Combatting the Opioid Epidemic with Regulatory Policy

Assessing the Effects of States' Opioid Controls

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MOTIVATION

Opioid abuse and overdoses have rocked the United States for the past two decades. The number of opioid overdose deaths has quadrupled since 1999, and more than half a million people died due to drug overdoses between 2000 and 2015.[1] Recently, opioid abuse has even contributed to a 2014-2017 decline in male life expectancy,[2] leading the President to declare a national opioid health emergency in 2017.

In response to the opioid epidemic, states have implemented policies with the goal of decreasing opioid prescriptions, addictions, and deaths. This report examines three states specific states that enacted stricter opioid regulations between 2007 and 2012 – Florida, Texas, and Washington. Their regulatory policies all sought to decrease the volume of opioids and number of overdoses within the state. If their policies effectively decrease opioid prescriptions and deaths, they can be used as justifications for, or frameworks of, future interventions.

Specifically, this report analyzes changes in opioid overdose trends before and after the new policies were implemented in all three states, as well as opioid shipment trends in Florida. A summary of the policies is as follows:

1. Florida (Effective in 2010)
    a. Changes: Requiring pain clinics prescribing controlled substances, to register with the state, conducting statewide drug raids and closing certain pain clinics, prohibiting physicians from dispensing schedule II or III drugs from their offices, implementing a prescription drug monitoring program, expanding wholesale drug distributors regulation, and creating a Statewide Task Force on Prescription Drug Abuse and Newborns.
2. Texas (Effective in 2007)
    a. Changes: Further regulating pain treatment using controlled substances and implementing additional physician guidelines before and during opioid treatment
3. Washington (Effective in 2012)

[1] "Ongoing Emergencies." (2020). Center for Medicare and Medicaid Services. Accessed October 26, 2020. https://www.cms.gov/About-CMS/Agency-Information/Emergency/EPRO/Current-Emergencies/Ongoing-emergencies.
[2] Gold M. S. (2020). The Role of Alcohol, Drugs, and Deaths of Despair in the U.S.'s Falling Life Expectancy. *MO Med*, *117*(2), 99–101.

a. Changes: Further regulating the prescribing of opioids for pain treatment, including:
    i. annual periodic reviews,
    ii. mandatory consultation thresholds, and
    iii. recommended prescriptions limits

RESEARCH DESIGN

The analysis uses both a pre-post design and a difference-in-difference design to assess changes between opioid deaths and prescriptions as a result of the states' policies. A pre-post analysis can show trends in opioid shipments and opioid-related deaths before and after the policy's implementation. If shipments and deaths decrease after the intervention, that may be evidence of an effective policy. However, a pre-post analysis cannot show external factors that may affect a state's opioid use around the same time that the policies above were implemented. Thus, a difference-in-difference (DD) analysis is useful.

DDs take context into account by using other states for comparison. For example, a decline in opioid deaths in Florida after a policy implementation may seem to show that Florida' policy caused the decline. But if there was a national law enacted around the same time that limited access to opioids, deaths may have gone down with or without Florida's policy. A DD analysis uses other states with similar baseline trends as the target state and compares their trends after the intervention. If the comparison and target states had similar trends before the policy and different trends after, one can be more confident that any changes are attributable to the policy itself and not external shocks.[3]

Opioid death comparison states were selected from each target state's region on the assumption that states in similar geographic regions face similar external shocks and trends. Nearby comparison states are likely to experience the same outcome as a target state if it had not been treated. Thus, they provide a useful counterfactual. Although not all comparison states had exactly parallel trends to the target state, aggregate trends are similar. *Appendix A* contains these individual DD graphs for each target state and its comparison states.

[3] For more on DD analyses, see here.

Five comparison states for each targeted state were selected:

- **Florida**: Alabama, Georgia, Mississippi, South Carolina, and Tennessee
- **Texas**: Arizona, Kentucky, Louisiana, Missouri, and New Mexico
- **Washington**: California, Idaho, Montana, Oregon, and Wyoming

DATA

Data on opioid prescriptions came from the Washington Post's Opioid Prescription Dataset, which includes all opioid shipments from 2006-2012. Data on overdose deaths (2003-2015) came from the U.S. Vital Statistics System.

Five variables in the opioid prescription dataset were used for this analysis: county, state, transaction date, a morphine milligram conversion factor, and the base weight of the active ingredient in grams. State and county were used to track opioid shipments by geography, and were later matched with county populations. The transaction date catalogued the year of each shipment to track any change in opioid shipments over time. The year extraction was done first by formatting the dates as strings, then by selectively slicing the last four characters. Total grams of the active opiate ingredient in each shipment (either hydrocodone or oxycodone) were multiplied by a morphine-in-milligrams-equivalent conversion factor, to account for differences in hydrocodone and oxycodone potency. Thus, total shipped opioid weight was standardized across each county and state in the units of morphine gram equivalents.

The U.S. Vital Statistics data included variables from all U.S. counties from 2003 through 2015. The dataset contained information on causes of many drug and alcohol related deaths: for the purposes of our analysis, only deaths related to accidental or intentional opioid overdoses were used. County names included the two-letter state abbreviation at the end, which were split into two columns containing either just the county name or just the state code. Counties with fewer than ten deaths in a given year were originally excluded from this dataset. To remedy this exclusion, the death rate per county per year was calculated by dividing deaths by population for all counties with data.

The median death rate was then selected from each state.[4] This median state death rate was multiplied by the number of people in each county with missing death data to calculate a projected death rate for that county. If ten or more deaths per 100,000 people were projected, the death rate was rounded down to nine because if there were actually ten or more deaths, that number would have been recorded.

Data on county populations sourced from the U.S. Census Bureau were also used. The Census is only conducted every ten years, so the Bureau derives intercensal estimates according to accepted scholarly literature, with some adjustments. They assume that population changes follow a geometric pattern. Estimates in this report are sourced from the Census' intercensal calculations.

FIPS codes were sourced from the USDA. FIPS codes were merged into the population dataset for ease of county identification. FIPS codes were also merged into the Opioid Shipment data; the Opioid Overdose data already included FIPS codes. The merged FIPS/population data was then merged into both the overdose and shipment datasets. Finally, total county deaths and total county opioid shipment weights were divided by the county's population to calculate per capita deaths and shipment weights. Per capita drug gram weights and overdose rates were multiplied by 100,000 to display a more understandable rate of overdose deaths or shipments per 100,000 people.

SUMMARY STATISTICS

Summary statistics for relevant variables in the final cleaned drug shipment and opioid overdose datasets can be found below in Tables 1 and 2, respectively. All summary statistics represent data from each county in every year for which data are available. For additional summary statistics, please see *Appendix B.*

[4] The median, as opposed to the mean, death rate per state was used to avoid large outliers skewing results.

Table 1

Summary Statistics for Opioid Overdose Deaths

All columns represent data per county per year

	Opioid Overdose Deaths	Population	Deaths Per 100,000 People
count	39,832	39,819	39,819
mean	12	100,070	13
std	38	316,386	8
min	0	55	0
25%	1	11,735	8
50%	3	26,474	12
75%	9	68,041	16
max	862	10,085,416	127

Table 2

Summary Statistics for Opioid Shipments

All columns represent data per county per year

	Total Weight *(Morphine Gram Equivalents)*	Population	Weight Per 100,000 People *(Morphine Gram Equivalents)*
count	3,548	3,548	3,548
mean	48,278	92,301	41,952
std	156,986	204,118	31,514
min	0	2,893	10
25%	4,342	16,846	21,230
50%	11,999	29,480	34,116
75%	35,026	74,865	52,643
max	3,026,737	2,576,554	263,276

ANALYSIS

FLORIDA

Florida's pre-post and difference-in-difference analyses show substantial policy effects on opioid shipments. As seen in the pre-post graph (Figure 1a), Florida's per capita opioid shipment weights were increasing over the 2006-2010 period.[5] After 2010, opioid shipments fell sharply. Preliminary analysis suggests the strict opioid prescription regulations had the intended effect of curbing opioid shipments. The DD analysis (Figure 1b) validates the pre-post results, since shipments in comparison states without policy interventions continued to rise, while Florida's declined. Thus, evidence suggests that Florida's policy had effects that were substantially larger than would have been expected without a policy, given the counterfactual situation in comparison states.

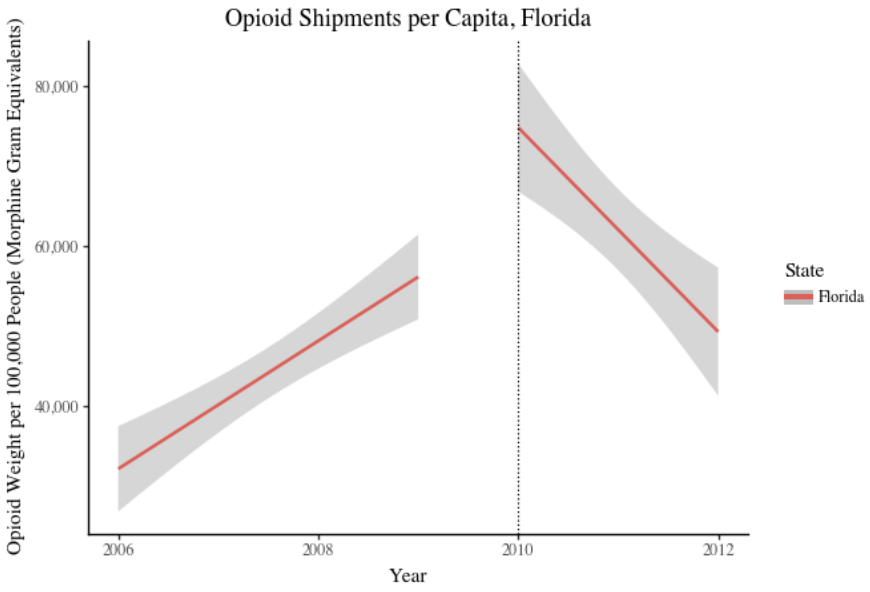


Figure 1a: Opioid shipment weight per 100,000 people, pre-post analysis of Florida counties, 2006-2012
Gray shading represents 95% confidence interval

[5] In all graphs, gray shading represents a 95% confidence interval.

