The Impact of Medicaid Expansion on Opioid Overdose Mortality Rates: A Difference-In-Differences Analysis

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The Impact of Medicaid Expansion on Opioid Overdose Mortality Rates: A Difference-In-Differences Analysis

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Abstract

In this difference-in-differences analysis, I examine how Medicaid expansion has affected opioid overdose death rates in US states. The majority of US states (27) passed Medicaid expansion when the Affordable Care Act went into effect, yet there are still states that have not. The opioid crisis has been an ongoing nationwide issue and persists with changes in legislation as well as US drug culture. Contrary to some other research papers, results from this analysis showcase higher opioid overdose mortality rates post-intervention in states that passed Medicaid expansion than states that chose not to.

KEYWORDS: (Medicaid expansion, Opioid overdose mortality rates, Affordable Care Act)

JEL CODES: (I13, I18, I14, I38)

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Sangay Mingyur

Signature

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2. Introduction

According to the Centers for Disease Control and Prevention, opioid-involved death rates have gone up by over 15% from 2020 to 2021 and over 75% of the almost 107,000 drug overdose deaths involved an opioid in 2021. Opioid usage has evolved throughout the years in the US and factors like the inappropriate prescription practices, lack of understanding of potential adverse effects of long-term therapy, opioid misuse, abuse, and dependence, have brought the crisis to its current stage (Vadivelu et al, 2018). The opioid epidemic in the United States has a long history going back to the first wave in the 90s with new innovations in the pharmaceutical industry such as the creation of OxyContin by Purdue Pharma in 1996. There were limited laws and regulations at the time and the medical field was gravitating towards the liberal use of opioids in pain treatment, particularly for chronic non-cancer related pain. This allowed for pharmaceutical companies like Purdue to aggressively market their drug for non-malignant pain and misrepresent the dangers of addiction. The company would host all-expenses paid conferences for more than 5,000 physicians, pharmacists, and nurses to influence prescribing rates. To add on, Purdue Pharma's internal sales force would grow exponentially with a competitive corporate culture to get as many sales as possible to gain bonuses (Van Zee, 2009). The result of their bold marketing strategies was evident in the company's own program designed to monitor abuse and characterize it. Their Research Abuse, Diversion and Addiction-Related Surveillance (RADARS) system showed the abuse of prescription drugs in 60% of the zip codes that were surveyed, with the highest growth with OxyContin and hydrocodone (Cicero et al, 2005).

It is important to recognize that OxyContin was not the only opioid that was abused because that limits the scope of the epidemic as a whole. Illicit opioid drugs such as heroin have

also seen an increase in abuse and in the most recent wave of the crisis, synthetic opioids like fentanyl and fentanyl analogs have become much more readily available on the streets. This has resulted in the synthetic opioid-involved death rate to increase 1,040% from 1.0 to 11.4 per 100,000 age-adjusted, from 2013-2019 (Mattson et al, 2021). To add on, there are many other variables to take into account when looking for solutions to the opioid crisis. Cicero et al (2005) found OxyContin abuse almost exclusively in Caucasians (>91%) in contrast to blacks and Hispanics being over-represented in the abuse of illicit opioids such as heroin. Variables like one's region, race, socioeconomic background, education, and health history all contribute to how the abuse of opioids looks like in the US. Therefore, it is difficult to find just one concrete solution to the opioid crisis. Government regulation most definitely is needed as the markets have not helped with the crisis, but rather exacerbate it. In 2016, Massachusetts passed more stringent regulations restricting prescribers to a maximum of 7 days' worth of opioids for a first prescription except for some rare exceptions and obligating them to advise their patients on the risks associated with opioid medications (Weiner et al, 2017). Legislation is a crucial point in the fight against the opioid epidemic and one of the biggest pieces of healthcare legislation in the United States was the Affordable Care Act which was signed into law on March 23, 2010.

The purpose of this research study is to destigmatize Medicaid expansion and its relationship to the ongoing opioid crisis in the United States. After data analysis, I hypothesize that a negative correlation will be found between Medicaid expansion and opioid overdose death rates. I expect to see lower death rates in states that passed Medicaid expansion and higher rates in US states that did not pass Medicaid expansion.

