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THE EFFECT OF THE AFFORDABLE CARE ACT ON OPIOID OVERDOSE
MORTALITY

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Economic Analytics

by
Caleb Patrick Jordan
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Accepted by:
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Abstract

The opioid epidemic is an ongoing health crisis in the United States, claiming the lives of thousands over the past two decades. In 2014, provisions of the Affordable Care Act expanding Medicaid officially came in effect, extending healthcare to millions of people in the United States. However, Medicaid expansion was optional for states, so some states greatly expanded healthcare to low-income people while others did not. People in expansion states gained more affordable access to prescription drugs and treatment centers, making opioids easier to obtain and addictions more affordable to treat. This makes the effect of the Affordable Care Act on the opioid epidemic ambiguous, since it could either help or worsen the crisis, depending on if easier access to opioids or treatment has a larger effect on overdoses. In this paper, I use a difference-in-differences approach using state-level data from 2008 to 2019 to compare Opioid overdose death rates between expansion states and non-expansion states. I find significant evidence that Medicaid expansion is correlated with an increase in Opioid overdose deaths.

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Introduction

The opioid epidemic in the United States has been raging since the late nineties. Many patients were unaware of the addictive and dangerous nature of opioids, leading to many addictions and deaths. Since 1999, over 500,000 individuals have died from opioid abuse, with around 68,000 deaths coming in 2020 alone, making up about 75% of all overdose deaths (CDC, 2022). In this paper I examine the roots of the opioid epidemic. I explore if increased access to care has led to an increase in opioid-related deaths in recent years. Most opioid deaths, about 80%, come from dangerous, synthetic opioids that are not prescribed to the individual but, instead, are stolen or bought on the black market without the guidance of a doctor (CDC, 2022). There is also a risk of secondary addictions to other hard drugs which frequently cause misuse and death, like heroin or methamphetamines (CDC, 2022). However, most addictions begin with initial prescriptions under medical guidance that turn into long-term dependence (Mayo Foundation for Medical Education and Research, 2022). Increased coverage lowers the cost of doctor visits and medicinal pain relief and, thereby, leads to increased opioid availability. Increased availability leads to more use, which can cause more addictions over time. Addiction to opioids can eventually lead to overdose, or further addiction to more dangerous drugs which eventually lead to overdose and death. There is also potential for riskier use resulting from increased availability of treatment as people use available treatment as a crutch, leading to more overdose deaths. These facts raise the question if policy decisions that increase the availability of health insurance have a negative effect on opioid overdoses.

In 2010, President Barack Obama signed into law the Affordable Care Act, which made healthcare coverage accessible for over 20 million Americans and reduced the uninsured population by nearly 50 percent (US Department of Health and Human Services, 2021). Most provisions of the act came into effect in 2014, increasing the availability of opioids but also increasing the availability of addiction treatment options (US Department of Health and Human Services, 2021). Therefore, it is not obvious what kind of effect the act would have on the opioid crisis since it introduces easier access to opioids but also easier access to treatment options to prevent opioid deaths. This paper uses the Affordable Care Act as a treatment in a difference-in-differences method, with states that have not adopted the Affordable Care Act acting as a control group. The results find that opioid overdose deaths increased significantly after the implementation of the Affordable Care Act in 2014, with the effects of the act not showing until a few years after implementation.

Literature Review

Previous literature on the opioid crisis as it relates to healthcare is extensive. The focus of previous papers has been on the relationship between access to care and opioid overdoses as well as overall mortality. The Affordable Care Act and naloxone access, among others, are used as treatments in difference-in-differences models. Other papers look at how opioid treatment facilities are utilized after expanding Medicaid to see if the policy changes lead to higher treatment utilization. There is also extensive research on the relationship between the legalization of medical marijuana and opioid overdoses to be discussed later in the section.

