MML while 6 percent have active and legal dispensaries. State unemployment rates vary from 2.3 to 13.8 percent over our sample period and about 62 percent of state observations have a prescription drug monitoring program during the sample period.

Table II. Summary statistics: 1999-2015.

Variable	Mean	St. Dev.	Min.	Max.
Age-Adjusted Mortality Rate Opioid Overdoses	5.17	3.84	0.30	30.0
Medical Marijuana Law	0.26	0.44	0.0	1.0
Marijuana Dispensary Law	0.06	0.24	0.0	1.0
Prescription Drug Monitoring Program	0.62	0.49	0.0	1.0
Alcohol Tax (Beer Excise Tax)	0.28	0.25	0.0	1.1
Unemployment Rate	5.80	2.04	2.3	13.8
Percent Population White	0.80	0.13	0.2	1.0
Percent Population Male	0.49	0.01	0.5	0.5
Democratic Governor **	0.45	0.49	0.0	1.0
Independent Governor **	0.01	0.11	0.0	1.0

**We use the political party of the Mayor of Washington, D.C.

4.2 Difference-in-Differences Results

In Table III, the results from estimating equation 1 are shown. Column 1 is a baseline regression that includes no covariates and no state or year fixed effects. The coefficient on the MML variable is positive and statistically significant. This positive correlation is not surprising as states have been passing MMLs over the same time frame as opioid overdose deaths have been rising. In column 2 of Table III, we add our full set of control variables described earlier. The coefficient on MML is now insignificant.

It is possible that the effect of MMLs on death rates depends on the level of other covariates. In particular, we allow there to be gender and race differentials in the effect of MMLs on death rates. In column 3, an interaction variable between percent male population and the MML dummy is added and in column 4, an interaction between percent white and the MML dummy variable is added. As reported by the Henry J. Kaiser Family Foundation, more males than females die of opioid overdoses, although the CDC (2013) reports that while more men die from opioid overdoses, the opioid overdose death rates of women have been rising faster than those of men since 1999. In addition, whites have a higher opioid death rate than other races (Kaiser Family Foundation, 2018a, b).

Table III. Difference-in-difference regression from years 1999-2015 including all 50 states and District of Columbia. Y = Log of Age-Adjusted Mortality Rate

VARIABLES	(1)	(2)	(3)	(4)	(5)
Medical Marijuana Law	0.465***	0.053	9.482***	-0.656*	0.089
	(0.117)	(0.099)	(2.606)	(0.332)	(0.088)
Legal Dispensary					-0.289***
					(0.103)
Alcohol Tax		-0.631**	-0.652**	-0.618**	-0.727***
		(0.271)	(0.274)	(0.279)	(0.262)
State unemployment rate		0.045*	0.038*	0.042*	0.045*
		(0.025)	(0.022)	(0.023)	(0.024)
% state population white		-0.175	-0.200	-0.636	-0.119
		(0.481)	(0.498)	(0.577)	(0.500)
% state population male		-5.379	-0.241	-5.961	-6.445
		(4.278)	(4.524)	(4.108)	(3.948)
=1 if state has dem. governor		0.026	0.019	0.023	0.022
		(0.044)	(0.044)	(0.044)	(0.046)
=1 if state has ind. governor		-0.069	-0.081	-0.069	-0.103
		(0.120)	(0.114)	(0.112)	(0.110)
=1 if state has PDMP		-0.056	-0.042	-0.061	-0.046
		(0.078)	(0.074)	(0.076)	(0.076)
Male x MML			-19.162***		
			(5.327)		
White x MML				0.922**	
				(0.420)	
Constant	1.276***	2.869	0.447	3.482	3.423
	(0.084)	(2.252)	(2.338)	(2.232)	(2.106)
Observations	796	796	796	796	796
R-squared	0.080	0.854	0.859	0.855	0.859

Notes: PDMP=prescription drug monitoring plan. Standard errors are clustered at the state level. Model 1 has no covariates. Models 2-5 have state and year fixed effects. ***p<0.01, **p<0.05, *p<0.1

Figures 2 and 3 present the marginal effects of these interactions. In figure 2, we calculate the marginal effects for values of percent male ranging from 40 to 60 percent which are the minimum and maximum values for states in our sample. We see that the differences in opioid death rates between states with and without MMLs is significant at the 5 percent level for all values and goes from positive to negative as the percent male in a state rises. Figure 3 plots the average marginal effects between states with and without MMLs as the percent white ranges from 25 percent to 95 percent, again consistent with the range of values in our sample. Here we find that in states with a lower population of whites, adopting MMLs lowers opioid overdose mortality rates but the effects are not significant at the 5 percent level.