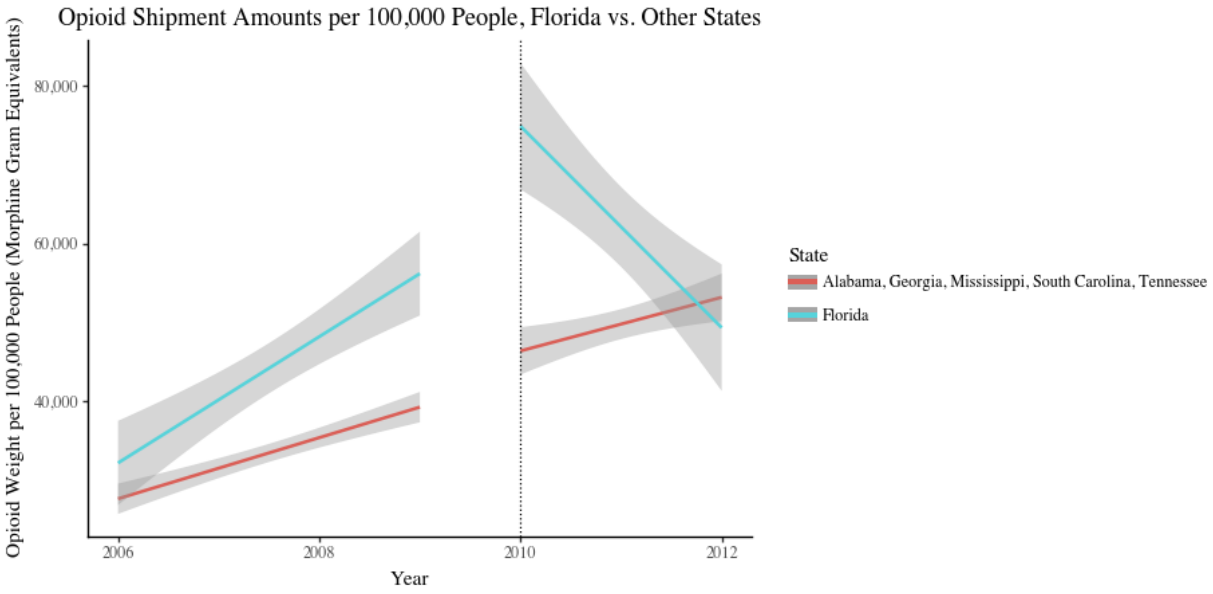


Figure 1b: Opioid shipment weight per 100,000 people, DD analysis of Florida counties vs. comparison states' counties, 2006-2012
Gray shading represents 95% confidence interval

The effectiveness of Florida's policy in reducing opioid shipments may have been a driving factor in lowering opioid overdose rates. Similar to the opioid shipment trends, overdoses were rising in Florida before the policy intervention. After 2010, they reversed course and began to decline (Figure 2a). In contrast, overdose rates in comparison states continued to rise with roughly the same trend both before and after 2010 (Figure 2b). Because Florida's shipment an overdoses trends reversed after its policy implementation, and surrounding states' trends did not, Florida's policy changes likely contributed to the observed results.[6]

[6] Note that data changes based on omitting versus interpolating data for counties with fewer than ten overdose deaths. In all target states, policy effects were stronger if such counties are dropped from analysis. We choose here to provide more methodologically sound, tempered results so as not to overstate the policies' effects.

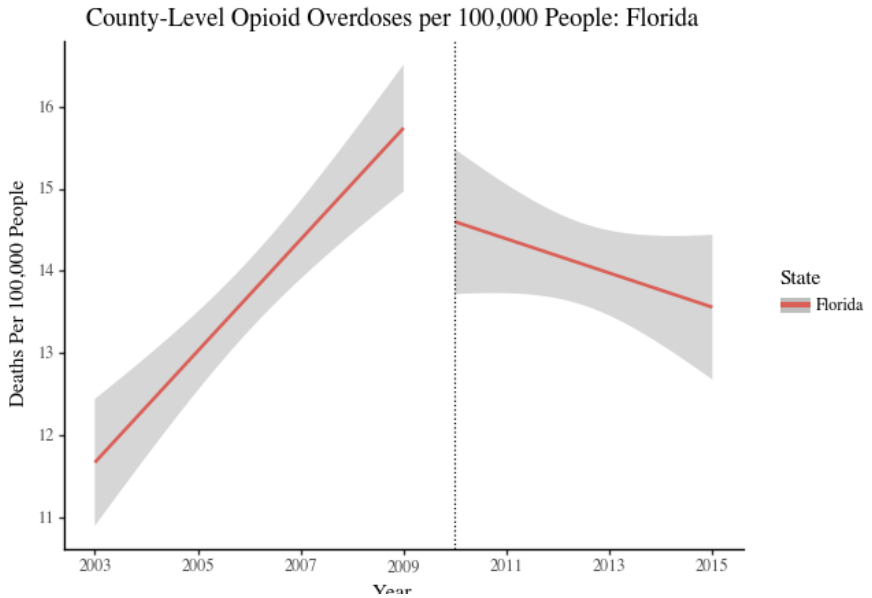


Figure 2a: Opioid overdoses per 100,000 people, pre-post analysis of Florida counties, 2003-2015
Gray shading represents 95% confidence interval

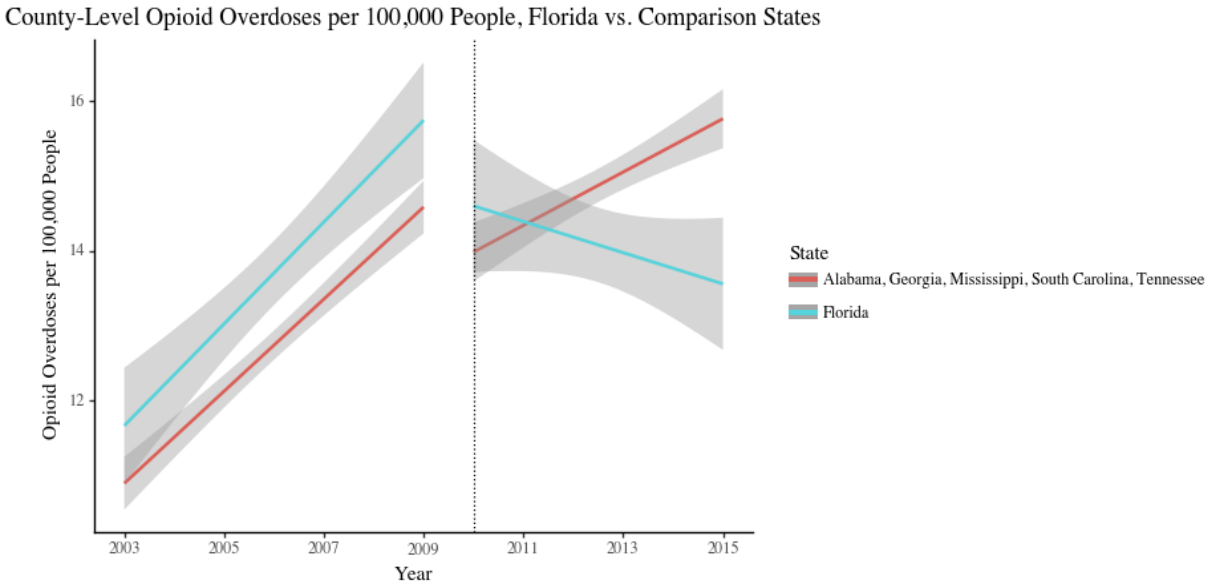


Figure 2b: Opioid overdoses per 100,000 people, DD analysis of Florida counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

TEXAS

Like Florida, Texas's new regulations likely contributed to their changing opioid overdose trend. Death rates were steadily increasing by about 1.25 deaths per 100,000 people over the 2003-2006 period, and continued to increase by less than one death per 100,000 after 2007 (Figure 3a). The rate of increase was slower than it had been previously. The DD analysis (Figure 3b) confirms that the noted decline comes from the policy itself, because comparison states saw increasing trends in death rates. Texas's neighboring states saw no significant change in the overdose trend, whereas Texas was able to curb its increases. Thus, the DD analysis provides a more complete picture of Texas's policy effects. Without the policy, Texas's trajectory may have continued to mirror that of its neighbor states.

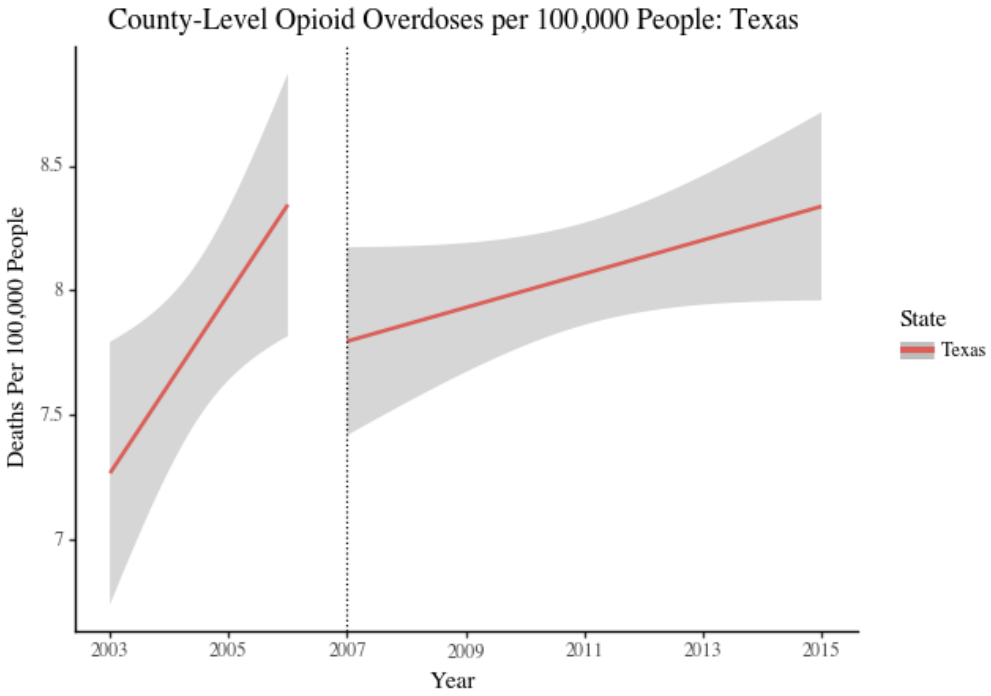


Figure 3a: Opioid overdoses per 100,000 people, pre-post analysis of Texas counties, 2003-2015
Gray shading represents 95% confidence interval