Averett, Smith, and Wang (2019) examine the relationship between healthcare coverage and opioid overdoses. They use the implementation of the Affordable Care Act (ACA) as a treatment, just as I will. A difference-in-differences model was used to see if there was a significant increase in opioid-related deaths after more people received healthcare coverage because of the ACA. States included in the treatment group adopted the Medicaid expansion in 2014 when the act was initially passed. States that implemented the act after or before 2014 are not included in the analysis, and states that never adopted the Medicaid expansion (in the time frame of the paper, so, pre-2017) are used as a control group. In the paper they control for the minimum wage, food insecurity, demographics, etc. as well as the availability of medical marijuana, naloxone access, and prescription drug monitoring programs. They find an increase in opioid overdose deaths after the Affordable Care Act was implemented, but insufficient evidence to definitively say this was a non-zero, significant increase.

Black, Hollingsworth, Nunes, and Simon (2019) analyze the relationship between health insurance and overall mortality, also using the ACA as a treatment in a difference-in-differences model. Since there was a considerable rise in mortality in non-expansion states compared with expansion states in the years leading up to the Affordable Care Act, it was difficult to account for this in a difference-in-differences model. They use several models, triple difference, and synthetic control approaches, but are unable to produce explanatory power because of the rise in mortality in the control group. This made them unable to pinpoint the exact relationship between the expansion of Medicaid and overall mortality on a causal level, as their results could be interpreted as expanding Medicaid having no effect on mortality or having a large effect on

mortality, leaving an ambiguous conclusion to be explored by future research. They also use power analysis to conduct a simulation, but this is still unable to produce a definite causal relationship with the given data provided by the real-life experiment of the Affordable Care Act. Data from a longer time span and more specific causes of mortality are needed to establish a definite and significant relationship between health insurance and mortality.

Meinhofer and Witman (2018) use state by state data from the Affordable Care Act to examine the relationship between health insurance and the treatment of opioid use disorders. Their method was using a difference in differences design to compare the utilization of opioid treatment centers before and after the expansion of Medicaid across states. They found that utilization of these facilities increased considerably when Medicaid was expanded to more people without crowding out patients with existing health insurance, implying that there may be a benefit to expanding healthcare coverage to combat the opioid crisis, as people utilize the resources provided by expanding Medicaid at a higher rate than before the expansion of Medicaid. This increase in utilization appears to be driven by increases in medication-assisted-treatment providers and greater acceptance of Medicaid payments by existing providers.

There have also been indications that expanding access to treatment options can increase opioid-related incidents and in some cases, mortality. Doleac and Mukherjee (2018) examine the effect of naloxone access on different health outcomes like opioid-related emergency room visits, overdoses, and mortality, as well as outcomes on crime and other drug-related issues. They find that having greater access to treatment

options, in this case naloxone, has several effects on different outcomes that would indicate moral hazard associated with greater access to healthcare. Some of those outcomes are an increase in opioid-related hospital visits, an increase in theft to finance opioid addictions, and a potential increase in the use of fentanyl, a particularly dangerous synthetic opioid, which contributes to a significant number of deaths in the United States every year. This shows some potential moral hazard present when healthcare access is expanded, as it may lead to greater mortality.

There has also been work done on the relationship between the legalization of medical marijuana and the utilization of opioids. To examine the relationship Shah et al (2018) obtain a sample of commercially insured people in the United States and get data on opioid use, chronic use, and high-risk use, controlling for patient, year, and state-level factors. They used a multilevel logistic regression analysis to find the effect of the legalization of medical marijuana on the three opioid measures. Legalization of marijuana significantly reduced the odds of any opioid use including normal use and chronic use (Shah et al., 2018). It also reduced the number of opioids prescribed by doctors. Marijuana may have a positive effect in helping alleviate the opioid crisis.

I will add to existing literature by using a wider time frame while following a model similar to Averett, Smith, and Wang (2019), since the Affordable Care Act has been available for several years now, allowing for more precise estimates and more treated observations. I also expand the data to 2008 rather than 2010 for more observations. I focus on Opioid overdose mortality rather than overall mortality, to avoid the problems faced by Black, Hollingsworth, Nunes, and Simon (2019). I attempt to either confirm or call into question the findings of previous literature, where I find that when using an

extended data frame, the Affordable Care Act appears to increase opioid-related mortality, a different finding from Averett, Smith, and Wang (2019).