2. Literature Review

2.1 Medicaid Expansion

Under the Obama administration, the Patient Protection and Affordable care Act (ACA) was passed. This major piece of legislation was highly controversial and sparked much political debate between the Democrats and Republicans. It greatly reformed how the American healthcare and insurance system operates with the goal of improving healthcare access for all Americans. There have been many flaws with the healthcare system in the US and it made it very difficult for Amercians to get quality healthcare. The country spent more on healthcare per capita ($8,608) and more on healthcare as a percentage of its gross national product (17.9%) than any other country. The three main goals of the ACA are to expand healthcare coverage, shift the focus of the health care delivery system from treatment to prevention, and finally to reduce the costs and improve the efficiency of health care (Hellerstedt, 2013). Most uninsured Americans are not the poorest, but rather part of the "working poor." They are the ones who because of their age and income make them ineligible for public insurance coverage like Medicare, which is the universal insurance program for the elderly in the US, and Medicaid, which is meant for low-income Americans with a focus on low income children. Not all jobs provide their employees health insurance either (Gruber, 2011). To combat this, the Affordable Care Act allowed states to expand eligibility for Medicaid to nonelderly adults with incomes up to 138% of the federal poverty level and although it was meant to be nationwide, the Supreme Court decided in 2012 that states could opt out (Mazurenko et al, 2018). The US does not have a universal health care system like many other developed nations and it becomes very difficult to get key healthcare reform legislation passed as it is always contested between the Republicans and Democrats.

One of the main goals of the ACA was to make insurance affordable and this was accomplished by many means, the most important one being the focus of this paper, expanding the Medicaid program. Gruber wrote his paper on the projections regarding the ACA in 2011 and this is important as the ACA was only fully implemented in 2014. There were many doubts regarding the efficacy of the ACA and Gruber provides a case study into Massachusetts and their reforms in healthcare. The state passed a healthcare reform bill very similar to the ACA in 2006 and the results were undeniable. Massachusetts soon had the lowest rate of uninsured in the US, the costs for administering the healthcare were quite low, premiums in the non-group market fell dramatically, and the reform had been popular, with the majority of state residents supporting it (Gruber, 2011). Although it worked on a state level, it is very different when trying to implement such a comprehensive healthcare reform law at the federal level. Different states have very different values. As of now, there are still ten states that have not adopted Medicaid expansion and these ten states, Wyoming, Kansa, Texas, Wisconsin, Tennessee, Mississippi, Alabama, Georgia, South Carolina, and Florida, all have a Republican governor or have a state legislature controlled by the Republican Party. Republicans are generally opposed to market intervention by the federal government and taxes while Democrats mostly support more government regulation and taxes to fund government programs. The US is the highest spending nation in the world for healthcare. However, it still continuously ranks lower than other developed nations in healthcare performance measures such as access to health care, healthcare outcomes, and healthcare equity. The Affordable Care Act seeks to improve the ratings of the US healthcare system, but all states need to be on board in order to see large systematic changes federally.

Mazurenko et al (2018) conducted a systematic review to look at the effects of Medicaid expansion under the Affordable Care Act and their findings found positive correlations between

Medicaid expansion and healthcare measures like quality of care and healthcare coverage. They looked at over 800 unique studies and found that the most popular outcomes to study included but are not limited to access to care, use of healthcare service, cost of care, and appointment wait times. Almost all across the board, results were similar in that Medicaid expansion was helping with the goals of the Affordable Care Act. They also bring up studies that had different conclusions and they were able to refute them with clear arguments such as some of the studies were not using peer-reviewed journals when conducting their work.

2.2 Medicaid Expansion's Impact on the Opioid Epidemic

With the expansion of Medicaid comes a jarful of externalities, both positive and negative. However, in regards to the opioid epidemic in the United States, the expansion of Medicaid has helped the nation combat the crisis. There have been a lot of misconceptions in regards to expanding Medicaid eligibility and the access to prescription opioids. Given the fact that the epidemic started with prescription opioids, I believe it is a valid and logical belief that allowing more Americans access to these drugs through insurance will worsen the epidemic. However, many studies have been conducted that beg to differ, surprisingly.