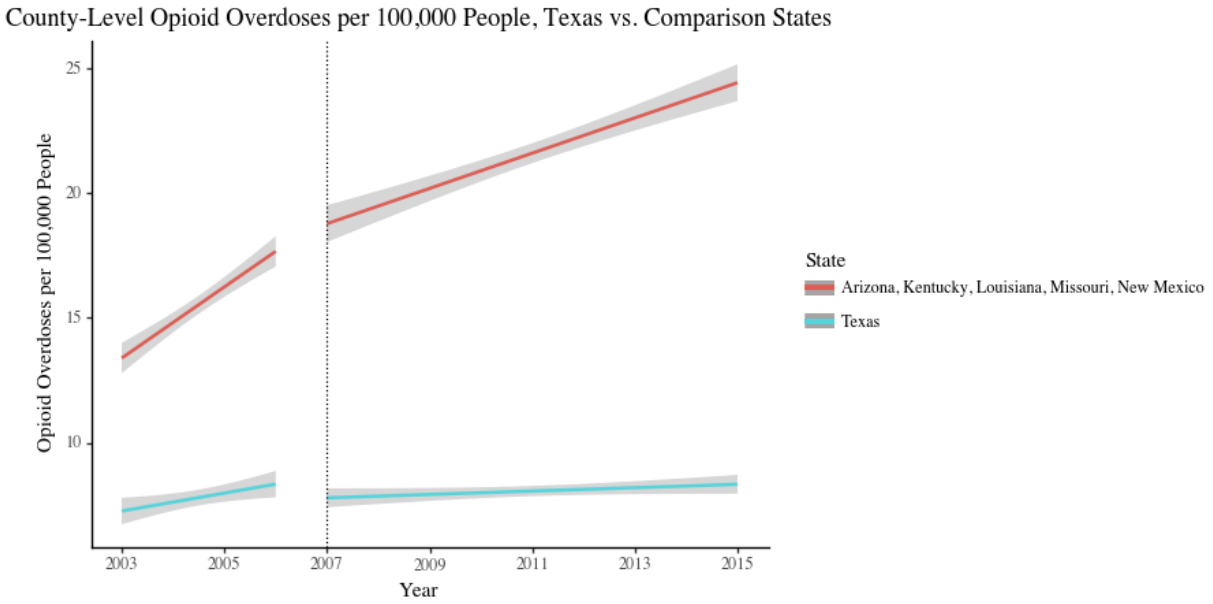


Figure 3b: Opioid overdoses per 100,000 people, DD analysis of Texas counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

WASHINGTON

Washington's pre-post trend (Figure 4a) is similar to Texas's in that the data show little change before and after the state's 2012 policy change. Overdose rates were increasing before 2012, and continue to rise at a slightly slower rate after. Although this policy may appear ineffective, a DD analysis shows that opioid overdoses in comparison states increased over the post-2012 period (Figure 4b). Washington appears to be converging with the death rates of comparison states around 2015 despite starting with about fifty percent more deaths. Thus, while Washington's policy may appear ineffective at curbing the opioid epidemic at first glance, their policy likely has a tempering effect on rising rates.

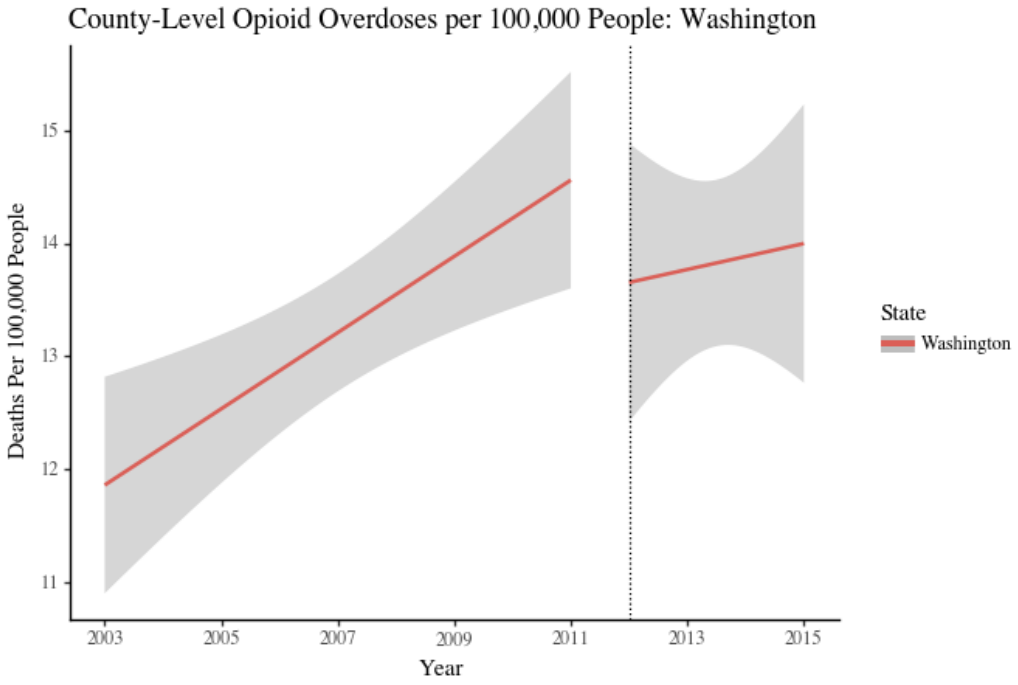


Figure 4a: Opioid overdoses per 100,000 people, pre-post analysis of Washington counties, 2003-2015
Gray shading represents 95% confidence interval

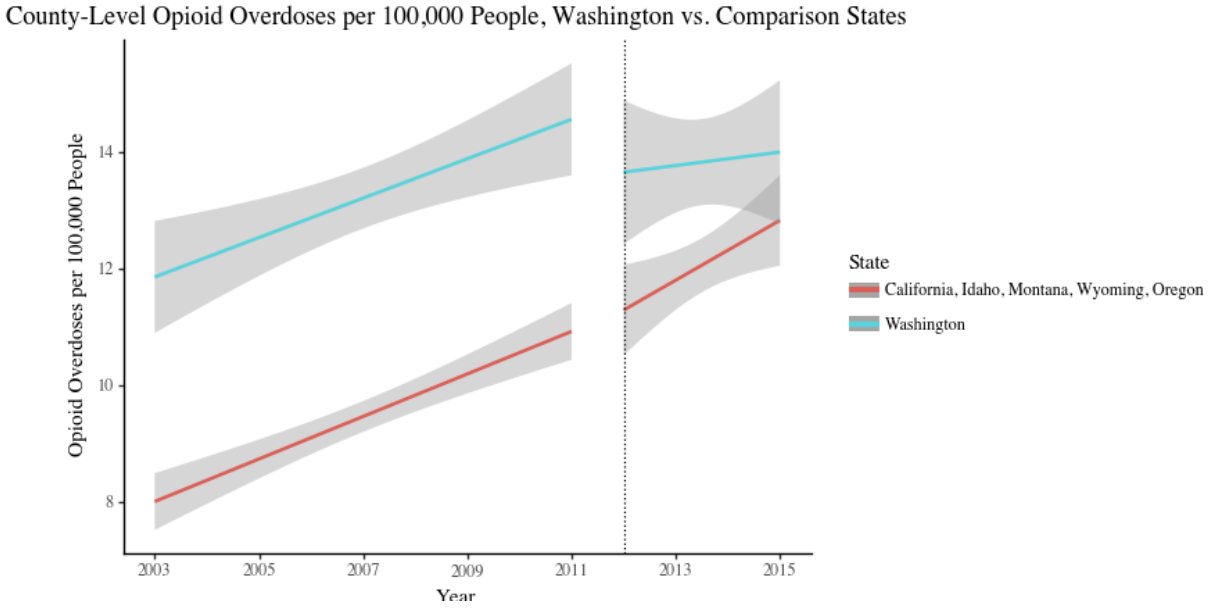


Figure 4b: Opioid overdoses per 100,000 people, DD analysis of Washington counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

INTERPRETATION

OPIOID SHIPMENTS

As seen in Figures 1a and 1b, opioid shipments per capita in Florida were increasing before the 2010 policy implementation but decreasing after, indicating that Florida's policy may have been effective in lowering opioid prescriptions among the public. The DD analysis in Figure 2 shows that comparison states have similar or parallel trend lines to Florida before 2010, and continue their trajectories after 2010. Because the sharp change in slope seen in Florida's graph was not observed in any three of the comparison states, it is likely that the decline in per capita opioid shipments was due to the opioid regulation policy.

OPIOID OVERDOSES

Declining availability of opioids likely contributed to the reduction in opioid deaths seen in Florida. Spiking death rates were reversed after policy implementation. Although shipment data were not measured for Texas and Washington, results can be extrapolated based on patterns observed in Florida. Per capita opioid overdoses in Texas and Washington, like in Florida, were increasing before the states changed their opioid policies. After, Texas and Washington saw a slower rate of increase.

The states' policies likely slowed Texas and Washington's expected overdose trajectory: comparison states saw continued increases in opioid deaths. In all cases, state opioid regulations are associated with changes in opioid overdoses rates. Measuring against comparison states provides compelling evidence that the decrease in overdose deaths can be attributed to the policy changes, instead of other external societal or cultural trends or events.

CONCLUSION

As seen in the difference-in-difference estimates, declines in opioid shipments and deaths for target states exceeded any changes in comparison states. Thus, robust evidence exists to suggest that the new policies in Florida, Texas, and Washington achieved their goals. While further research is needed into the structure, execution, and other consequences of these regulations, all three states can serve as a model for future opioid interventions. In particular, Florida's aggressive policies that

turned steep increases in shipments and deaths into steep declines could guide other state legislatures as they enact and evaluate their own opioid regulations.