DATA

The data come from a variety of sources to account for the political, economic, and medical factors that go into healthcare coverage and opioid overdoses in different states. The main response variable of interest is the age-adjusted opioid overdose death rate per one-hundred thousand people in a state. The age-adjusted rate uses the 2000 U.S. standard population to allow for comparison between states that have different age structures. Data for the variable come from the CDC wonder website's ICD-10 multiple cause of death data using death codes X40-44, X60-64, X85, and Y10-14, which covers opioid related deaths of all intents. The percentage of people without health insurance by state comes from the Current Population Survey Annual Social and Economic Supplement (CPS ASEC) HIC tables, provided by the U.S. Census Bureau. Economic controls included in the model are the unemployment rate, median household income (in US dollars), and the percentage of people in the state with a high school diploma. These variables were obtained from the Bureau of Labor Statistics, the St Louis Federal Reserve Economic Data, and the U.S. Census Bureau American Community Survey Educational Attainment data, respectively. Demographic variables including the percentages of white, black, and Hispanic people as well as the percentage of people aged 18 to 25 in each state are included as well, obtained from the Kaiser Family Foundation's 1-year estimates from the U.S. Census Bureau American Community Survey. This paper also controls for states that have passed a medical marijuana access law using a dummy variable, attained from state-by-state

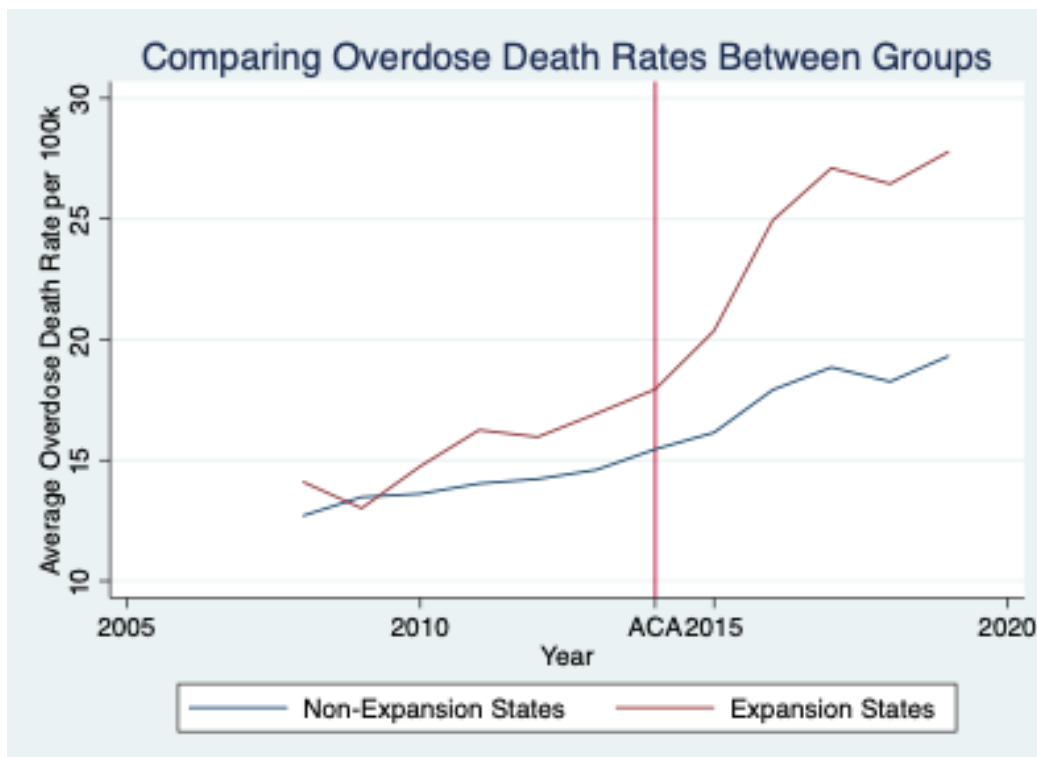
medical marijuana data at procon.org. Information on Medicaid expansion status by state was obtained from KFF's status of state Medicaid decisions interactive map. All data are from the years 2008 to 2019.