With the crisis reaching national level, there is a lot of data on Medicaid expansion and its effects. Cher et al (2019) looked at differences between states that expanded Medicaid and states that did not. More specifically, they were focused on Medicaid-paid prescriptions of opioid pain relievers and opioid addiction therapies. After 2014 when the ACA was fully implemented, overall prescription use increased, which was expected. However, prescriptions for treating opioid addiction were much higher than other drugs. Their analysis found that there was an

association between Medicaid expansion and greater increases in per enrollee opioid addiction therapy prescriptions in high overdose states compared with low overdose states (88% vs. 28%) (Cher et al, 2019). This showcases just what one large issue with the opioid epidemic looks like. Many opioid addicts start with prescription medications, but then move on to illicit and more dangerous drugs. When caught in that cycle, treatment is necessary. However, treatment is not easy to come by. By expanding Medicaid eligibility, more Americans have access to life-safing and life-changing prescriptions medications and therapies that help on their journey to fight addiction.

A tremendous negative externality of the opioid crisis is the amount of tax-dollars that go to opioid-related hospital use, whether emergency or not. One of the goals of the Affordable Care Act was to reduce the cost of healthcare and if it can help prevent hospitalizations, it is a success. Similarly to Cher et al (2019), Wen et al (2020) builds onto the effects of Medicaid expansion using a difference-in-differences study. With statistical analysis, they found that there was a statistically significant 9.7% decrease in the rate of opioid-related inpatient hospitalizations. This could mean that the Americans that became eligible and enrolled for Medicaid are controlling their use of prescribed opioids better. To add on, it could also signify that opioid abuse treatment medications are working.

However, Wen et al (2020) did not find a significant reduction in opioid-related emergency room visits. These emergency room visits are many times as a result of an overdose on an opioid or mix of opioids. Although Medicaid expansion has made great strides in access to treatment, there is much still to be done to prevent addiction in Americans in the first place. One of the goals of the ACA is to move healthcare focus from treatment to prevention. Treatment is most definitely a necessity with Americans already with opioid disorders, but prevention is

crucial in order to ensure the crisis doesn't continuously pass from each generation of Americans to the next.

Unintentional injuries are the leading cause of death for Americans aged 1-44 according to the Centers for Disease Control and Prevention. Opioid overdoses fall in that category. Like Cher et al (2019) and Wen et al (2020), Averett et al (2019) used a difference-in-differences study to look at Medicaid expansion and opioid deaths. In their analyses, they found that there was no effect of Medicaid expansion on opioid death rates. They justify their findings with the fact that there are two opposing effects at play with Medicaid expansion. There is increased access but also increased treatment and it is possible that the two cancel the effects in some way. When looking at opioid deaths in America, there are many other variables at play. One of the findings from Ruhm's research was that counties facing relative economic decline experienced higher growth rates in drug mortality than those with more sturdy growth. However, the relationship was very weak from confounding factors and they argue that the opioid epidemic deaths are mostly reflective of changes in the drug environment (Ruhm, 2018). The opioid epidemic is not an economic issue, but rather a social one. However, the large scale of the crisis means that many economic aspects of healthcare in America need reform. Although Medicaid expansion has not shown any effect on the opioid death rates in America, it helps set up the foundation for other solutions.

2.3 Solutions

News coverage is a driving force in many people's behaviors and beliefs and it is a crucial element necessary to combat the opioid epidemic. Many of the misrepresentative advertisements on television caused Americans to fall prey and become addicted to opioids. From 1998-2012, during the first wave of the epidemic leading into the second, news media coverage of the opioid epidemic put a lot of emphasis on criminal justice-oriented solutions (McGinty et al, 2019). However, the American criminal justice system has many flaws in itself. These proposed solutions were most likely inspired from the war on drugs that we've seen has been a failure and targets low-income BIPOC in America. After the passage of the Affordable Care Act, McGinty et al found that news coverages made shifts towards emphasizing public health-oriented solutions focusing on treatment, harm reduction, and prevention. These are great strides in how Americans are informed about the crisis and they can help their fellow citizens. News coverage should also emphasize breakthroughs in opioid disorder medications and therapies as those rose at high rates after Medicaid expansion.