Figure 2: Avg Marginal Effects of MML with 95% CI

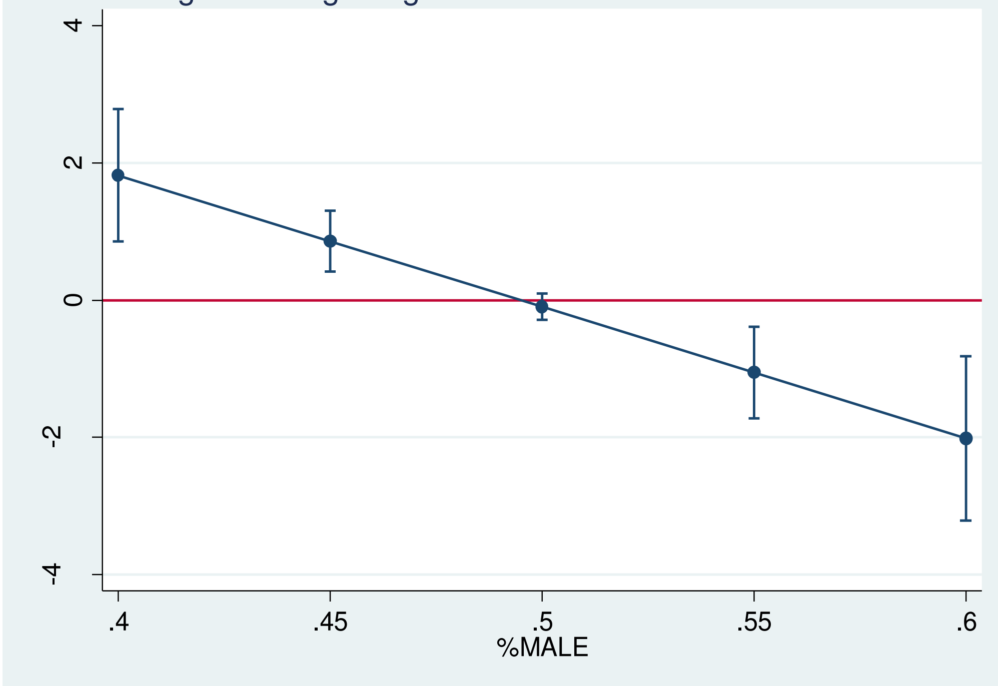
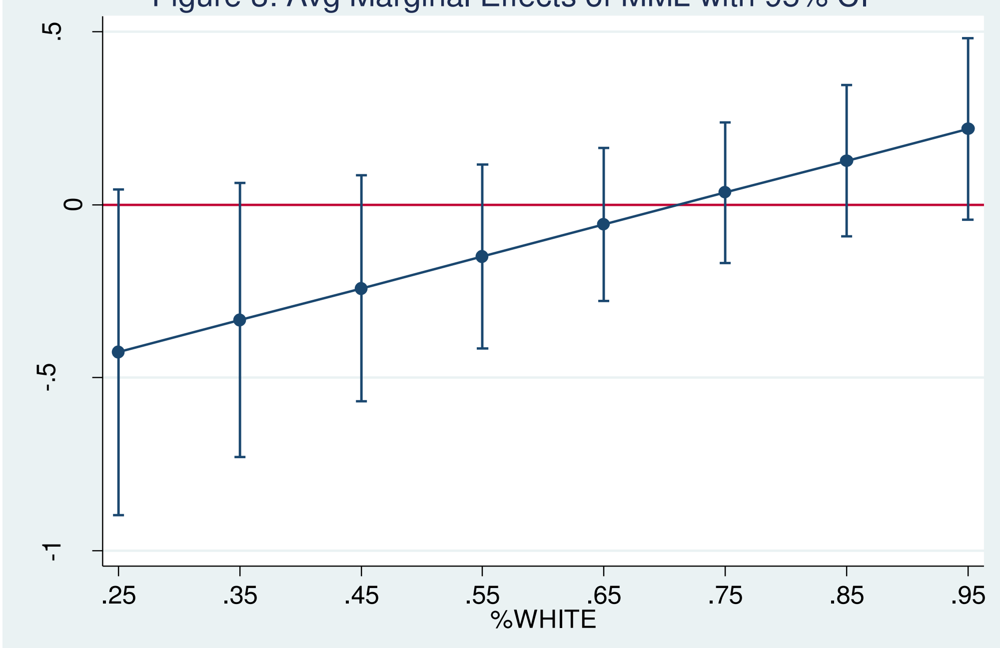