Summary statistics for each group of states can be found in Table 1. Many of the trends shown before and after ACA implementation are similar for expansion and non-expansion states, like decreased unemployment and percentage of people aged 18 to 24 as well as increased median household income and percentage of people with a high school diploma. Demographic variables remain similar, with both groups showing an increase in the Hispanic population and a decrease in the white population. Both groups also show an increase in overdose deaths per 100,000, but the expansion states have a much larger increase. There is also a large difference between the two groups in the implementation of medical marijuana laws, which are implemented at a much higher rate in expansion states. The similarities in data trends suggest that non-expansion and expansion states are good comparison groups, since they have similar trends in most independent variables before and after ACA expansion. Figure 1 shows the similarities in overdose trends prior to the expansion and the divergence in overdoses occurring after the expansion of Medicaid.

Table 1: Summary Statistics for Expansion and Non-Expansion States Before and After Medicaid Expansion

Variables	Non-Expansion Before	Non-Expansion After	Expansion Before	Expansion After
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Overdose deaths per 100,000	13.78 (4.130)	17.66 (5.875)	15.17 (6.460)	24.10 (10.99)
Median Household Income (\$)	55,117 (6,636)	59,386 (7,700)	62,276 (9,038)	67,870 (11,114)
Unemployment Rate	7.259 (2.195)	4.262 (1.140)	7.813 (2.166)	4.670 (1.290)
% of state with high school diploma	88.56 (2.991)	89.99 (2.483)	89.69 (3.316)	91.10 (2.874)
% Black	13.05 (11.23)	13.22 (11.32)	9.653 (10.68)	9.776 (9.881)
% Hispanic	9.743 (8.539)	10.89 (8.911)	12.98 (11.29)	14.29 (11.58)
% White	71.89 (12.04)	69.72 (12.31)	67.91 (18.58)	65.33 (18.37)
% of people age 18 to 24	9.431 (0.634)	9.077 (0.643)	9.251 (0.841)	8.960 (0.615)
Medical Marijuana Law	0 (0)	0.0980 (0.299)	0.513 (0.501)	0.865 (0.342)
Observations	N=102	N=102	N=156	N=156

Figure 1: Overdose Deaths Over Time for Expansion vs. Non-Expansion States



Methods

The main method used in this paper is a difference-in-differences model, shown below, which will assess the effect of Medicaid expansion on opioid overdose deaths:

$$y_{st} = \beta_0 + \beta_1 \text{Expansion} * \text{Post} + \beta_2 X + \delta_s + \tau_t + \varepsilon_{st}$$

where y_{st} is the log of the opioid overdose death rate per 100k adjusted for age by state. X includes all controls mentioned previously, while δ_s and τ_t represent state and year fixed effects, respectively, while ε_{st} is an error term. States that expanded Medicaid in 2014 are assigned to the treatment group, while states that adopted the Medicaid expansion at a different time are dropped from the analysis for simplicity purposes (states included in the treatment and control groups are shown in Table 2). States that have not adopted the Medicaid expansion are assigned to the control group. The pre-expansion period is defined as before 2014 and is assigned a value of 0. The post-expansion period is 2014 and after, assigned a value of 1. Standard errors are clustered by state. I also present a regression showing the differences between the treatment and control groups by year using a year*expansion interaction variable, shown below:

$$y_{st} = \beta_0 + \beta_1 \text{Year} * \text{Expansion} + \beta_2 X + \delta_s + \varepsilon_{st}$$