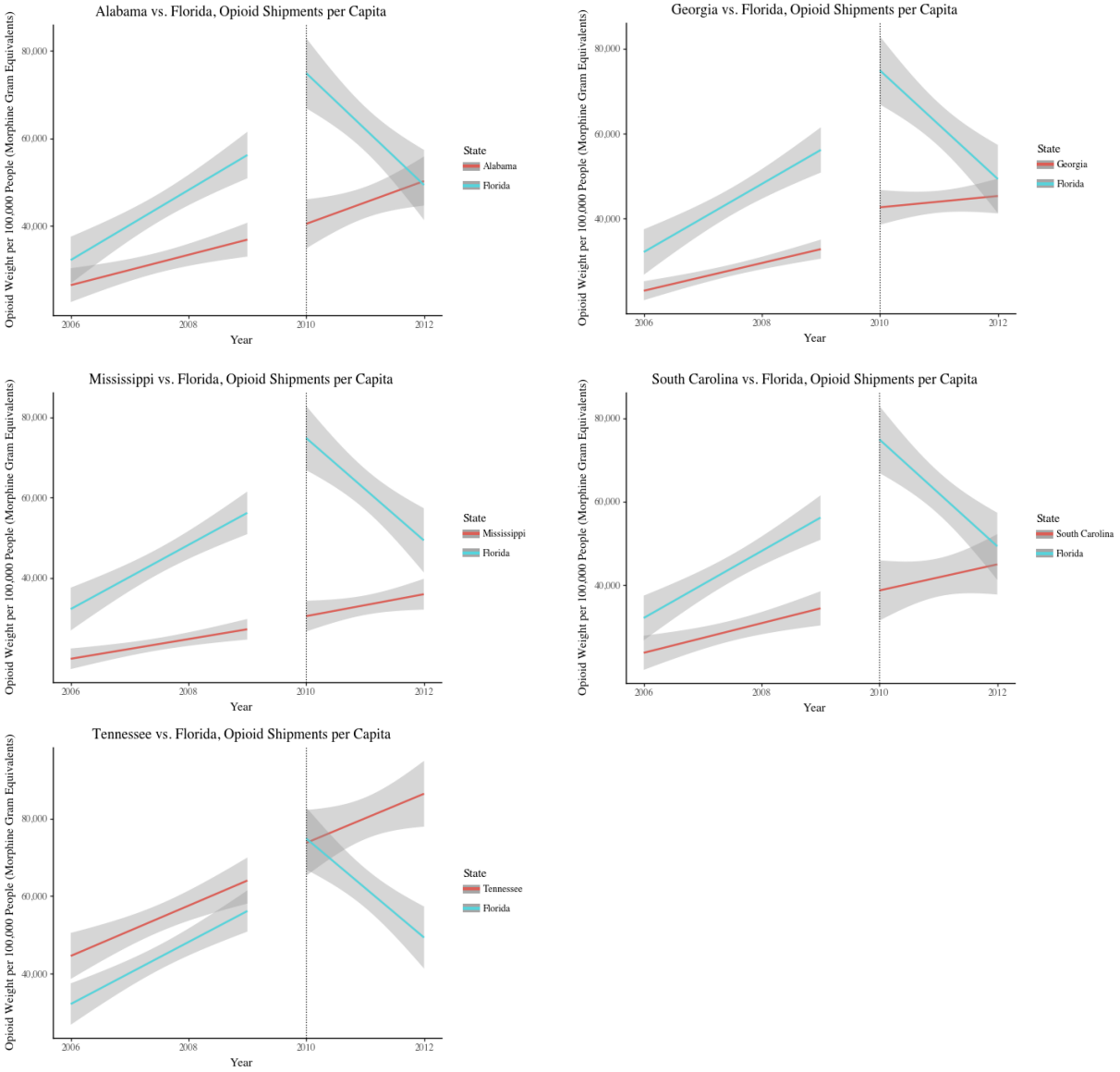
APPENDIX A

Difference-in-difference analyses of opioid shipments and overdose rates in comparison states relative to Florida, Texas, and Washington

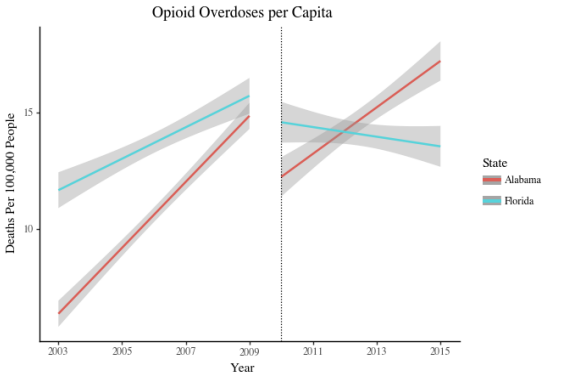
Comparison states:

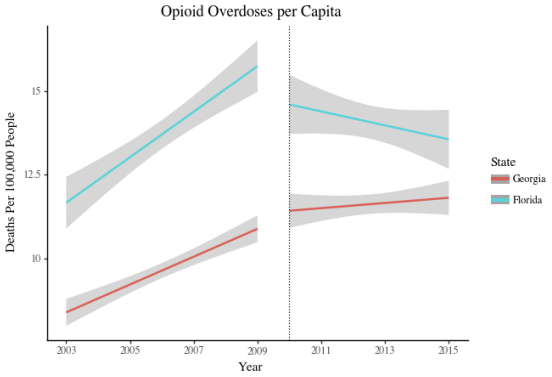
- **Florida**: Alabama, Georgia, Mississippi, South Carolina, and Tennessee
- **Texas**: Arizona, Kentucky, Louisiana, Missouri, and New Mexico
- **Washington**: California, Idaho, Montana, Oregon, and Wyoming

