Does Access to Recreational Cannabis Reduce Opioid Related Deaths?

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Spring, 2020

I. Introduction

The opioid epidemic in the U.S. has grown dramatically over the last 20 years, in 2018 alone approximately 47,000 people died of an opioid related overdose compared to 10,000 in 1999 (NIDA, 2020). The epidemic occurred in three distinct waves; the first wave began in the early 1990s when doctors began increasing the frequency of opioid prescriptions for pain management. During this period pharmaceutical companies reasurred healthcare providers that these drugs posed little risk for addiction. The second wave began in 2010 after increased regulations reduced the ease of obtaining an opioid prescription. As a result many dependent patients turned to heroin, a potent unregulated opioid, in turn opioid deaths spiked once again. The third wave began in 2013 as a synthetic opioid named fentanyl became increasingly common among opioid users (Liu et al., 2018).

A lethal dose of fentanyl can be as low as 3-miligrams making it 20 times more potent than heroin and 100 times more potent than morphine (Bond, 2016). Making matters worse, dealers occasionally mix their heroin with small doses of fentanyl to increase their profit margins (Katz, 2017). Fentanyl is especially risky when unknowingly mixed with another drug as it's difficult to accurately measure and the effects vary based on tolerance. In turn this can lead to increased accidental overdose if someone takes a stronger opioid than their bodies can handle (NIDA, 2019).

Some people have suggested that access to medical cannabis can reduce opioid deaths through reducing the number of prescriptions filled (Bradford et al., 2018). The theory is that if some people choose to treat their pain with cannabis rather than opioids then less people would become dependent, reducing overdose deaths. Providing hope to those looking for alternative pain treatments, research has shown that cannabis can effectively treat chronic pain in adults (Romero-Sandoval et al., 2018). Additionally, medical marijuana laws are associated with a decrease in opioid related deaths (Bachhuber et al., 2014). On the other hand, some say that cannabis can act as a gateway drug; causing users to become more likely to experiment with other drugs as a result of using cannabis, potentially amplifying the number of opioid users rather than decrease it (Bachhuber et al., 2014).

Since 2012, 11 states have passed laws to fully legalize recreational cannabis yet little research has examined whether recreational cannabis can have the same effect as medical cannabis on reducing opioid deaths (NORML, 2020). In addition, a majority of the previous leading literature surrounding cannabis use and overdoses was based on data prior to 2012 resulting in estimates that may be significantly different when repeated with recent data. The purpose of this paper is to see if there is there is a link between recreational cannabis access and opioid deaths. My hypothesis is that access to recreational cannabis leads to a reduction in opioid overdoses.

II. Literature Review

Early research on the effect of cannabis accessibility on opioid deaths provides evidence that states with access to medical cannabis experience reduced opioid deaths. Bachhuber et al. (2014) reviewed opioid overdoses from states with medical marijuana laws prior to 1999 (California, Oregon, and Washington), states that implemented medical marijuana laws between 1999 and 2010 (Alaska, Colorado, Hawaii, Maine, Michigan, Montana, Nevada, New Mexico, Rhode Island, and Vermont) and nine states that did not have medical marijuana laws prior to 2010 (Arizona, Connecticut, Delaware, Illinois, Maryland, Massachusetts, Minnesota, New Hampshire, and New York). They conclude that states with a medical marijuana law saw an average reduction in opioid deaths of 25%.

While the results of this study support the hypothesis that access to cannabis can reduce opioid related deaths, there are several limitations. First, since the researchers do not examine years beyond 2010 this data fails to capture the effect of the third wave of the opioid crisis and potentially parts of the second wave. In addition, state policies reguarding cannabis have changed dramatically since 2010 with many states voting to offer recreational cannabis as opposed to medical only.

Powell et al. (2018) analyze state-level opioid overdoses from 1999 to 2013 using a generalized difference in differences regression with state-year fixed effects and state-specific linear time trends. They find that states with active medical marijuana laws saw a decrease in opioid overdoses of 21% compared to states who did not have active laws. In addition, they show that states with legalized medical marijuana but without active dispensaries did not experience the same decrease in opioid overdoses as those who did have active dispensaries. These findings suggest that the degree of accessibility to medical cannabis plays an important role in the effectiveness of such policies on reducing opioid overdoses. In my analysis I will use a similar generalized difference in difference model to estimate the effect of recreational cannabis on the opioid death rate.

More recently, Bradford et al. (2018) conduct a longitudinal analysis of Medicare Part D; a plan to help cover prescription drug cost for those on Medicare. The researchers examine the total number of opioid prescriptions in states with and without cannabis laws and those with and without open dispensaries. They find that states who had implemented any medical cannabis law experienced a decrease in opioid prescriptions by 2.11 million daily doses per year. States who had active cannabis dispensaries in addition to a medical law saw opioid prescriptions decrease by 3.74 million daily doses per year. For reference, the average total prescriptions for states before any medical cannabis law was enacted was 23.08 million daily doses per year, suggesting an average decrease in daily opioid doses per year of about 10% for states with a medical cannabis law.