The first model I estimate is one using the percentage of uninsured people by state as the response variable to show how adopting the Medicaid expansion measures of the ACA reduced the uninsured population, with other controls included as well. The purpose of this model is to show if the Medicaid Expansion was successful in significantly lowering the uninsured population, making it a reasonable treatment to observe if increasing coverage increases overdose deaths. Then, a difference-in-differences model is constructed using the same controls, but the main variable of

interest is the Medicaid expansion variable, which shows how the opioid overdose death rate is affected by the adoption of Medicaid expansion. Another regression shows the interactions between years and states in the expansion group, to show how the difference in overdose deaths between the expansion group and non-expansion group changes over time with respect to the adoption of the affordable care act. Each regression is run while controlling for state and year fixed effects and log-opioid overdose rate is used as the response variable for each regression other than the percent uninsured regression. Absent policy differences, expansion and non-expansion states have similar upward trends for opioid overdose deaths before the expansion of Medicaid, making non-expansion states a reasonable control group. Also, it is assumed there are no major changes that take place outside of Medicaid expansion during this time in expansion or non-expansion states that are not controlled for.

Table 2: Treatment Group Assignments

Expansion States	Non-Expansion States	Dropped from Analysis
Arizona	Alabama	New Hampshire
Arkansas	Florida	Pennsylvania
California	Georgia	Indiana
Colorado	Idaho	Alaska
Connecticut	Kansas	Montana
Delaware	Mississippi	Louisiana
District of Columbia	Missouri	Virginia
Hawaii	Nebraska	Maine
Illinois	North Carolina	
Iowa	Oklahoma	
Kentucky	South Carolina	
Maryland	South Dakota	
Massachusetts	Tennessee	
Michigan	Texas	
Minnesota	Utah	
Nevada	Wisconsin	
New Jersey	Wyoming	
New Mexico		
New York		
North Dakota		
Ohio		
Oregon		
Rhode Island		
Vermont		
Washington		
West Virginia		

Results

The results from the first regression model are presented in Table 3, showing the expected negative and significant coefficient on the Medicaid expansion variable both with and without controls included, as well as significant coefficients on several of the control variables, showing their relevance in the next regression models with overdose deaths as the response variable. The results show that expanding Medicaid is associated, on average, with a decrease of about 1.4 in the percentage of people

without health insurance, which is consistent with previous estimates and data on the Affordable Care Act, as well as the overall goal of the act (U.S. Department of Health and Human Services, 2021).

The results of the difference-in-differences model with log(overdoses) as the response variable mentioned previously are presented in Table 4, with and without controls, with the second column using only data from 2010 to 2017 to replicate results from the paper by Averett, Smith, and Wang (2019). The Medicaid expansion coefficient for the regression using only 2010 to 2017 data is slightly lower with a higher standard error, showing that using fewer years in the analysis may lead to a lower and less precise estimate of the Medicaid expansion coefficient. The regression using the full range of data shows a significant and positive coefficient on the Medicaid expansion variable, as well as a positive and significant coefficient on the medical marijuana dummy variable, showing there is some evidence the Affordable Care Act led to about 15.4% higher overdose deaths in expansion states than if they had not expanded Medicaid. The summary statistics show a 58.8% increase in opioid overdoses in expansion states before and after Medicaid expansion, meaning about one-fourth of this increase can be attributed to Medicaid expansion. The magnitude of this coefficient is larger than in the previous study, which had coefficients around 10%, consistent with the replication presented in Table 4.

Figure 1 shows the raw data using the average opioid overdose death rates in each year for both the expansion states and non-expansion states, showing the different patterns of overdose growth in the 2 groups, with both groups having similar numbers of overdoses, conditional on controls, before the Affordable Care Act, but

expansion states having significantly higher rates of overdoses after the Affordable Care Act. Figure 2 shows the year*expansion interaction dummies using 2014 as a base year, illustrated by the vertical red line. The graph shows positive and significant coefficients from 2016 to 2019, showing expansion states had significantly higher opioid overdose in those years than states that didn't expand, likely because of the adoption of Medicaid expansion in 2014. It is worth noting the insignificant coefficients in years prior to 2014, showing the lack of differences in overdoses pre-expansion and implying that the two groups had similar trajectories for opioid overdoses before the policy changes.