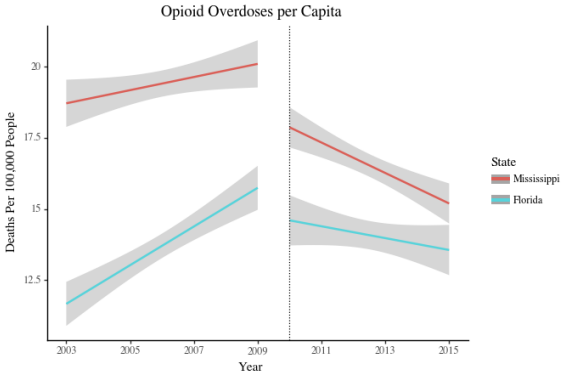
OPIOID SHIPMENT DD ANALYSIS, FLORIDA VS. COMPARISON STATES

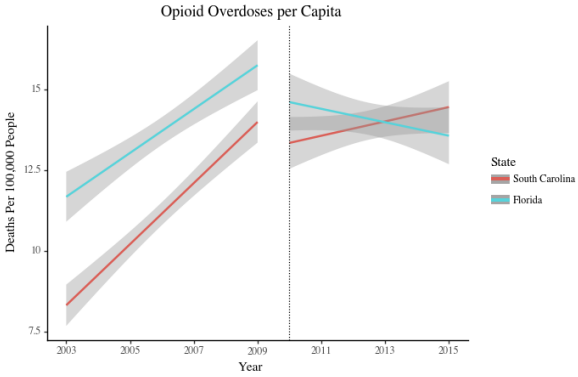


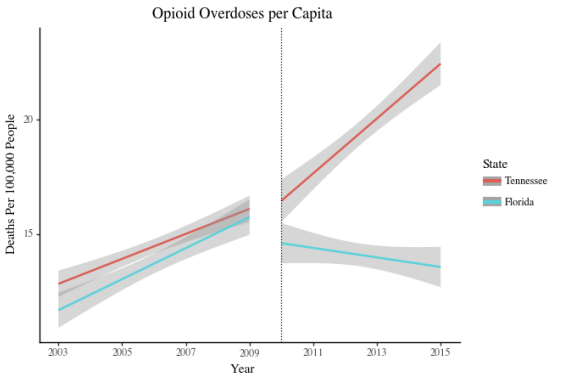
OPIOID OVERDOSES DD ANALYSIS, FLORIDA VS. COMPARISON STATES



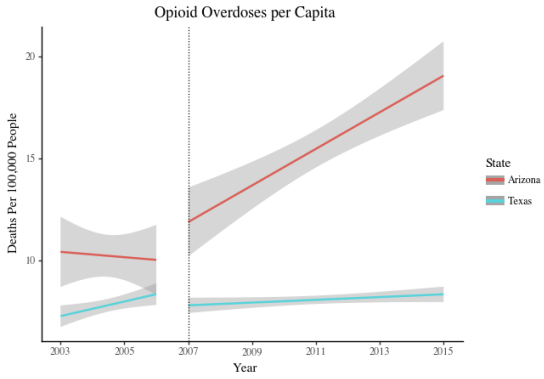


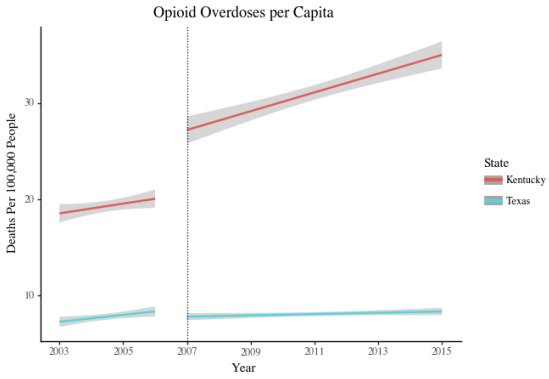


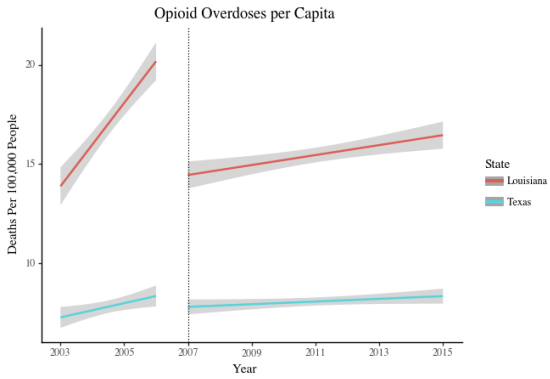


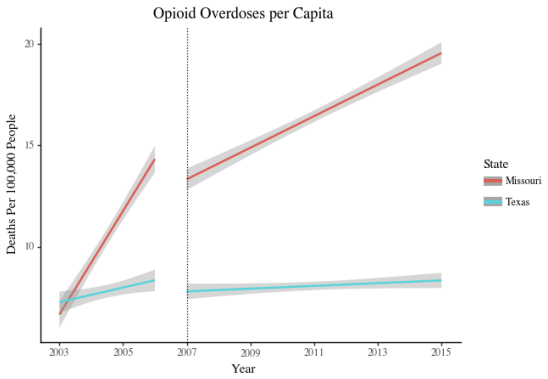


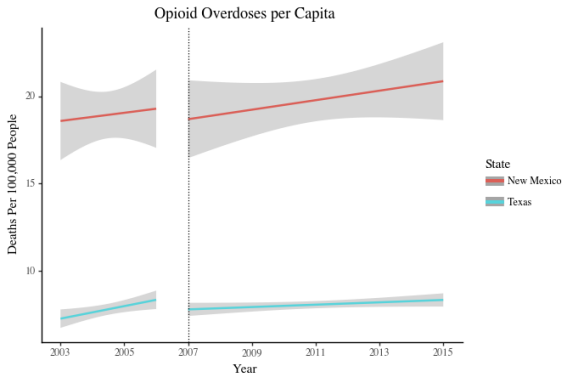
OPIOID OVERDOSES DD ANALYSIS, TEXAS VS. COMPARISON STATES



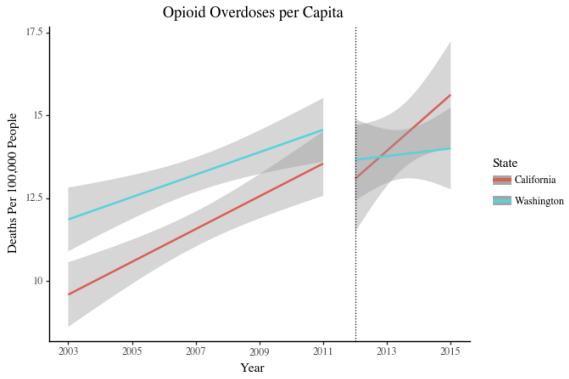


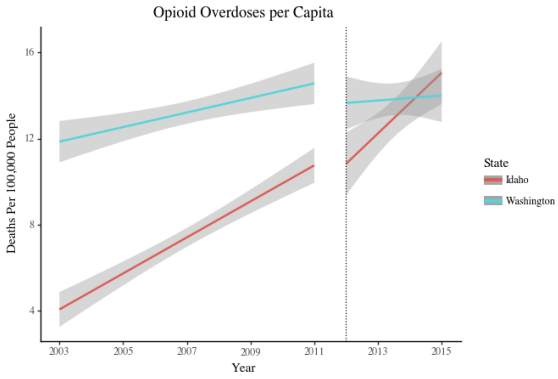


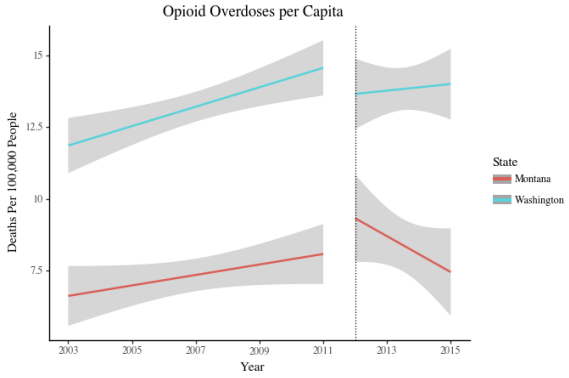


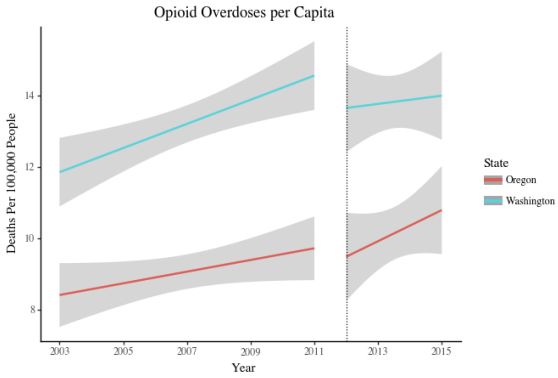


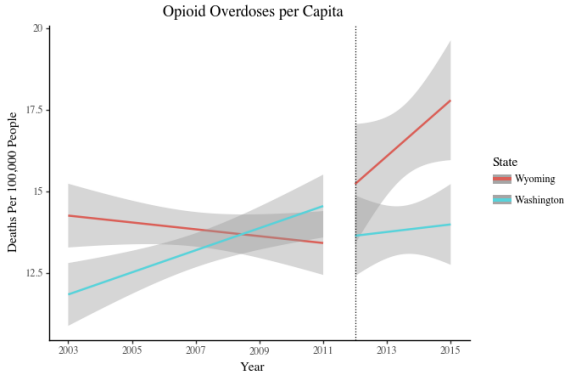
OPIOID OVERDOSES DD ANALYSIS, WASHINGTON VS. COMPARISON STATES











APPENDIX B

Summary Statistics

Summary Statistics for Opioid Shipments: Variable Averages

	Total Weight *(Morphine Gram Equivalents)*	Population	Weight Per 100,000 People *(Morphine Gram Equivalents)*
Alabama	30,448.49	70,742.13	37,513.63
Florida	190,876.40	280,845.43	51,939.78
Georgia	19,993.07	62,860.28	34,804.21
Mississippi	11,372.96	36,442.10	27,607.28
South Carolina	43,054.55	99,210.63	34,608.50
Tennessee	40,088.28	66,572.55	65,439.22

Summary Statistics for Opioid Overdoses: Variable Averages

Columns are averaged across all years of data

	Avg. Opioid Overdose Deaths	Avg. Population	Avg. Deaths Per 100,000 People
Alabama	8.45	70,386	12.52
Arizona	66.34	417,691	13.86
Arkansas	3.69	38,376	10.22
California	68.92	638,163	12.42
Colorado	10.42	77,587	11.30
Connecticut	52.26	444,019	11.69
Delaware	36.90	295,386	11.70
District of Columbia	90.15	605,323	14.93
Florida	39.21	278,729	13.88
Georgia	5.83	59,789	10.56
Hawaii	32.38	336,629	9.09
Idaho	3.29	34,772	9.12
Illinois	12.76	125,089	9.88
Indiana	9.16	69,916	14.27
Iowa	2.56	30,620	8.60
Kansas	2.41	26,891	6.96
Kentucky	8.14	35,819	27.46
Louisiana	10.84	70,805	15.93
Maine	9.41	82,789	11.58
Maryland	30.87	239,464	12.59
Massachusetts	67.68	468,019	13.86
Michigan	18.57	119,986	12.78
Minnesota	4.81	60,601	7.41
Mississippi	5.67	35,932	18.07
Missouri	7.24	51,547	14.60
Montana	1.78	17,480	7.67
Nebraska	1.02	19,499	2.71
Nevada	30.49	154,339	18.27
New Hampshire	16.63	131,376	12.38
New Jersey	40.53	416,689	10.30
New Mexico	12.79	61,111	19.52
New York	29.61	312,207	9.28
North Carolina	10.45	93,280	13.15
Ohio	20.82	130,949	15.60
Oklahoma	8.43	48,154	18.76
Oregon	12.08	105,151	9.41
Pennsylvania	29.76	188,476	14.39
Rhode Island	34.71	211,880	14.82
South Carolina	12.09	98,757	12.41
South Dakota	0.96	12,248	5.55
Tennessee	9.93	65,913	16.76
Texas	8.75	97,333	7.99
Utah	15.93	92,808	13.36
Vermont	5.29	44,560	13.10
Virginia	5.30	59,297	11.48
Washington	22.78	170,120	13.40
West Virginia	9.10	33,444	30.87
Wisconsin	9.18	78,422	10.62
Wyoming	3.54	23,908	14.67

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Specifically, this report analyzes changes in opioid overdose trends before and after the new policies were implemented in all three states, as well as opioid shipment trends in Florida. A summary of the policies is as follows:

1. Florida (Effective in 2010)
    a. Changes: Requiring pain clinics prescribing controlled substances to register with the state, conducting statewide drug raids and closing certain pain clinics, prohibiting physicians from dispensing schedule II or III drugs from their offices, implementing a prescription drug monitoring program, expanding wholesale drug distributors regulation, and creating a Statewide Task Force on Prescription Drug Abuse and Newborns.
2. Texas (Effective in 2007)
    a. Changes: Further regulating pain treatment using controlled substances and implementing additional physician guidelines before and during opioid treatment
3. Washington (Effective in 2012)

[1] "Ongoing Emergencies." (2020). Center for Medicare and Medicaid Services. Accessed October 26, 2020. https://www.cms.gov/About-CMS/Agency-Information/Emergency/EPRO/Current-Emergencies/Ongoing-emergencies.
[2] Gold M. S. (2020). The Role of Alcohol, Drugs, and Deaths of Despair in the U.S.'s Falling Life Expectancy. *MO Med*, *117*(2), 99–101.

a. Changes: Further regulating the prescribing of opioids for pain treatment, including:
    i. annual periodic reviews,
    ii. mandatory consultation thresholds, and
    iii. recommended prescriptions limits

DATA

Data for this analysis came from the following sources:

- Opioid prescription shipment data: Washington Post's Opioid Prescription Dataset (2006-2012)
- Opioid overdose deaths: U.S. Vital Statistics System (2003-2015)
- County populations: U.S. Census Bureau (2000-2019)
- County-level FIPS codes: USDA

Opioid shipment data were analyzed at the county level and standardized to report opioid weight in standardized morphine gram equivalents per 100,000 people per county per year. Opioid overdose data were manipulated to report overdose deaths per 100,000 people per county per year. Counties that had fewer than 10 deaths were omitted in the dataset, so were filled in using the median county death rate per state (calculated from all counties with data), weighted by the county's population.[3] Alaska was dropped as a potential comparison state because of substantial changes in their county boundaries during this time period.

RESEARCH DESIGN

Two methods of analysis were used to evaluate the efficacy of states' policy changes: a pre-post and difference-in-difference analysis. A **pre-post** analysis shows the effect of a policy change by measuring a variable's trend *before* and *after* the change goes into effect. If the trend changes after the policy's implementation year, the policy may have been effective. In the context of this analysis, pre-post graphs measure the number of opioid shipments or overdoses in a state's counties before and after the state's new opioid policy took effect. An effective policy would have a trend line that decreases in the years after the policy's implementation. If the trend does not change, the policy may

[3] If this calculation resulted in a number of 10 or more deaths, a death rate of nine was used instead. If there truly were ten or more deaths in that county, it would have shown in the data.

not be effective. Figure 1 shows an example pre-post analysis graph for an effective and ineffective policy.[4]

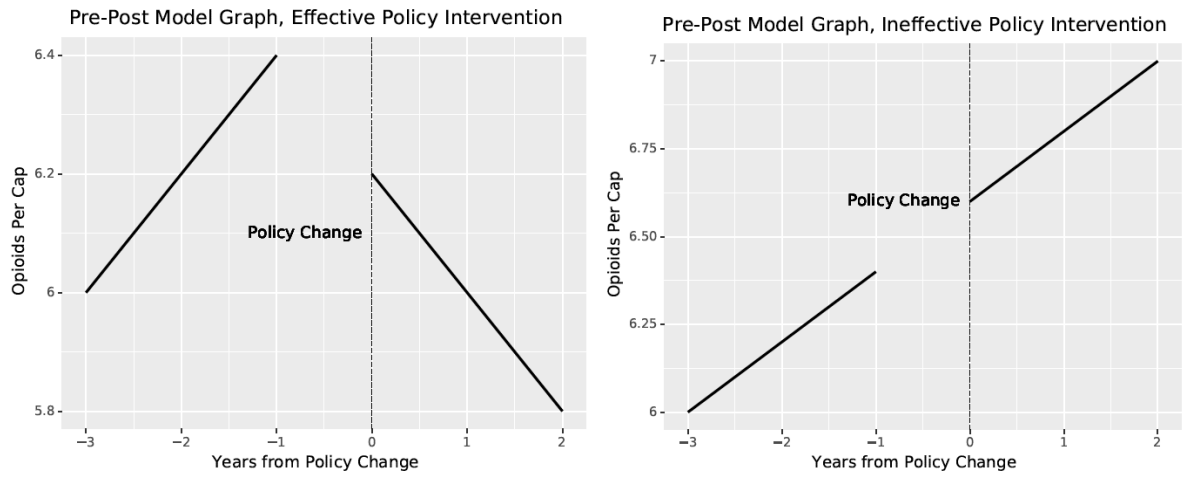


Figure 1: Pre-Post Analysis Example

The pre-post analysis is a useful tool, but it is not without shortcomings: it does not leave room for external context. Pre-post analyses cannot account for overarching trends or situations that may impact the measurement of interest. Thus, any observed changes actually caused by an outside factor may be misattributed to the policy. For example, a hurricane in Florida in 2010 may cause supply chains to be disrupted and prevent opioid shipments from entering the state. A pre-post analysis would show a decline in opioid shipments after their policy's implementation in 2010, but that decline is not caused by Florida's opioid policies. To combat this effect, a **difference-in-difference** (DD) analysis was used.