The prior results show there is a negative association between medical cannabis and opioid use, but do people actually substitute opioids for cannabis? Or could the reduction in deaths come from another mechanism? Corroon et al. (2017) use a cross-sectional study to determine whether cannabis users intentionally substitute cannabis for prescription drugs. They surveyed 2,774 individuals who had used cannabis at least one time in the past 90 days in the US. They found that 46% of respondents reported using cannabis as a substitute for prescription drugs with 35.8% specifically stating that they substituted opioids for cannabis. The odds of reporting substituting were 4.59 greater among medical cannabis users than non-cannabis users.

Their model shows that the effectiveness of cannabis legalization may be different for those who use cannabis strictly for medicinal purposes compared to those who use recreationally. Furthermore, the results support the hypothesis that people may substitute opioids for cannabis products when treating chronic pain. A concern of this study is that over half of the respondents reside in Washington, California, Oregon, or Colorado; four of the earliest adopters of any cannabis laws. This can cause the data to become skewed since it seems possible that people are more open to substituting opioids for cannabis in locations where its use is already somewhat widespread.

Further evidence of people substituting opioids for cannabis has been observed outside the U.S. Lake et al. (2019) analyze a longitudinal study of 1,152 people who reported chronic pain from 2014-2017 in Vancouver, Canada. They use a linear regression model with regularization to estimate a relationship between cannabis use and illicit opioid use. The researchers find the odds of illicit opioid use were about half as much in daily cannabis users compared to people who had reported no cannabis use after adjusting for confounding variables.

These results provide evidence that people who are frequent users of cannabis may be substituting opioids for cannabis in the Vancouver area. However, this study is limited to only one Canadian city making it unlikely the results will generalize to U.S. cities.

The growing collection of literature reguarding cannabis legalization and opioid use provides preliminary evidence that access to cannabis can reduce opioid use and abuse by acting as a substitute for prescription pain-killers. Moreover, benefits of providing legal access to cannabis appear to outweigh the downsides observed here, throughout all of these studies there was never an increase in opioid deaths as a result of cannabis access. While cannabis may have a gateway effect towards other drugs it does not appear that there is a significant gateway effect towards opioids.

III. Data

My analysis uses state-year level data on the opioid death rate per 100,000, while observations from 1999-2018 were available I chose to limit the observations to 2008-2018 because finding data on all covariates prior to 2008 became unfeasable. The opioid death rate will act as a measure of opioid abuse and will be the dependent variable in my model. There were 11 observations on 50 states and Washington D.C resulting in a total of 561 observations in my final dataset.

In order to create the panel data I obtained data on the percentage white, the average monthly SNAP (Supplemental Nutrition Assistance Program) benefit, the percent of people without any health insurance, the percent of people under the poverty line, the unemployment rate (Annual Average), and the average income for each state from 2008-2018. This data was obtained from the Kaiser Family Foundation's (www.KFF.com) health statistics and the American Community Survey from the U.S. Census (www.Census.gov).

Using information from the National Organization for the Reform of Marijuana Laws (www.NORML.com) an indicator variable was created to control for the year that recreational cannabis went into effect for each state. This variable essentially divide states into treatment and control groups for this model. As of 2018 ten states had legalized recreational cannabis (Alaska, California, Colorado, Maine, Massachusetts, Michigan, Nevada, Oregon, Vermont, and Washington) but only eight had active dispensaries (Alaska, California, Colorado, Maine, Massachusetts, Nevada, Oregon, and Washington).

While aggregating the data there were six missing values for the opioid death rate over the 2008-2018 time period. Rather than drop these observations from the dataset I used a random forest regression to predict the missing values of the opioid death rate, this was implemented using the missForest package in r.

IV. Empirical Framework

The goal of my empirical analysis is to compare the opioid overdose rate in states with recreational cannabis laws to states who did not have recreational cannabis laws. My model aims to treat states without a recreational cannabis law as control states and will use the differential timing of states with recreational cannabis laws as treatments to estimate the effect of recreational cannabis laws on opioid overdoses. Given the differential timing of the treatment states I will use a generalized difference in difference model with state-year fixed effects and other covariates (see Angrist and Pischke, 2014). To estimate the generalized difference in difference I use Eq.(1):

$$Y_{s,t} = \alpha_s + \gamma_t + \beta_1 InEffect_{s,t} + \beta_{2-7}\boldsymbol{X'}_{s,t} + \epsilon_{s,t} \tag{1}$$

Where $\mathrm{Y}_{\mathrm{s,t}}$ is the opioid death rate for state s in year t. α_s are state fixed effects. γ_t are year fixed effects. $inEffect_{\mathrm{s,t}}$ is a dummy variable indicating whether state s has an active recreational cannabis law in year t. These fixed effects were created by including an indicator variable for each state and each year in the model. $\mathbf{X'}_{\mathrm{s,t}}$ is a vector of the following covariates: the percent white, the average monthly SNAP (Supplemental Nutrition Assistance Program) benefit, the percent of people without any health insurance, the percent of people under the poverty line, the unemployment rate (Annual Average), and the average income for each state from 2008-2018.