The opioid epidemic has been going on for over two decades now and it will require many different short term as well as long term solutions. There are now opioids that incorporate abuse-deterrent features and this helps prevent users from using the medication as an injection. Other short term solutions include but are not limited to medication-assisted therapies and large scale distribution of naloxone. Naloxone helps to reverse the effects of a drug overdose and can be life-saving if administered in time. Skolnick (2018) compiled possible solutions to the opioid epidemic that are long term as well as innovative. The opioid epidemic arose because of a misunderstanding of pain and it needs to be reevaluated. He argues that the best long-term solution to the crisis is to work towards development of alternatives to opioids. Extensive

research and funding will be needed to better understand the neurology of pain, but there is potential for breakthrough discoveries that can help. In order for this to happen, federal and state governments will have to be involved.

Federal agencies like the FDA (Food & Drug Administration) and the DEA (Drug Enforcement Agency) all play a key role and with better resources will be able to get dangerous drugs off the market as well as prosecute pill mills and physicians illegally prescribing opioids (Soelberg et al, 2017). At the state level, lawsuits can be filed against opioid manufacturers to help the victims of the epidemic. I believe it is crucial to continue medical education and it helps inform Americans more about the issue and how they can avoid becoming addicted. In order to combat the opioid epidemic, federal and state programs will require extensive funding. Although it is highly debated, it is the job of the government to protect its citizens.

3. Methodology

3.1 Difference-in-Differences Model

In this economic research study, the Difference-in-Differences (DiD) method will be employed in order to examine the impact of the implementation of a policy. The pre and post-treatment difference in the outcomes for the intervention (treatment) group is first calculated. This is followed up by calculating the pre and post difference in the outcomes for the control group. Lastly, the difference between the difference in outcomes for the treatment group and the difference in outcomes for the control group is calculated. This method assumes that, in the absence of the intervention, the average change in the outcome for the treatment group would have been similar, if not identical, to the change in the control group

Panel data is utilized, capturing information before and after Medicaid expansion went into effect in each state. This analysis controls for both observable and unobservable confounders that could influence the outcome, ensuring a robust estimation of the policy's effect. Fixed effects models are applied to account for time-invariant characteristics across states. This greatly enhances the accuracy of the causal inference.

This approach involves comparing opioid overdose death rates before and after Medicaid expansion in states that adopted the policy (treatment group) in 2014 against states that did not (control group) within the timeframe of the data (2010-2019). The pretreatment time period is from 2010 to 2013 and is represented when $ME = 0$. The post-treatment time period for the treatment group is from 2014 when Medicaid expansion took effect to 2019, a year before the start of the Covid-19 Pandemic. This design allows the inference of the causal effects of Medicaid expansion by controlling for time-invariant differences between states and common trends affecting all states. Heteroskedasticity robust standard error was used and standard errors

were clustered at the state level. Year fixed effects were implemented to control for anything that impacted a specific year in all the states. This analysis contributes to understanding the policy's role in addressing the opioid crisis, offering insights into the effectiveness of Medicaid as a tool for improving public health outcomes.

3.2 Data

Data for this research study was collected from a number of sources. Opioid overdose death rates per 100,000 population (age-adjusted)[1] as well as the status of Medicaid expansion in the US states[2] come from the Kaiser Family Foundation, a non-profit organization focusing on major health issues in the US. Population trends for US states were derived from the United States Census Bureau[3]. Data on some form of a naloxone law being passed in US states come from the Legislative Analysis and Public Policy Association, a non-profit organization dedicated to legislative research and analysis in the public health sector and more[4]. Data on educational attainment (percent) comes from the Federal Reserve Bank of St. Louis's online database[5]. It is an estimate of educational attainment for the population 18 years old and over whose highest degree was a bachelor's, master's, or professional or doctorate degree. Data on the passage of recreational and medical marijuana laws in the US states comes from MJBiz, a media company