The coefficients being significant in 2016 through 2019 is consistent with what one would expect, since it would take time for the policy to be implemented and utilized, so the effects on opioid overdoses would not be felt for a couple years after the initial implementation. This time lag could be explained by several theories. A potential cause of increased overdoses is easier and more frequent access to opioids through healthcare providers, leading to new addictions and eventually, more overdose deaths. This would likely take some time to show an effect, since people would need to enroll in the new healthcare plan, gain an opioid prescription, get addicted, and eventually overdose. This is a relatively simple economic explanation, since lowering the cost of acquiring opioids leads to a greater quantity demanded, and given the highly addictive nature of opioids, a greater number of addictions. These addictions can worsen over time, leading to overdoses or addictions to more dangerous, synthetic opioids, which can ultimately lead to death, explaining the time lag between expanding Medicaid and the increase in overdose deaths. Another possibility, to be explored by further study, is moral hazard associated with increased treatment, as people act more recklessly and

overdose more frequently since they know there is treatment available when they overdose. This would likely have a more immediate effect on overdoses, which could potentially explain the slight increase in the 2015 year*expansion coefficient, but this is not certain.

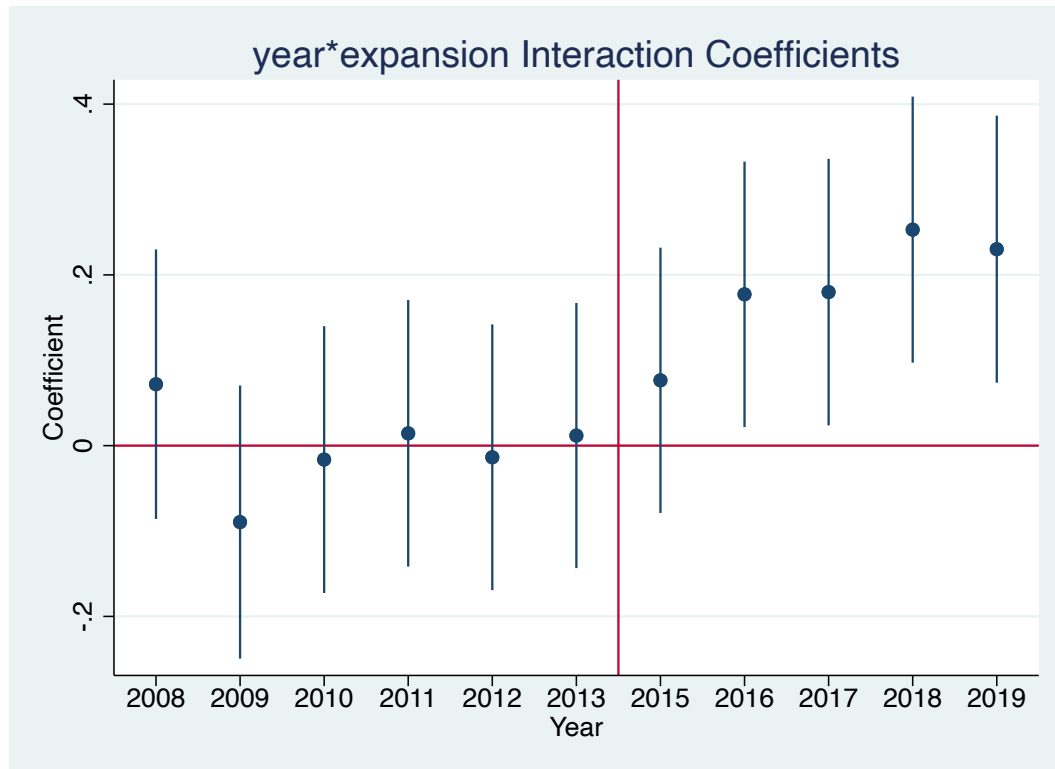
Table 3: Diff-in-Diff Showing Effect of Medicaid Expansion on Uninsured Population