For this model to yield a causal interpretation we need to satisfy the commmon trends assumption. The common trends assumption says that changes in the treated groups would have been the same as changes in the control group had they not been treated.

In the case of recreational cannabis and opioid death the common trends assumption requires that any trend in opioid deaths for states without recreational cannabis should be approximately parallel to the pre-treatment trend in opioid deaths for states with recreational cannabis. Since different states legalized recreational cannabis at different times it is difficult to accurately depict their trends graphically. In an attempt to develop a crude idea of treatment and control trends I created Fig.1, a plot of the opioid death rate for all states that had ever legalized recreational cannabis against states who had never legalized recreational cannabis.

The dashed line at the year 2012 in Fig.1 represents the year that Colorado and Washington became the first U.S. states to legalize recreational cannabis. The trend lines in Fig.1 show an approximately parallel trend starting in 2010 until 2012; in contrast, prior to 2010 the state trend lines appear to be quite different. States that would eventually become legal saw a decrease in the opioid death rate from 2008 until 2010 while illegal states saw an increase over the same period. Fig.2 and Fig.3 plot the opioid death rate for Washington and Colorado state individually against all states who had never legalized recreational cannabis. The trend in Washington from 2010-2012 appears to follow the trend of nonlegal states in an approximately parallel fashion whereas the trend in opioid deaths for Colorado appears to decrease sharply in 2009 before an equally as sharp increase in the following year. Fig.1, Fig.2, and Fig.3 demonstrate the differing trends in opioid death rates among states, while some treatment state trends share a common trend with the control, others can vary dramatically.

To increase the robustness of my results I used an event study to examine any leading or lagging impacts that recreational cannabis legalization may have on the opioid overdose rate. In the event that the treatment effect is lagging estimates of the generalized difference in difference model may fail to distinguish treatment effects from differential trends, this can result in imprecise estimates. Another benefit of using the event study specification is that it can be used to test the common trends assumption, if the pre-treatment coefficients are non-significant we can be confident that there are no significant pre-policy trends among the states. In the case of legalizing recreation cannabis it seems plausible that it takes a few years for the policy to take effect; using an event study will allow for the magnitude of the effect to vary over time. To estimate the event study I use Eq.(2):

$$\begin{aligned} Y_{s,t} = \alpha_s + \gamma_t + (\beta_{t-4}Pre_4 + \beta_{t-3}Pre_3 + \beta_{t-2}Pre_2)+ \\ (\beta_t Post_0 + \beta_{t+1}Post_1 + \beta_{t+2}Post_2 + \beta_{t+3}Post_3+ \\ \beta_{t+4}Post_4 + \beta_{t+5}Post_5 + \beta_{t+6}Post_6) + \epsilon_{s,t} \end{aligned} \tag{2}$$

Where $\mathrm{Y}_{\mathrm{s,t}}$ is the opioid death rate for state *s* in year *t*, α_s are state fixed effects, and γ_t are year fixed effects. The terms *Pre* and *Post* measure specific difference in difference effects for each year relative to one year before state *s* has legalized cannabis. For example β_{t-4} measures the change in the treatment and control difference between *t-4* and *t-1* (i.e., The change in the treatment and control opioid death rate between four or more years before legalization and one year before legalization). β_{t+1} measures the change in the treatment and control difference between *t+1* and *t-1* (i.e., One year after legalization and one year before legalization). The pre-treatment β terms will be used to test for differential pre-treatment trends from our common trends assumption. If the assumption is valid these pre-policy β estimates should be close to 0 (Sun and Abraham, 2014). The pre and post β terms will allow for leading or lagging effects to be seen in a plot of the estimated coefficients.

V. Results

Table 1 displays my results from estimating two versions of Eq. (1). Column (1) of Table 1 displays results for the generalized difference in difference without covariates. The Legal Active coefficient of -2.60 suggest that states with a recreational cannabis law are estimated to experience an average yearly decrease of 2.60 opioid related deaths per 100,000. Providing a robustness check, Column (2) of Table 1 includes the covariates seen in Eq. (1). The additional controls shrink the Legal Active coefficient -1.75 but it remains statistically significant at the 10% level; the relatively small decrease in magnitude on Legal Active suggest that the fixed effects are able to control for a majority of differences between states and time periods.