[1] View data on opioid overdose death rates per 100,000 (age-adjusted)
https://www.kff.org/other/state-indicator/opioid-overdose-death-rates/?activeTab=graph&currentTimeframe=1&startTimeframe=11&sortModel=%7B%22colId%22:%222012__Opioid%20Overdose%20Death%20Rate%20(Age-Adjusted)%22,%22sort%22:%22desc%22%7D

[2] View data on the status of state Medicaid expansion decisions
https://www.kff.org/medicaid/issue-brief/status-of-state-medicaid-expansion-decisions-interactive-map/#:~:text=To%20date%2C%2041%20states%20

[3] View data on population
https://www.census.gov/programs-surveys/popest/technical-documentation/research/evaluation-estimates/2020-evaluation-estimates/2010s-state-total.html

[4] View data on naloxone access laws
https://legislativeanalysis.org/wp-content/uploads/2022/09/Naloxone-Access-Summary-of-State-Laws.pdf

[5] View data on educational attainment
https://fred.stlouisfed.org/release/tables?rid=330&eid=391444&od=2010-01-01#

focusing on the cannabis and hemp industries[6]. Data on the homeless population per state comes from the US Department of Housing and Urban Development[7].

3.3 Grouping of States

To utilize the difference-in-differences model, a treatment and a control group need to be created. In this study, the treatment group includes all the US states that expanded Medicaid in 2014, the year that the Affordable Care Act went into effect. The District of Columbia was also included as there is much available data. The control group includes the US states that did not expand Medicaid between 2010 and 2019. States that expanded Medicaid after 2014 and before or in 2019 were excluded from this research study. These states are Alaska (2015), Indiana (2015), Louisiana (2016), Maine (2019), Montanna (2016), and Pennsylvania (2015). The treatment and control groups along with the year Medicaid was expanded in each state are shown in Table 1.

[6] View data on the legalization of recreational and medical marijuana in US states https://mjbizdaily.com/map-of-us-marijuana-legalization-by-state/

[7] View data on homeless population https://www.hudexchange.info/resource/3031/pit-and-hic-data-since-2007/

Treatment Group	Year of Medicaid Expansion	Control Group	Year of Medicaid Expansion
Arizona	2014	Alabama	Not Adopted
Arkansas	2014	Florida	Not Adopted
California	2014	Georgia	Not Adopted
Colorado	2014	Idaho	2020
Connecticut	2014	Kansas	Not Adopted
Delaware	2014	Mississippi	Not Adopted
District of Columbia	2014	Missouri	2020
Hawaii	2014	Nebraska	2020
Illinois	2014	North Carolina	2021
Iowa	2014	Oklahoma	2021
Kentucky	2014	South Carolina	Not Adopted
Maryland	2014	South Dakota	2023
Massachusetts	2014	Tennessee	Not Adopted
Michigan	2014	Texas	Not Adopted
Minnesota	2014	Utah	2023
Nevada	2014	Wisconsin	Not Adopted
New Hampshire	2014	Wyoming	Not Adopted
New Jersey	2014		
New Mexico	2014		
New York	2014		
North Dakota	2014		
Ohio	2014		
Oregon	2014		
Rhode Island	2014		
Vermont	2014		
Washington	2014		
West Virginia	2014		

Table 1

3.4 Econometric Models

This research first runs an ordinary least squares regression as follows:

(Equation 3.4.1)

$$OD = \beta_0 + \beta_1 Nal + \beta_2 RecMj + \beta_3 MedMj + \beta_4 Ed + \beta_5 ME + \beta_6 hl + \beta_7 logPop$$

where

OD (opioid overdose death rates per 100,000 age adjusted) is the dependent variable. β_0 is the value of *OD* when all independent variables are zero. The dummy independent variables are *Nal* (whether a state has passed some form of a naloxone access law or not), *RecMj* (whether or not recreational marijuana is legal), *MedMj* (whether or not medicinal marijuana is legal), and *ME* (whether or not Medicaid has been expanded). The remaining independent variables are *Ed* (the estimated percentage of the population 18 years old and over whose highest degree was a bachelor's, master's, or professional or doctorate degree), *hl* (estimates of the homeless population/ total population of a state), and *logPop* (the log of a state's population). β_1 to β_7 represent the coefficients for the independent variables. They represent the expected change in *OD* when there is a one unit increase in that variable, holding all other variables constant. The regression controls for heteroscedasticity with robust standard errors.