A DD analysis uses comparison regions over the same time period to provide a baseline trend. An effective policy would then have an effect above and beyond the trendline of comparison states. If an external factor affected trends in opioid shipments or deaths, this shock would likely be reflected in the target state *and* comparison states. For example, if a hurricane decreased opioid shipments to Florida and to surrounding states that were also impacted by the hurricane, a DD analysis would show that Florida did not have a decline in comparison to the other states. Thus, their policy was *not* effective, as the pre-post analysis would suggest. For this analysis, states with similar pre-regulation

[4] Eubank, N. (2020). "Estimate the Impact of Opioid Control Policies Mid-Semester Project," *Practical Data Science*, Duke University. Retrieved from https://www.practicaldatascience.org/html/index.html.

trends were used as comparisons. Examining opioid shipments and overdoses trends before a state's intervention and comparing them to the target states ensured that any observed effects were truly attributable to a policy change, and not external shocks. Figure 2 shows an example DD analysis graph for an effective and ineffective policy.[5,6]

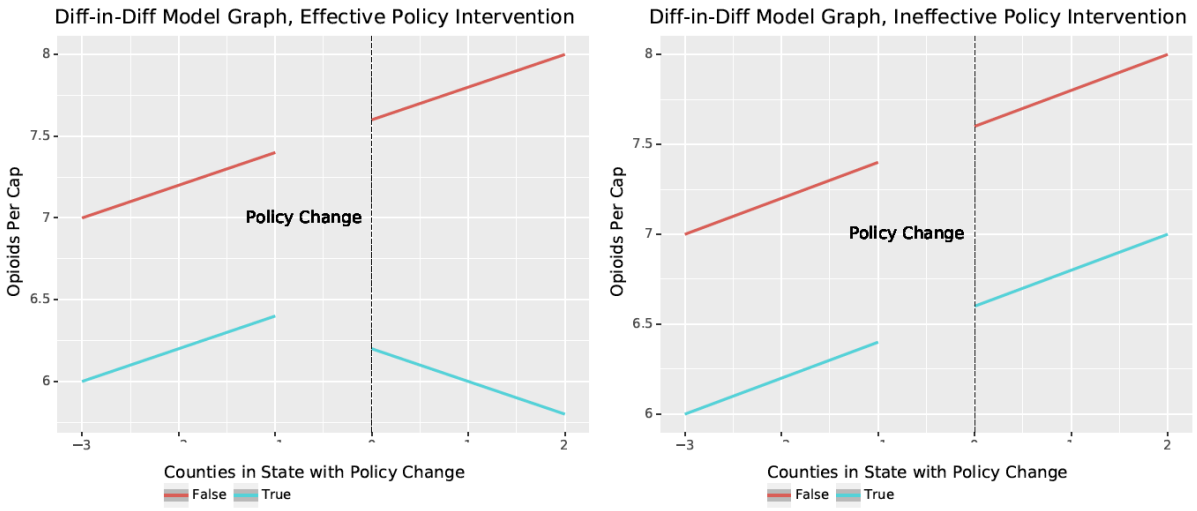


Figure 2: Difference-in-Difference Analysis Example

Opioid death comparison states were selected from each target state's region on the assumption that states in similar geographic regions face similar external shocks and trends. Nearby comparison states are likely to experience the same outcome as a target state if it had not been treated. Although not all comparison states had exactly parallel trends to the target state, aggregate trends are similar. *Appendix A* contains these individual DD graphs for each target state and its comparison states.

Five comparison states for each targeted state were selected:

- **Florida**: Alabama, Georgia, Mississippi, South Carolina, and Tennessee
- **Texas**: Arizona, Kentucky, Louisiana, Missouri, and New Mexico
- **Washington**: California, Idaho, Montana, Oregon, and Wyoming

[5] Ibid.
[6] For more on DD analyses, see here.

ANALYSIS

FLORIDA

Florida's pre-post and difference-in-difference analyses show substantial policy effects on opioid shipments. As seen in the pre-post graph (Figure 3a), Florida's per capita opioid shipment weights were increasing over the 2006-2010 period.[7] After 2010, opioid shipments fell sharply. Preliminary analysis suggests the strict opioid prescription regulations had the intended effect of curbing opioid shipments. The DD analysis (Figure 3b) validates the pre-post results, since shipments in comparison states without policy interventions continued to rise while Florida's declined. Thus, evidence suggests that Florida's policy had effects that were substantially larger than would have been expected without a policy, given the counterfactual situation in comparison states.

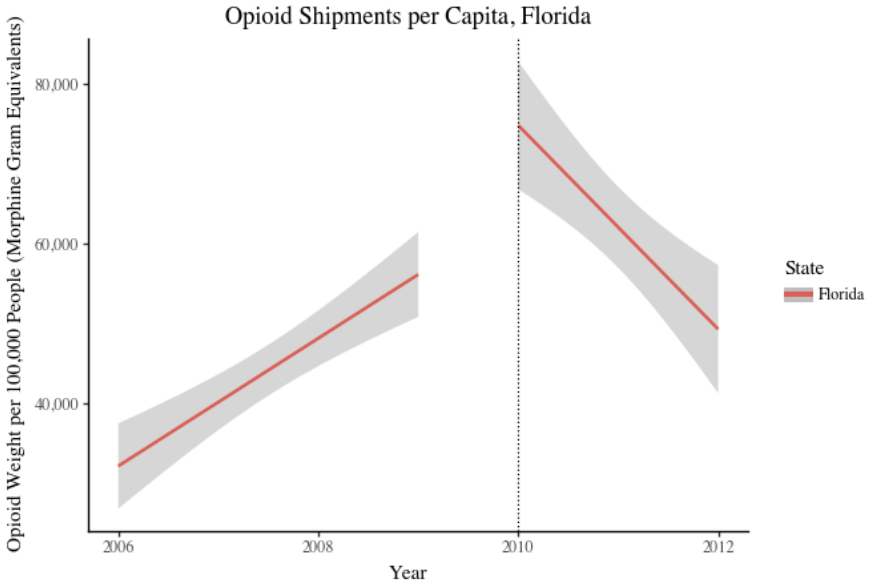


Figure 3a: Opioid shipment weight per 100,000 people, pre-post analysis of Florida counties, 2006-2012
Gray shading represents 95% confidence interval

[7] In all graphs, gray shading represents a 95% confidence interval.

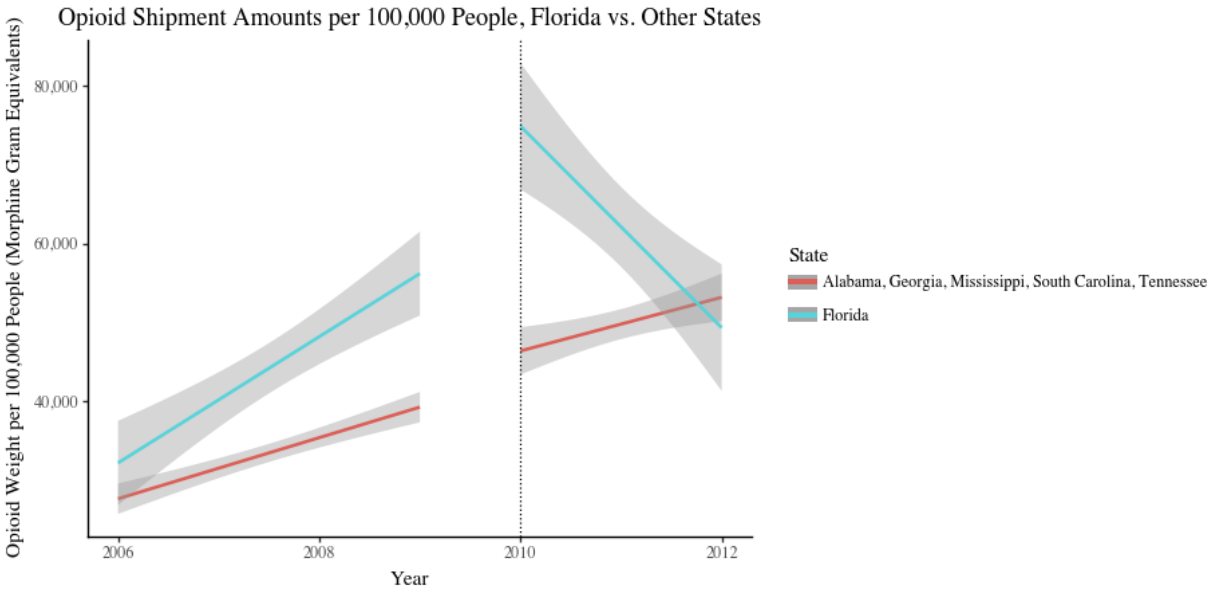


Figure 3b: Opioid shipment weight per 100,000 people, DD analysis of Florida counties vs. comparison states' counties, 2006-2012
Gray shading represents 95% confidence interval

The effectiveness of Florida's policy in reducing opioid shipments may have been a driving factor in lowering opioid overdose rates. Similar to the opioid shipment trends, overdoses were rising in Florida before the policy intervention. After 2010, they reversed course and began to decline (Figure 4a). In contrast, overdose rates in comparison states continued to rise with roughly the same trend both before and after 2010 (Figure 4b). Because Florida's shipment and overdose trends reversed after its policy implementation, and surrounding states' trends did not, Florida's policy changes likely contributed to the observed results.[8]

[8] Note that data changes based on omitting versus interpolating data for counties with fewer than ten overdose deaths. In all target states, policy effects were stronger if such counties are dropped from analysis. We choose here to provide more methodologically sound, tempered results so as not to overstate the policies' effects.