The results from estimating the event study specification seen in Eq. (2) with and without covariates are displayed in Table 2. In addition, Fig. 4 and Fig. 5 plot the coefficient estimates based on years before or after the policy. The green area surrounding the blue line provide the 95% confidence interval for each estimate. Both plots show that the confidence interval contains 0 at every point up until β_{t+3} or three years after legalization has been implemented; since no pre-policy coefficients are significant we can be confident we have satisfied the common trends assumption. The addition of covariates seen in Column (2) of Table 2 and Fig. 5 confirm these results as the coefficient estimates experience little change and remain insignificant until β_{t+3}.

VI. Conclusion

While early research shows that access to medical cannabis can reduce opioid related deaths few researchers have examined if accessibility to recreational cannabis has a similar effect. This paper attempts to identify if there is an effect of recreational cannabis on opioid deaths by building on the difference in differences framework from Powell et al. (2018) and Bachuber et al. (2014). To account for demographic and policy changes over the previous decade I include observations up to 2018 and use state level recreational cannabis status as the treatment variable rather than medical cannabis status. Furthermore, I estimate an event study to examine whether there are any leading or lagging effects on opioid related deaths as a result of access to recreational cannabis.

The results of this paper suggest that states with a recreational cannabis law are expected to see a reduction of four to five opioid deaths per 100,000 three years after the law went into effect compared to one year before the law went into effect. This means for a state like California, with a population of 40 million we would expect up to 2000 fewer opioid related deaths three years after recreational cannabis became legalized compared to one year before it was legalized. In addition, the impact of recreational cannabis on opioid deaths becomes larger in magnitude as we move farther from the implementation date, suggesting there is a delay between when the policy is put into effect and when the effects of the policy are actually observed. Future studies could improve upon the results of this paper by collecting information on covariates from 1999 - 2007 and examining if the reduction in opioid related deaths remains.

Although access to recreational cannabis is unlikely to solve the opioid epidemic on its own there is evidence of a marginal reduction in opioid related deaths in states with access to recreational cannabis. Moving forward, policy makers should consider implementing a recreational cannabis law in addition to traditional drug abuse reduction methods such as state sponsored methadone clinics, rehabilitation programs, and stricter prescription guidelines to reduce opioid overdoses. While the reduction in opioid deaths is relatively small, a few lives saved seems better than no lives saved.

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Table 1: Dependent variable: Opiate Overdoses per 100K

	Difference in Differences	
	(1)	(2)
Legal Active	-2.60***	-1.75*
	(0.97)	(0.95)
Unemployment Rate		-95.31***
		(23.67)
% White		73.67***
		(22.82)
Average Income (Log)		1.37
		(7.03)
Average SNAP Benefit		-0.17***
		(0.04)
% Poverty		113.30***
		(25.40)
% Uninsured		44.27***
		(10.97)
Observations	561.00	561.00
R-sqr	0.73	0.76
RMSE	4.00	3.80
Fixed Effects	Yes	Yes
Covariates	No	Yes

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

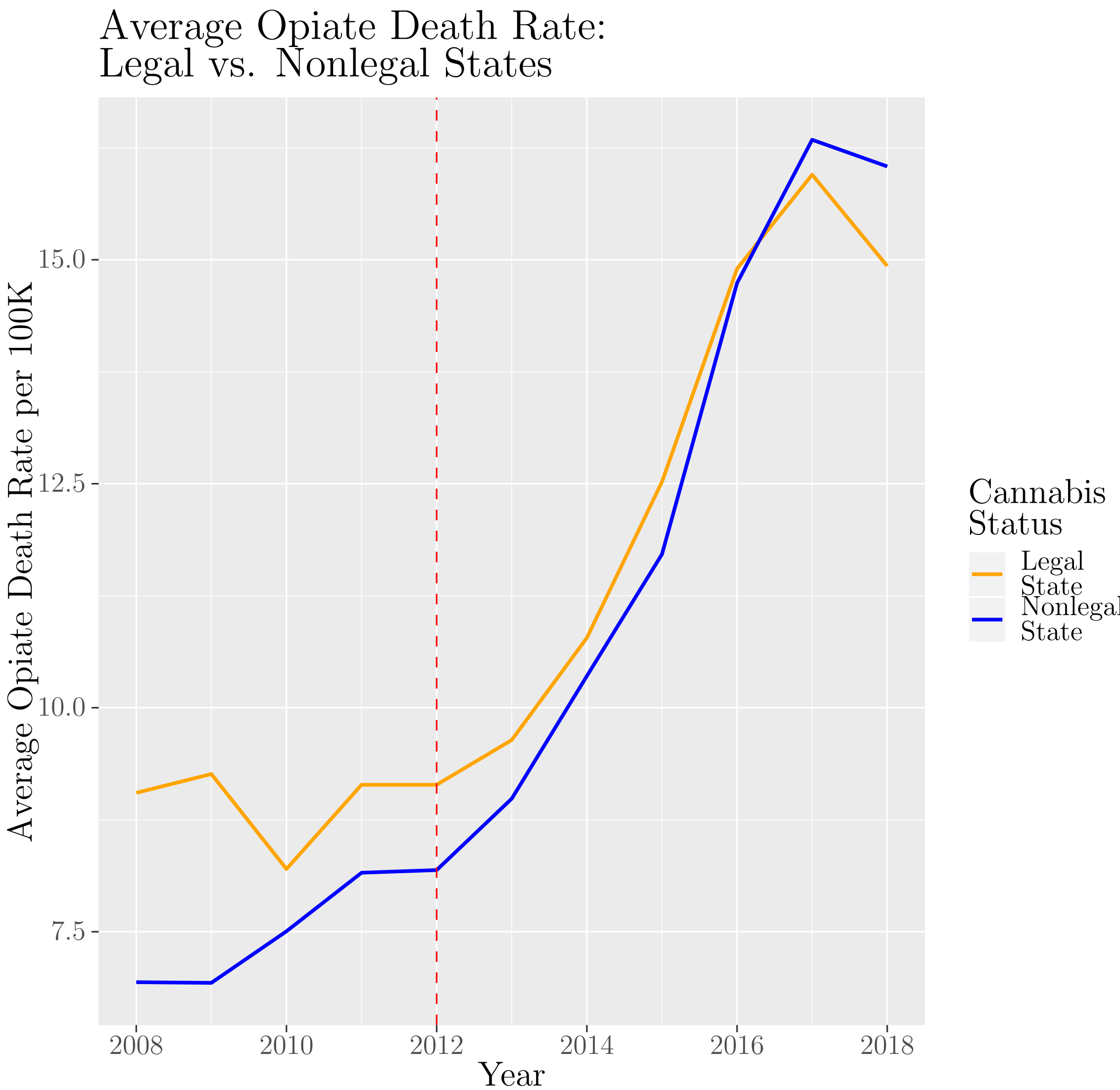
Table 2: Dependent variable: Opiate Overdoses per 100K