	(1)	(2)
VARIABLES	% Uninsured	% Uninsured
Medicaid Expansion	-1.217*** (0.206)	-1.391*** (0.194)
Medical Marijuana Law		0.437** (0.191)
Median Household Income		4.51e-05*** (1.65e-05)
% of people age 18 to 24		-0.00800 (0.122)
Unemployment Rate		0.529*** (0.0612)
% of state with high school diploma		-0.274*** (0.0523)
% White		-0.259* (0.153)
% Black		-0.277 (0.179)
% Hispanic		-0.266 (0.212)
Constant	11.66*** (0.375)	55.34*** (16.19)
Observations	516	516
R-squared	0.944	0.957
State FE	YES	YES
Year FE	YES	YES
Standard errors in parentheses		
*** p<0.01, ** p<0.05, * p<0.1		

Table 4: Diff-in-Diff Showing Effect of Medicaid Expansion on Opioid Overdoses

	2008-2019 No Controls	2010-2017	2008-2019
VARIABLES	log(Overdose rate per 100k)	log(Overdose rate per 100k)	log(Overdose rate per 100k)
Medicaid Expansion	0.220*** (0.0349)	0.101*** (0.0350)	0.154*** (0.0346)
Medical Marijuana Law		0.196*** (0.0408)	0.208*** (0.0340)
Median Household Income		1.81e-06 (3.22e-06)	3.01e-06 (2.93e-06)
% of people age 18 to 24		-0.0287 (0.0376)	0.0251 (0.0218)
Unemployment Rate		0.0276** (0.0129)	0.0135 (0.0109)
% of state with high school diploma		0.00248 (0.0125)	-0.00869 (0.00932)
% White		-0.0645* (0.0368)	-0.00319 (0.0272)
% Black		-0.0997** (0.0418)	-0.0759** (0.0318)
% Hispanic		-0.0215 (0.0522)	0.0283 (0.0378)
Constant	2.619*** (0.0635)	9.408** (3.659)	5.009* (2.884)
Observations	516	344	516
R-squared	0.837	0.901	0.861
State FE	YES	YES	YES
Year FE	YES	YES	YES
Standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Figure 2: Expansion Group Time Interaction Coefficients



Limitations and Extensions

Like any model attempting to establish causality, the model is limited by the potential for other confounding variables which could be leading to upward bias in the Medicaid expansion coefficient as they could be correlated with both opioid overdoses and the expansion of Medicaid, like specific treatment access variables which are not readily available in the data, like variables for naloxone access laws and prescription drug monitoring programs, both of which were used by Averett, Smith, and Wang (2019). This could potentially lead to a higher estimate than is actual. One could potentially include more controls for urbanicity, politics, or other variables that may be linked to both opioid overdoses and the rate at which people are insured, but the Medicaid expansion coefficient seems to be robust, not changing tremendously when more controls are introduced to the model, since many of these controls are not

changing differently for treatment states post-expansion. This paper also only looks at states which adopted the Medicaid expansion in 2014, not states that expanded Medicaid before or after the 2014 adoption of the Affordable Care Act. Further study to better corroborate or refute previous literature could use treatment groups for each adoption time over a longer time frame, giving more observations to yield more reliable results. A more detailed paper might also use more detailed data at the county or individual level to control for characteristics and risk-factors at the individual level, like gender, age, health measures, etc.

Conclusion

The expansion of Medicaid can have an unclear effect on opioid overdose deaths, as it provides easier access to opioids for many at-risk groups but also increases the availability of treatment options. Based on the results of this paper, I find that Medicaid expansion in the Affordable Care Act led to significantly higher opioid overdose death rates in states that implemented the measure, with a larger magnitude than previously studied. This result contradicts the findings of Averett et al. who found no significant increase or decrease in opioid mortality related to the Affordable Care Act. This difference can be attributed to the increased data accumulated after the passage of the Affordable Care Act, which provides more insight into the lasting effects of the act years after passage. There are also differences in controls, as Averett et al. included treatment option controls for Naloxone laws and prescription drug monitoring programs, for which the data was unavailable for use in this paper, but the results of the regressions seem to be robust as the coefficients do not change to a large degree with or without the inclusion of several similar controls. Nonetheless, this paper finds

sufficient evidence to conclude that the Affordable Care Act has led to a greater number of opioid overdose deaths from increased and easier access to opioids, with the effects setting in a few years after its implementation.

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