The linear regression was then taken and changed to account for fixed effects. The data was clustered by states and fixed effects were implemented to create the model as such:

(Equation 3.4.2)

$$OD_{st} = \alpha_s + \beta_1 Nal_{st} + \beta_2 RecMj_{st} + \beta_3 MedMj_{st} + \beta_4 Ed_{st} + \beta_5 ME_{st} + \beta_6 hl_{st} + \beta_7 logPop_{st}$$

$$+ \sum_j \gamma j Year_{jt} + \epsilon_{st}$$

where

The subscript *s* and *t* index the states and time. OD_{st} is the predicted value for the dependent variable for state *s* at time *t*. Nal_{st}, $RecMj_{st}$, $MedMj_{st}$, Ed_{st}, ME_{st}, $logPop_{st}$ and are independent variables for state *s* at year *t*. α_s is the state-specific intercept. It represents the fixed effects for each state. β_1 to β_7 represent the coefficients for all independent variables.

$\sum_j \gamma j Year_{jt}$ represents the capture of year fixed effects. γj represents the effect of year *j* on *OD*.

The error term for state *s* and time *t* is represented by ϵ_{st}. This model allows for analyzing changes within states over time and how it affects the dependent variable.

3.4.1 Application of Difference-In-Differences

The Difference-In-Differences is estimated with the model: (Equation 3.4.3)

$$OD_{st} = \alpha + \beta_1 ME_{st} + \beta_2 Nal_{st} + \beta_3 RecMj_{st} + \beta_4 MedMj_{st} + \beta_5 Ed_{st} + \beta_6 hl_{st} + \gamma_s + \delta_t + \theta_{st}(ME_{st} \cdot Post_t) + \epsilon_{st}$$

Where

OD_{st} is the dependent variable for state *s* and time *t*. The binary treatment indicator is represented by ME_{st} where it equals 1 if Medicaid expansion was enacted or 0 if it has not been. The covariates are Nal_{st}, $RecMj_{st}$, $MedMj_{st}$, Ed_{st}, and hl_{st} for state *s* and time *t* with β_1 to β_6 representing the coefficients for the treatment and control variables. The constant term is represented by α. The fixed effects for each state *s* is represented by γ_s. The fixed effects for each time period *t* is represented by δ_t. θ_{st} represents the interaction effect between the treatment and post-treatment period indicator, represented by $Post_t$. The coefficient θ is of great interest as it is the estimate of the impact of the treatment on the outcome. $Post_t$ is a binary variable that is implied and represents the post treatment time period. 1 would mean the post-treatment time period and 0 would mean the pre-treatment time period. ϵ_{st} is the error term for state *s* at time *t*.

3.4.2 Parallel Trends Assumption

In order for the difference-in-differences model to hold, the parallel trends assumption needs to be upheld. The assumption is that without the intervention of Medicaid expansion, the difference in the opioid overdose death rates between the treatment and control groups would be constant over time. This research utilizes three different methods to test the parallel trends assumption.

Figure 1 graphs the observed means and the linear trends model of the treatment and control groups pre and post-treatment. Visual analysis shows that although the observed means are not exactly parallel, the control and treatment groups both show a general upward trend.