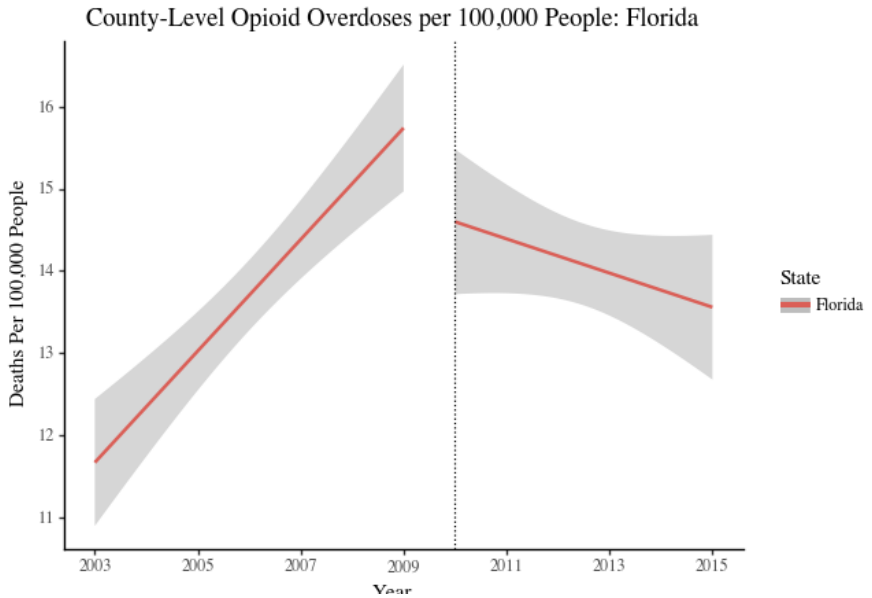


Figure 4a: Opioid overdoses per 100,000 people, pre-post analysis of Florida counties, 2003-2015
Gray shading represents 95% confidence interval

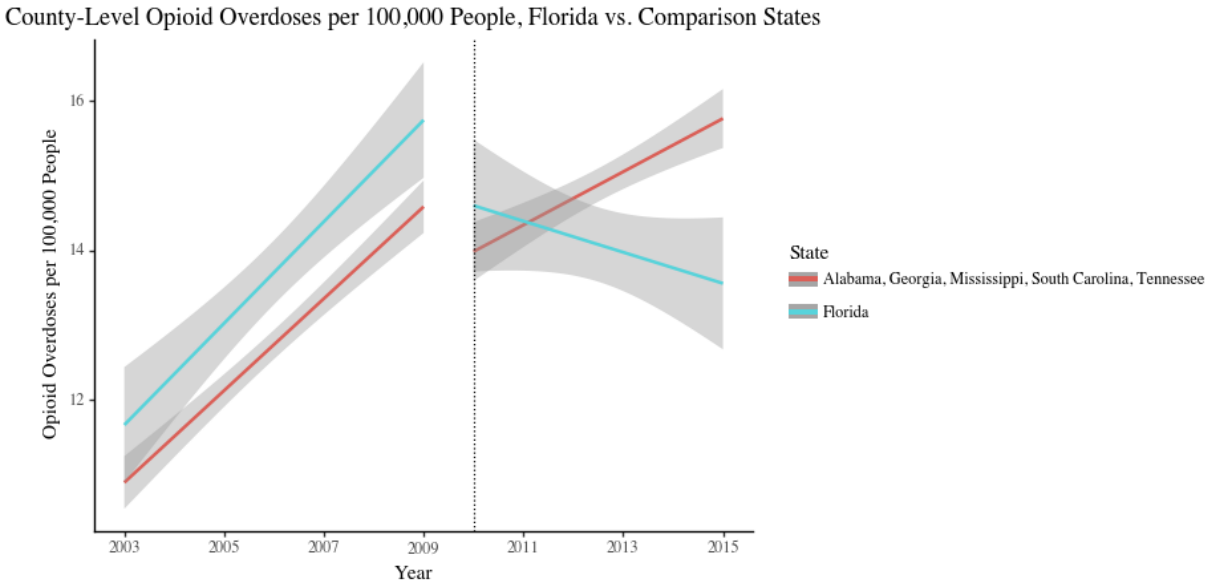


Figure 4b: Opioid overdoses per 100,000 people, DD analysis of Florida counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

TEXAS

Like Florida, Texas's new regulations likely contributed to their changing opioid overdose trend. Death rates were steadily increasing by about 1.25 deaths per 100,000 people over the 2003-2006 period, and continued to increase by less than one death per 100,000 after 2007 (Figure 5a). . The rate of increase was slower than it had been previously. The DD analysis (Figure 5b) confirms that the noted decline comes from the policy itself, because comparison states saw increasing trends in death rates. Texas neighboring states saw no significant change in the overdose trend, whereas Texas was able to curb its increases. Thus, the DD analysis provides a more complete picture of Texas's policy effects. Without the policy, Texas's trajectory may have continued to mirror that of its neighbor states.

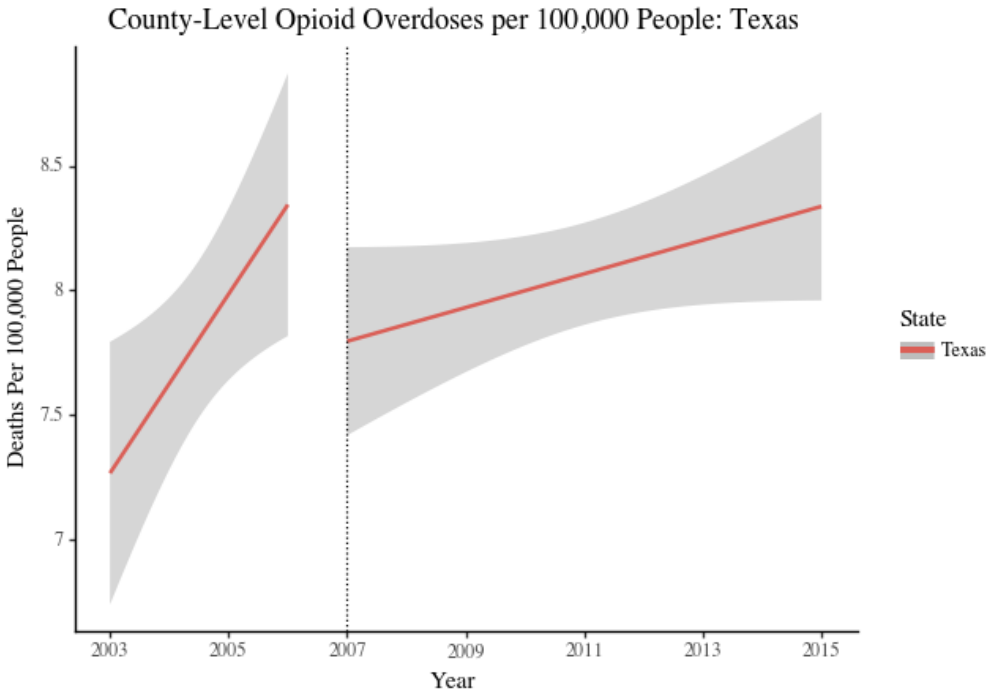


Figure 5a: Opioid overdoses per 100,000 people, pre-post analysis of Texas counties, 2003-2015
Gray shading represents 95% confidence interval

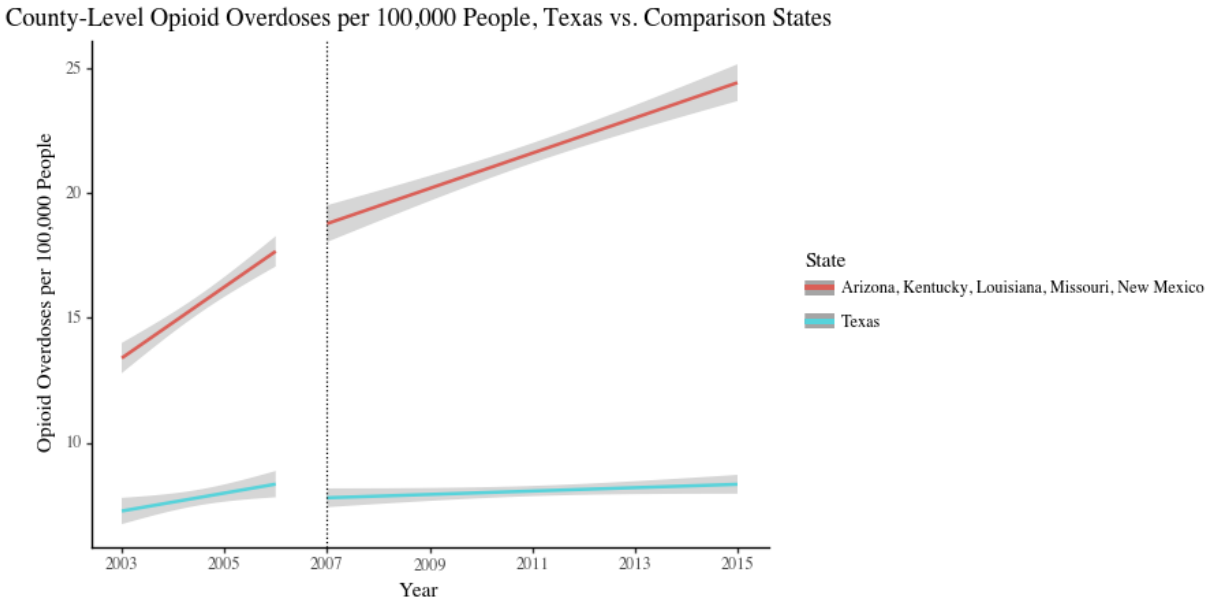


Figure 5b: Opioid overdoses per 100,000 people, DD analysis of Texas counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

WASHINGTON

Washington's pre-post trend (Figure 6a) is similar to Texas' in that the data show little change before and after the state's 2012 policy change. Overdose rates were increasing before 2012, and continue to rise at a slightly slower rate after. Although this policy may appear ineffective, a DD analysis shows that opioid overdoses in comparison states increased over the post-2012 period (Figure 6b). Washington appears to be converging with the death rates of comparison states around 2015 despite starting with about fifty percent more deaths. Thus, while Washington's policy may appear ineffective at curbing the opioid epidemic at first glance, their policy likely has a tempering effect on rising rates.

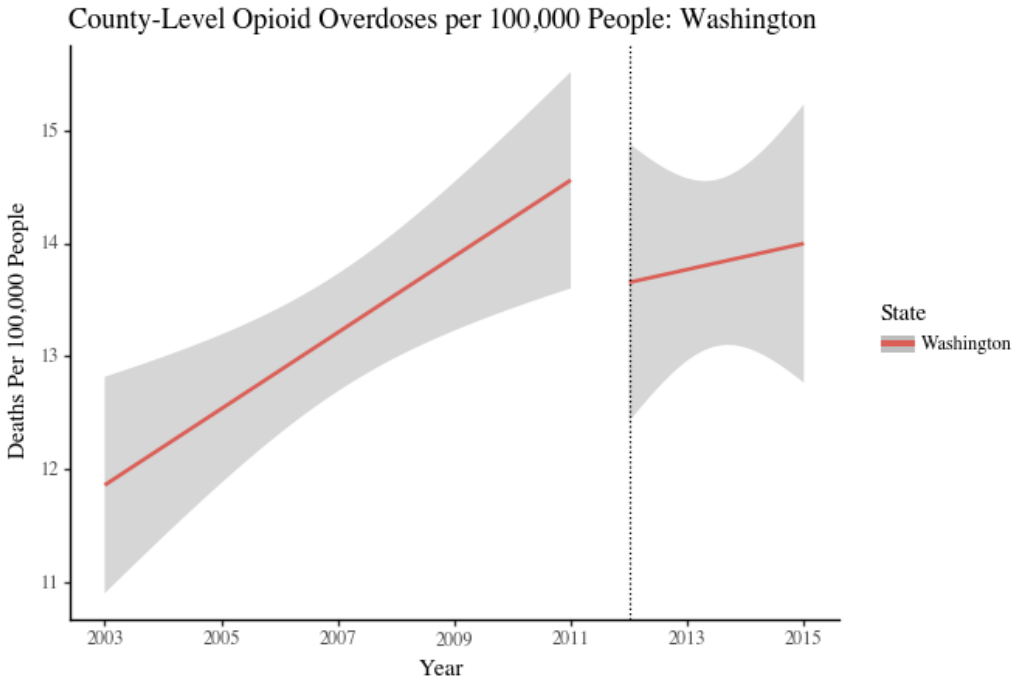


Figure 6a: Opioid overdoses per 100,000 people, pre-post analysis of Washington counties, 2003-2015
Gray shading represents 95% confidence interval