Figure 3: Avg Marginal Effects of MML with 95% CI

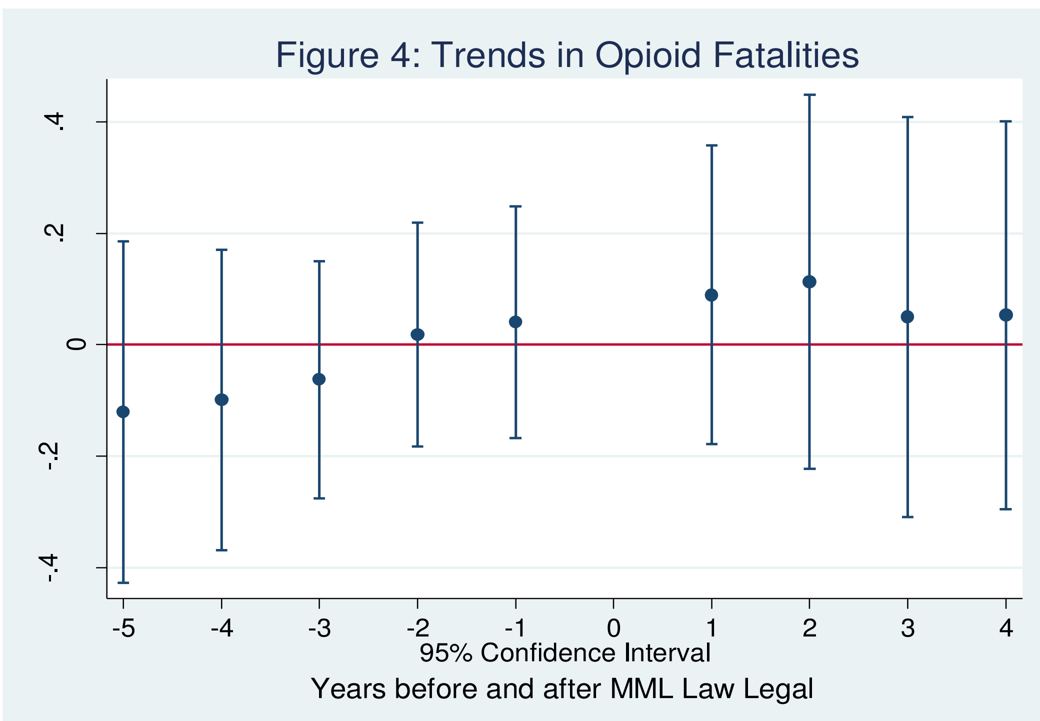


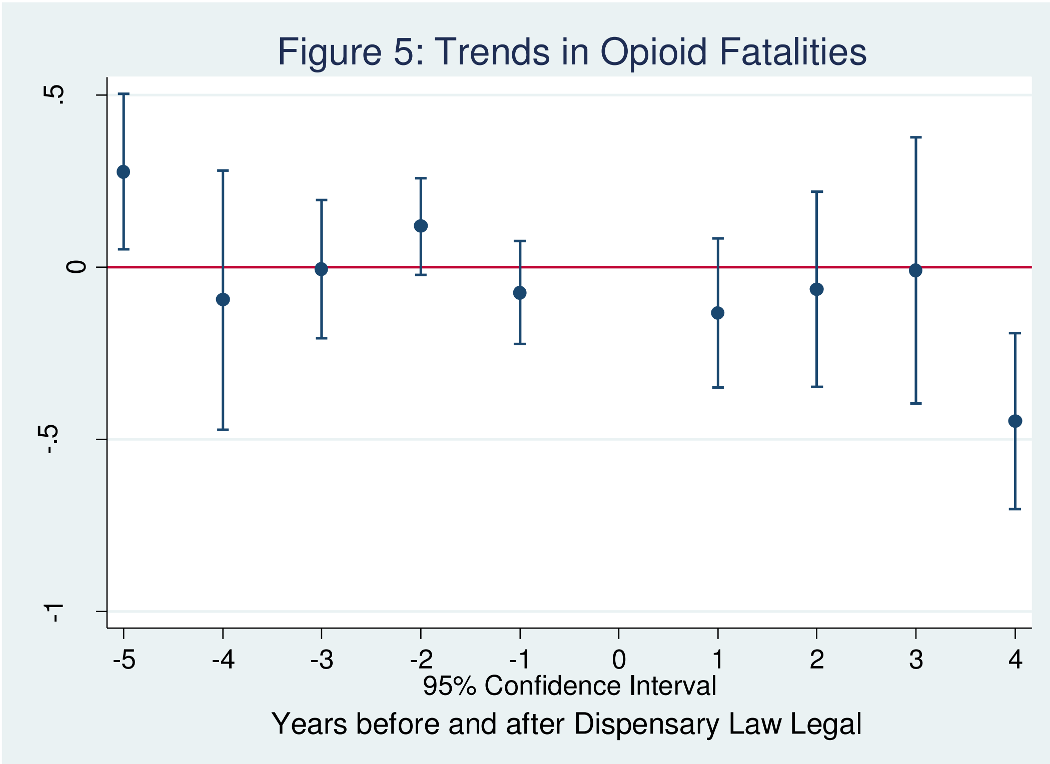
Finally, in column 5 of Table III, we add a control for whether the state has an active legal marijuana dispensary. We see that the coefficient on dispensary is negative and statistically significant. The coefficient on MML remains insignificant. We also conduct a joint F-test of the coefficients on MML and dispensary and find them to be jointly significant (p=.01). This indicates that the presence of an active and legal dispensary may act to reduce opioid overdose death rates.

We also find that higher state alcohol taxes reduce opioid overdose death rates consistent with the hypothesis that alcohol may be a substitute for opioids. Finally, we also find that higher unemployment rates increase opioid death rates.

4.3 Event Study Results

In order to test for the existence of pre-trends, we run an event study model as suggested by Angrist and Pischke (2013). The results of the event studies can be seen in figures 4 and 5. Although we show two figures, the event study coefficients for MML and dispensary laws are estimated jointly in one equation. In figure 4, where we use MML as our variable of focus, the F-statistic on the leads is .69 indicating that pre-trends are not a problem, but we see no significant impact of enacting MMLs on opioid overdose death rates. In figure 5, we do see a drop in opioid overdose deaths several years after dispensaries are active and legally operating in a state. In this case, the F-statistic on the leads is .04 suggesting that this effect could be driven by pre-existing trends. However, similar to Powell et al. (2018) when we do a test of significance of the *sum* of the coefficients on MML and dispensaries in the pre-period, this sum is not statistically significant (p=.95) suggesting that pre-existing trends may not be driving these results.