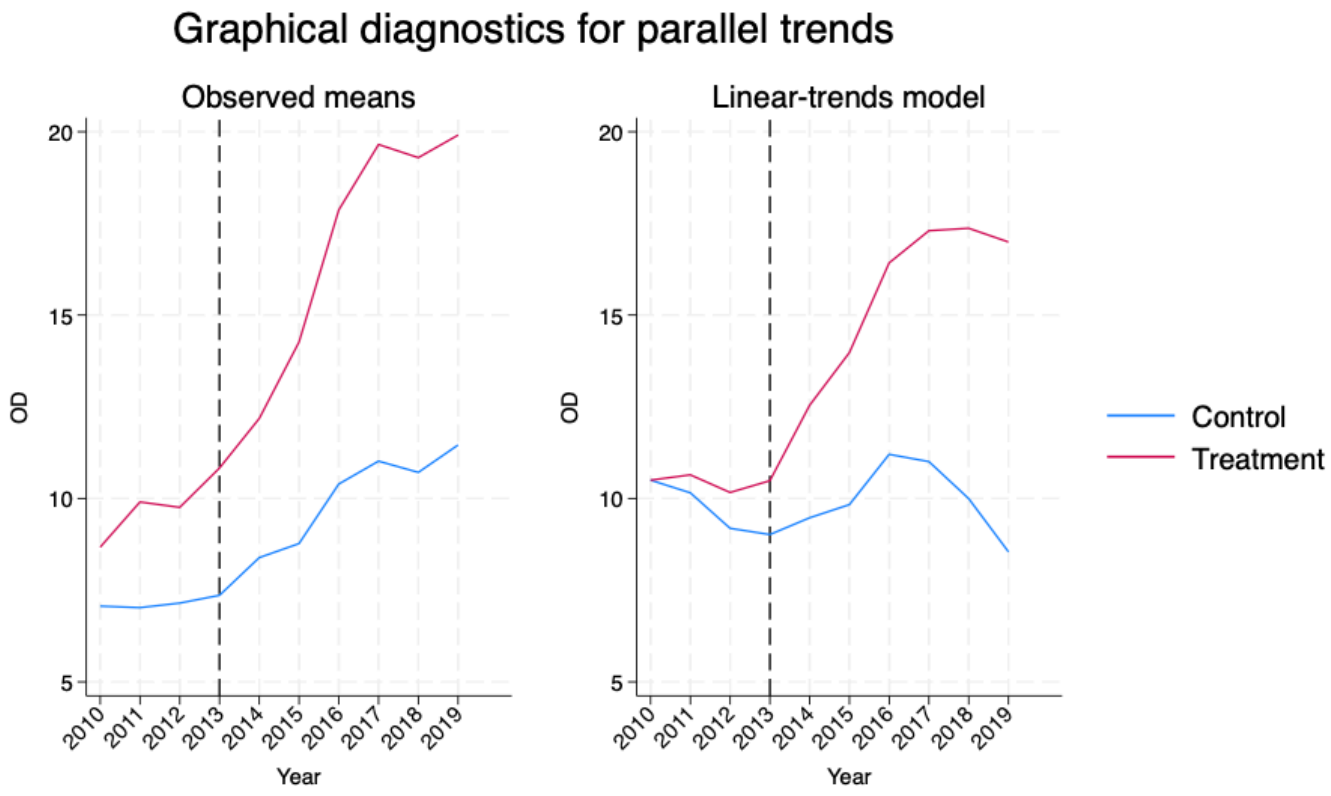

Table 2: Parallel-trends test (pretreatment time period)

H0: Linear trends are parallel
F(1, 43) = 3.24
Prob > F = 0.0790

The second test conducted also looks at the pre-treatment time period for parallel trends. Table 2 displays the results from the test. At a 5% significance level and the p-value being 0.079, there is failure to reject the null hypothesis that the linear trends in the pretreatment time period are parallel.

Table 3: Granger Causality Test

H0: No effect in anticipation of treatment
F(3, 43) = 2.02
Prob > F = 0.1248

The last test is the Granger causality test, which tests if past values of the treatment variable predict future values of the dependent variable. It looks to see if there are anticipatory effects before the intervention. At the 5% significance level, there is failure to reject the null hypothesis that there is no effect in anticipation of treatment because the p-value of 0.1248 > 0.05. Therefore, past values of the treatment variable do not statistically significantly predict future values of the dependent variable (opioid overdose death rate per 100,000, age-adjusted).

These three tests validate the parallel trends assumption and uphold the results of the difference-in-differences model.