	Event Study	
	(1)	(2)
>=4 years before	0.10	-0.23
	(1.67)	(1.60)
3 years before	-0.26	-0.85
	(2.02)	(1.93)
2 years before	-0.44	-1.04
	(2.05)	(1.96)
year of policy	-0.21	-0.90
	(2.05)	(1.97)
1 year after	-1.25	-0.95
	(2.02)	(1.93)
2 years after	-2.74	-1.91
	(2.05)	(1.97)
3 years after	-5.33**	-4.38*
	(2.51)	(2.41)
4 years after	-7.83***	-5.63**
	(2.55)	(2.46)
5 years after	-8.30**	-6.50**
	(3.34)	(3.21)
>=6 years after	-8.43**	-5.83*
	(3.34)	(3.22)
Observations	561.00	561.00
R-sqr	0.92	0.93
RMSE	3.98	3.80
Fixed Effects	Yes	Yes
Covariates	No	Yes

Standard errors in parentheses

* p<0.10, ** p<0.05, *** p<0.01

Figure 1:



*First legalization of recreational cannabis: 2012

Figure 2:

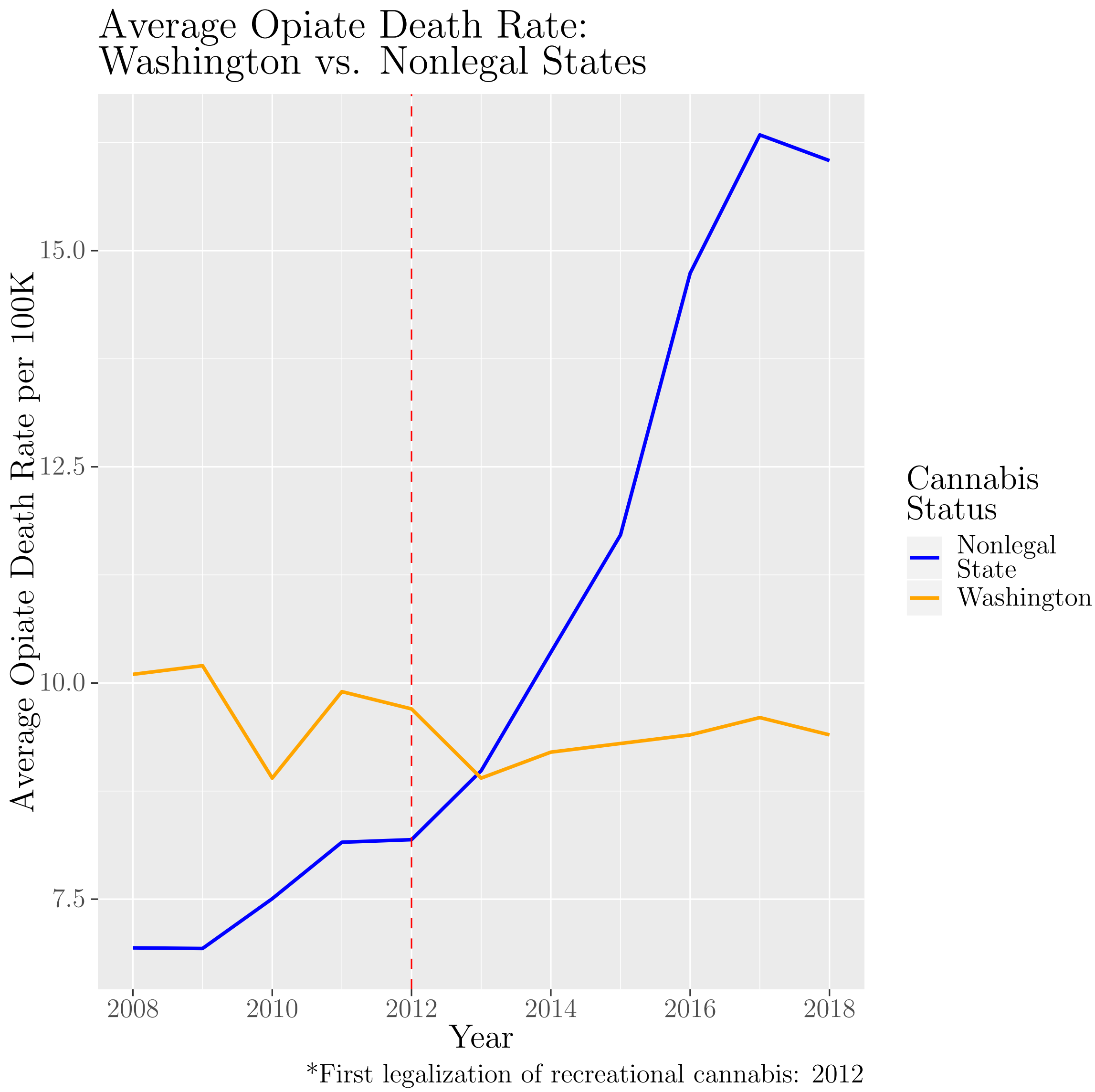
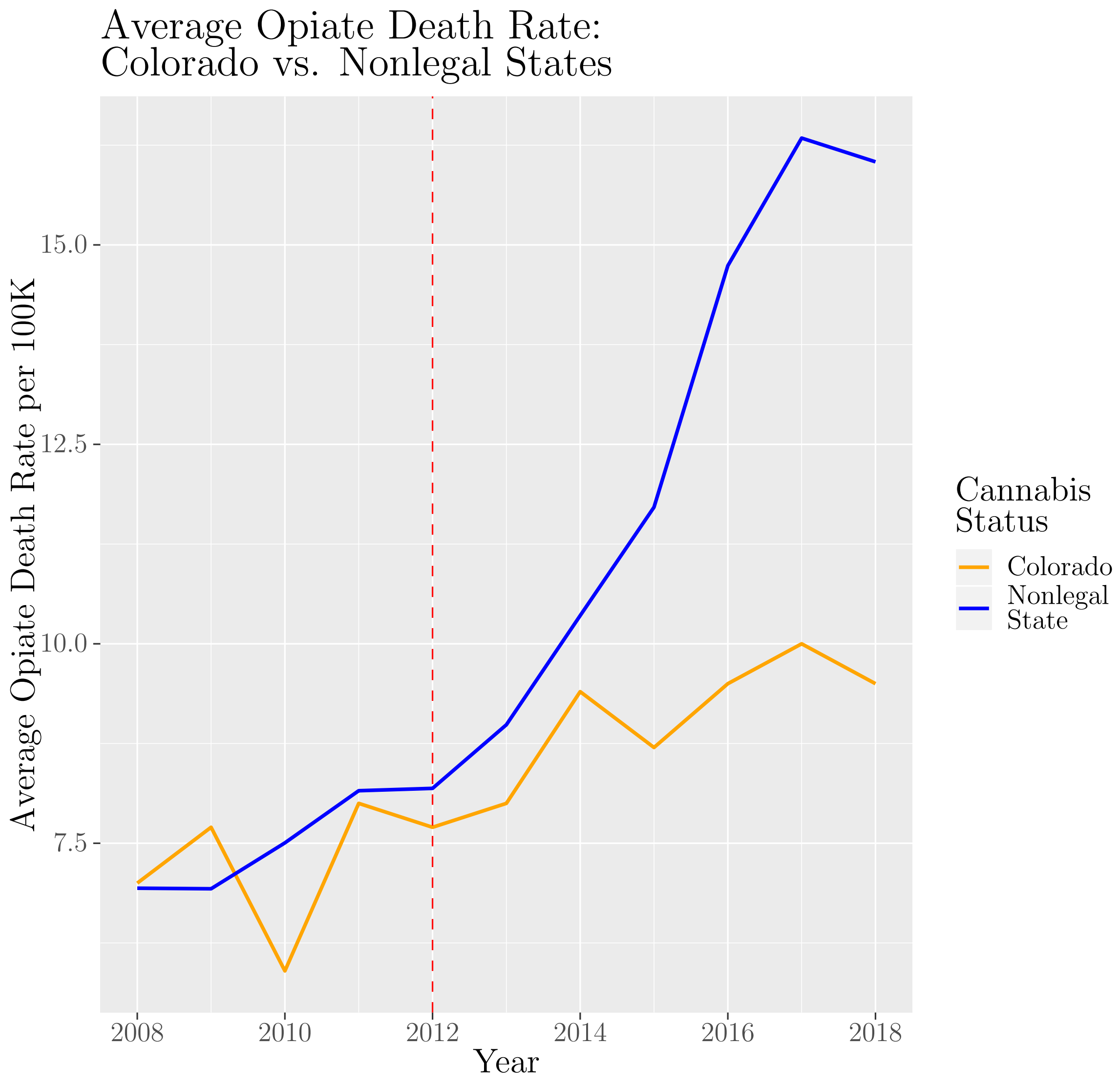
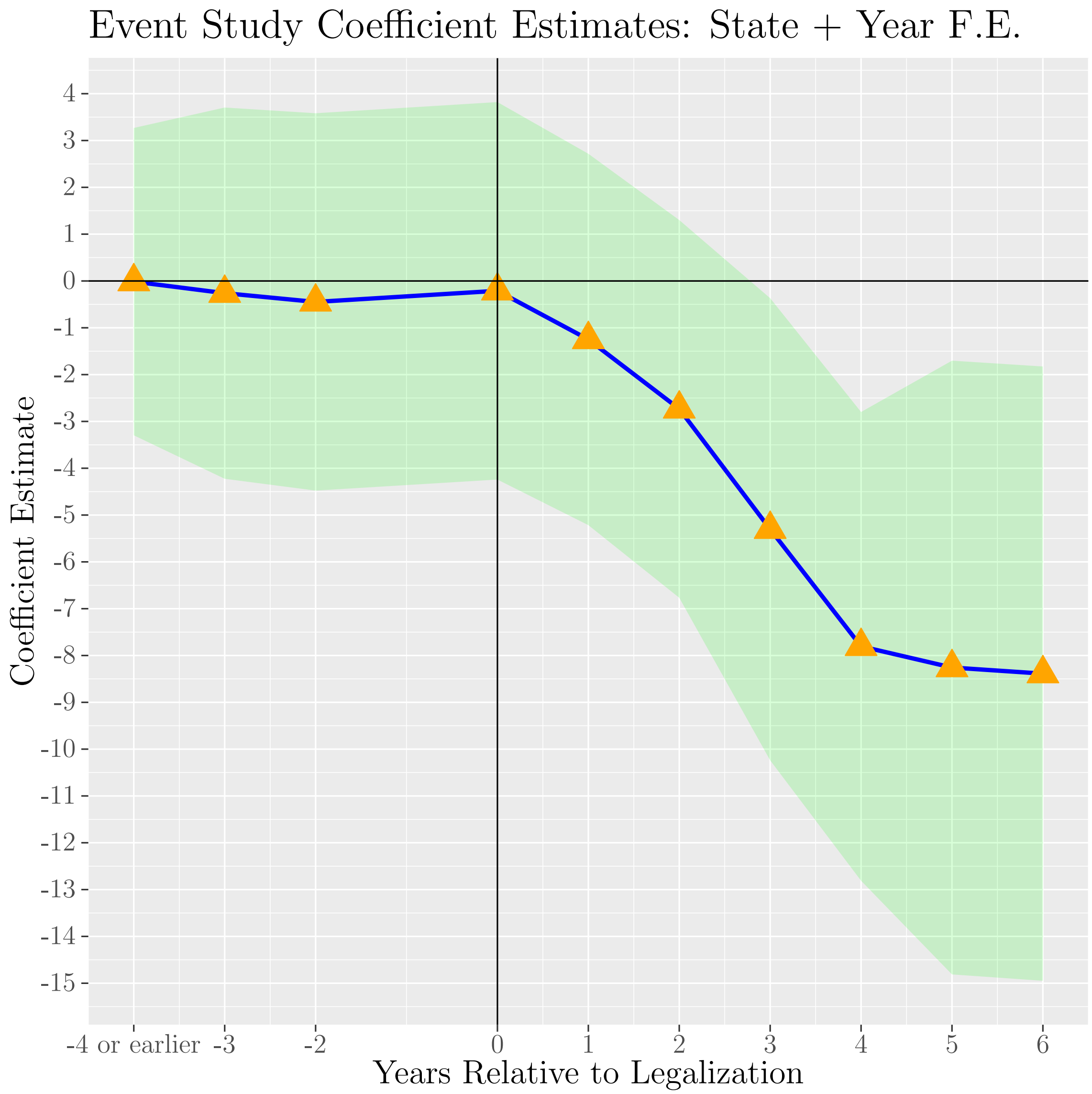