5. Conclusion

In this research, we have examined the effect of MML laws and the presence of active legal dispensaries on CDC age-adjusted opioid overdose death rates over the years 1999-2015. Our results suggest that states with active legal dispensaries see a drop in opioid death rates over time. These results are consistent with Powell et al. (2018) who also find that dispensaries reduce opioid death rates. However, our updated data do not confirm Bachhuber et al.'s finding of a negative and significant effect of MMLs on opioid death rates. Given that our set of covariates is quite similar to those of Bachhuber et al. (2014) but we have an additional five years of data, we suspect that the differing results are a function of more recent data over a time period when opioid deaths are rising and states continue to pass MMLs. It may be the case that there has been a structural break in the relationship between MMLs and opioid death rates. Furthermore, Bachhuber et al. (2014) do not take into account the presence of active, legal dispensaries. Overall, this research provides evidence that states with MMLs may see a decline in opioid overdose death rates if they enact legal dispensaries.

Several caveats are in order. Our data are at the state level as opposed to the individual level. Access to individual-level data could improve the precision of the estimates and would allow us to explore the association between MMLs and opioid deaths among specific demographic groups (e.g. young adults, males). Using individual-level data would also allow us to control for a richer set of covariates. Finally, we do not control for whether the state allows for recreational marijuana or whether the state had decriminalized marijuana usage. Further research is needed to disentangle the effects of these laws.

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