4. Results & Analysis

The results of Equation 3.4.1 are displayed in Table 4:

Table 4
Linear regression

OD	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Nal	2.045	.717	2.85	.005	.637	3.453	***
RecMj	-2.74	1.322	-2.07	.039	-5.338	-.143	**
MedMj	1.077	.893	1.21	.228	-.678	2.832	
Ed	.133	.101	1.31	.191	-.066	.331	
ME	6.556	1.077	6.09	0	4.439	8.673	***
hl	-711.624	318.337	-2.24	.026	-1337.322	-85.926	**
logPop	-.808	.346	-2.33	.02	-1.488	-.128	**
Constant	17.799	6.381	2.79	.006	5.257	30.342	***

Mean dependent var	12.207	SD dependent var	8.421
R-squared	0.254	Number of obs	436
F-test	15.180	Prob > F	0.000
Akaike crit. (AIC)	2982.444	Bayesian crit. (BIC)	3015.066

**** p<.01, ** p<.05, * p<.1*

With an R-squared of 0.254, it can be concluded that about 25.4% of the variance in OD can be explained by the model. Medicaid expansion is statistically significant at the 5% significance level. Nal, RecMj, hl, and logPop are all also statistically significant at conventional levels.

The results of Equation 3.4.2 are displayed in Table 5:

Table 5

Regression results

OD	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
Nal	-.925	1.062	-0.87	.389	-3.066	1.216	
RecMj	-1.397	2.367	-0.59	.558	-6.171	3.377	
MedMj	.996	1.436	0.69	.492	-1.9	3.893	
Ed	1.921	.679	2.83	.007	.551	3.29	***
ME	3.988	1.523	2.62	.012	.917	7.06	**
hl	-476.318	938.775	-0.51	.614	-2369.538	1416.903	
logPop	-52.595	23.983	-2.19	.034	-100.962	-4.228	**

Mean dependent var	12.207	SD dependent var	8.421
R-squared	0.519	Number of obs	436
F-test	7.529	Prob > F	0.000
Akaike crit. (AIC)	2388.872	Bayesian crit. (BIC)	2454.115

*** *p<.01, ** p<.05, * p<.1*

With an R-squared of 0.519, it can be concluded that 51.9% of the variance in OD can be explained by this model. Medicaid expansion is still statistically significant at the 5% significance level. Ed and logPop are also statistically significant at conventional levels.

The results of Equation 3.4.3 are displayed in Table 6:

Table 6

Treatment and time information
Time variable: Year
Control: ME = 0
Treatment: ME = 1

	Control	Treatment
Group		
StateNumber	17	27
Time		
Minimum	2010	2014
Maximum	2010	2014

Difference-in-differences regression — Number of obs = 436
Data type: Longitudinal

(Std. err. adjusted for 44 clusters in StateNumber)

OD	Coefficient	Robust std. err.	t	P>t	[95%	conf.interval]
ATET						
ME						
(1 vs 0)						
	4.832	1.548	3.12	0.003	1.711	7.953

Note: ATET estimate adjusted for covariates, panel effects, and time effects.

The p-value of 0.003 means that at the 5% significance level, the treatment effect of Medicaid expansion is statistically significant. The null hypothesis that the treatment has no effect on the outcome can be rejected. The coefficient of ME is 4.832. This can be interpreted as there is an association of approximately a 4.832 increase in opioid overdose death rate per 100,000 (age-adjusted) for states in the treatment group, with other factors held constant. Overall, this Difference-In-Differences analysis suggests that Medicaid expansion has a positive effect on opioid overdose death rates. This is contrary to Averett et al (2019) who found that Medicaid expansion did not have a significant effect on opioid deaths.

Conclusion

Overall, this difference-in-differences analysis has shown that expanding Medicaid had adverse effects on the opioid overdose mortality rates. States that expanded Medicaid had higher rates of opioid overdose mortality post-intervention (2014) than states that did not. It is important to note that the opioid crisis is still ongoing and has seen many changes and developments since its emergence in the United States. The opioid epidemic has taken a large toll on Americans and their families and it is imperative that solutions be implemented. There is a push back effect as there is increased access to opioids along with increased access to treatments. More government regulation is needed at both the federal and state levels as opioid deaths look to be implicative of a change in the drug environment. It is of great importance to spread awareness, make life-saving overdose medications like naloxone widely available, and work towards the development of alternatives to opioids by researching the neurology of pain more. These short and long-term solutions will require great effort and collaboration between many organizations in the US.

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