Average Opiate Death Rate:
Washington vs. Nonlegal States
Average Opiate Death Rate per 100K
15.0
12.5
10.0
7.5
2008
2010
2012
2014
2016
2018
Year
Cannabis
Status
Nonlegal
State
Washington
*First legalization of recreational cannabis: 2012

Figure 3:



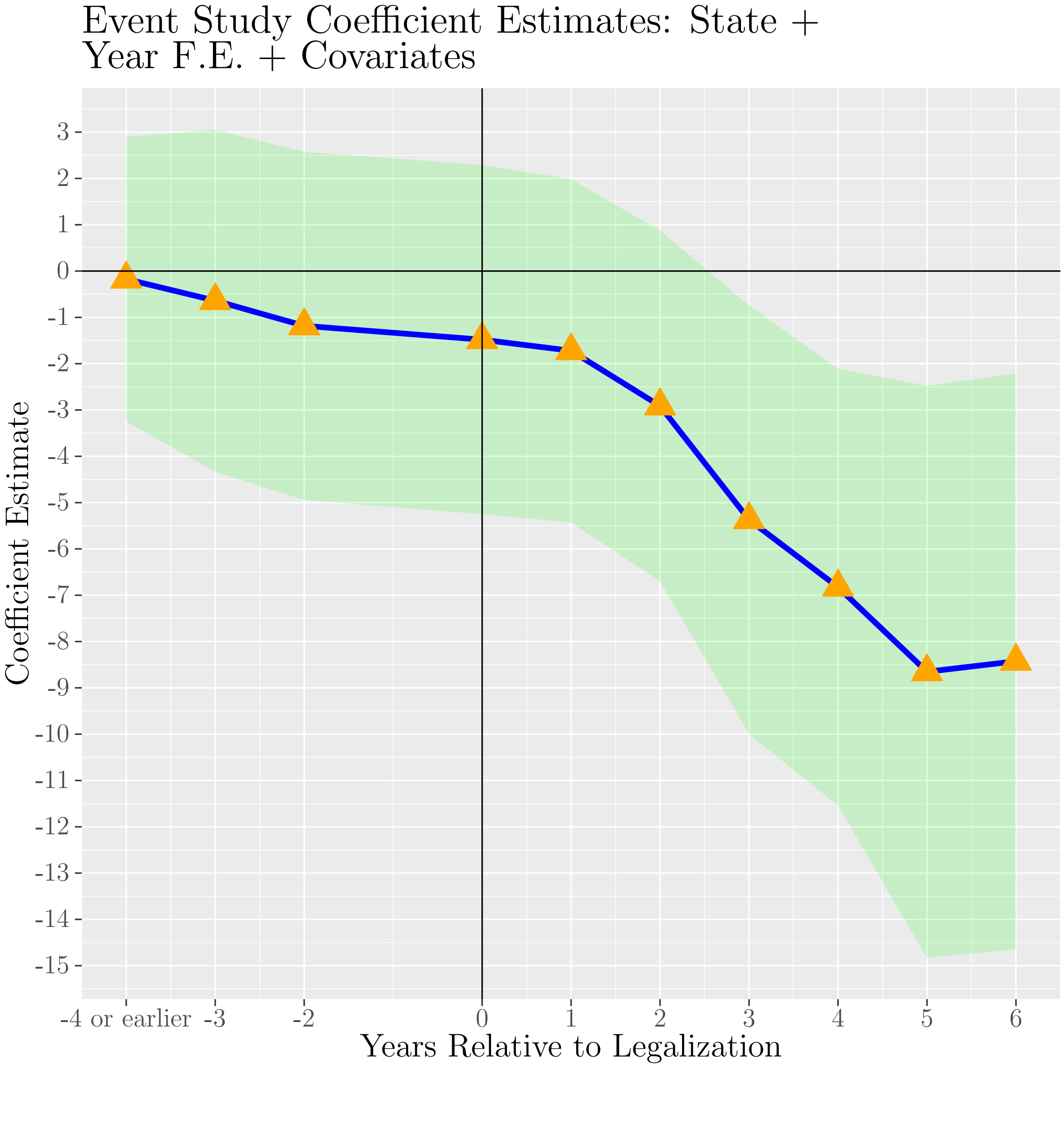
*First legalization of recreational cannabis: 2012

Figure 4:



Event Study Coefficient Estimates: State + Year F.E.
Coefficient Estimate
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-4 or earlier
-3
-2
0
1
2
3
4
5
6
Years Relative to Legalization

Figure 5:



Event Study Coefficient Estimates: State +
Year F.E. + Covariates
Coefficient Estimate
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
-4 or earlier
-3
-2
0
1
2
3
4
5
6
Years Relative to Legalization