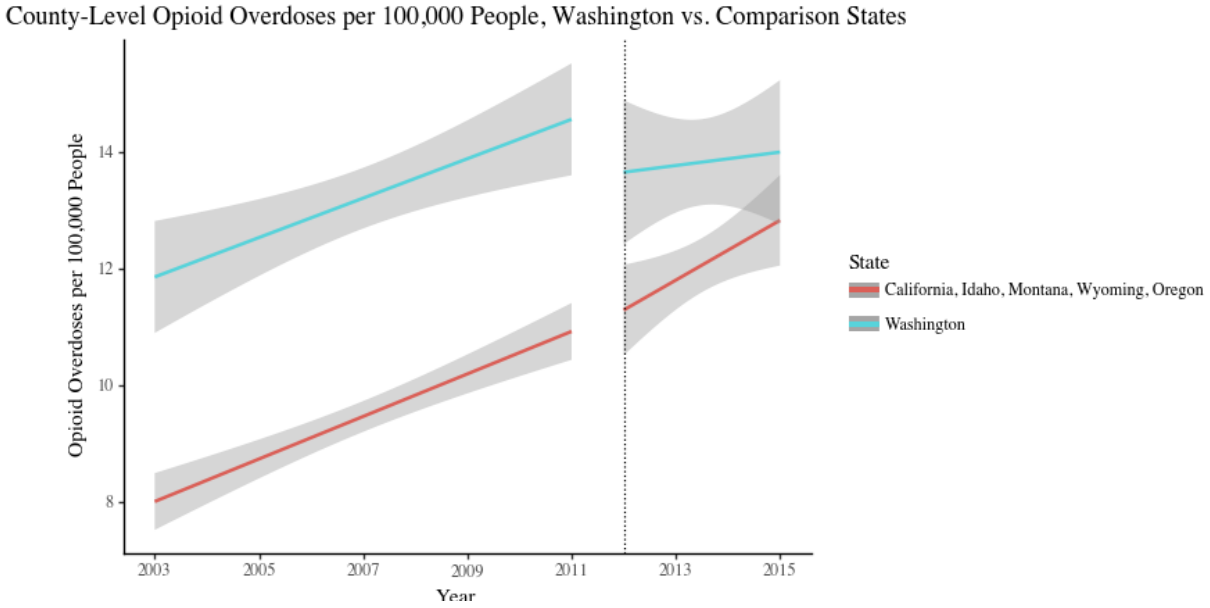


Figure 6b: Opioid overdoses per 100,000 people, DD analysis of Washington counties vs. comparison states' counties, 2003-2015
Gray shading represents 95% confidence interval

INTERPRETATION

OPIOID SHIPMENTS

As seen in Figure 3a, opioid shipments per capita in Florida were increasing before the 2010 policy implementation but decreasing after, indicating that Florida's policy may have been effective in lowering opioid prescriptions among the public. The DD analysis in Figure 3b shows that comparison states have similar or parallel trend lines to Florida before 2010, and continue their trajectories after 2010. Because the sharp change in slope seen in Florida's graph was not observed in any three of the comparison states, it is likely that the decline in per capita opioid shipments was due to the opioid regulation policy.

OPIOID OVERDOSES

Declining availability of opioids likely contributed to the reduction in opioid deaths seen in Florida. Spiking death rates were reversed after policy implementation. Although shipment data were not measured for Texas and Washington, there may be a similar causal chain of events. Per capita opioid overdoses in Texas and Washington, like in Florida, were increasing before the states changed their opioid policies. After, Texas and Washington saw a slower rate of increase, likely due to in part to a lower opioid volume in the state.

The states' policies likely slowed Texas and Washington's expected overdose trajectory: comparison states saw continued increases in opioid deaths. In all cases, state opioid regulations are associated with changes in opioid overdoses rates. Measuring against comparison states provides compelling evidence that the decrease in overdose deaths can be attributed to the policy changes, instead of other external societal or cultural trends or events.

CONCLUSION

As seen in the difference-in-difference estimates, declines in opioid shipments and deaths for target states exceeded any changes in comparison states. Thus, robust evidence exists to suggest that the new policies in Florida, Texas, and Washington achieved their goals. While further research is needed into the structure, execution, and other consequences of these regulations, all three states can serve as a model for future opioid interventions. In particular, Florida's aggressive policies that

turned steep increases in shipments and deaths into steep declines could guide other states legislatures as they enact and evaluate their own opioid regulations.

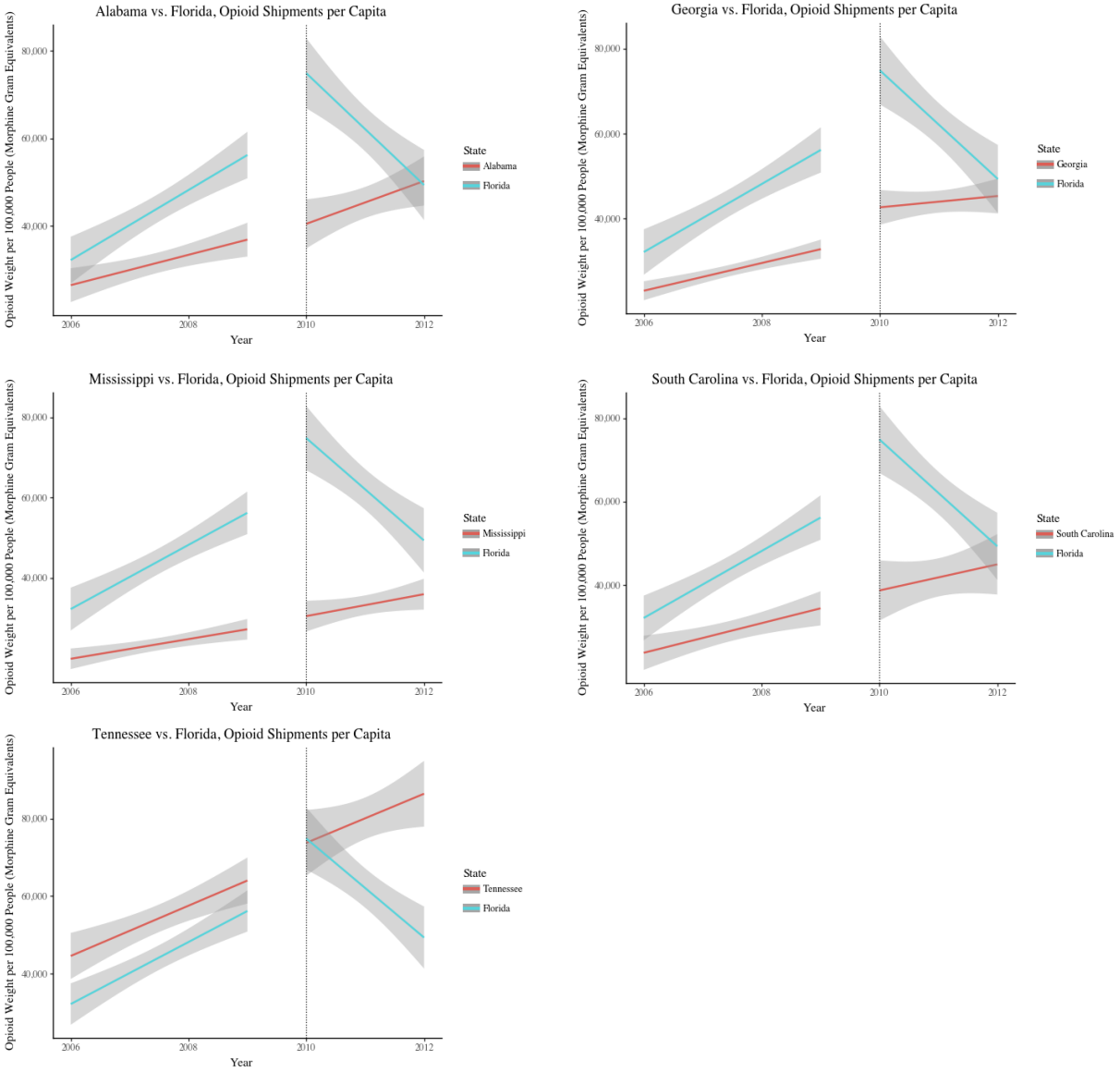
APPENDIX A

Difference-in-difference analyses of opioid shipments and overdose rates in comparison states relative to Florida, Texas, and Washington

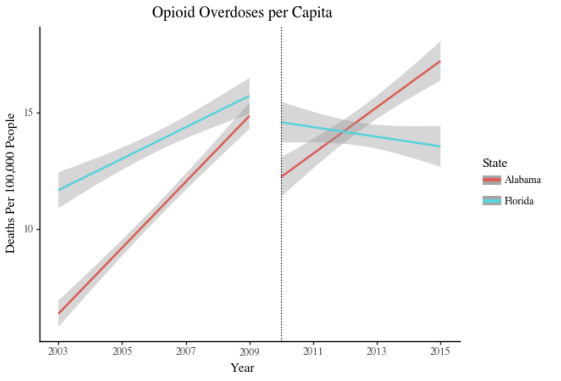
Comparison states:

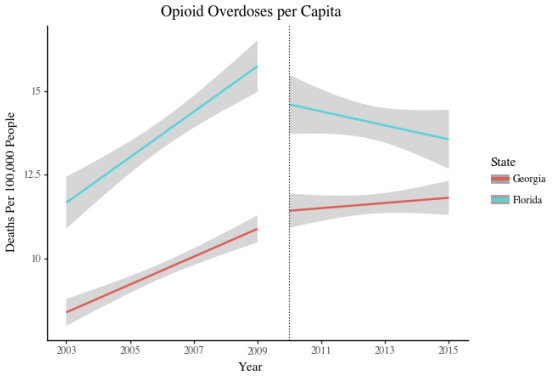
- **Florida**: Alabama, Georgia, Mississippi, South Carolina, and Tennessee
- **Texas**: Arizona, Kentucky, Louisiana, Missouri, and New Mexico
- **Washington**: California, Idaho, Montana, Oregon, and Wyoming

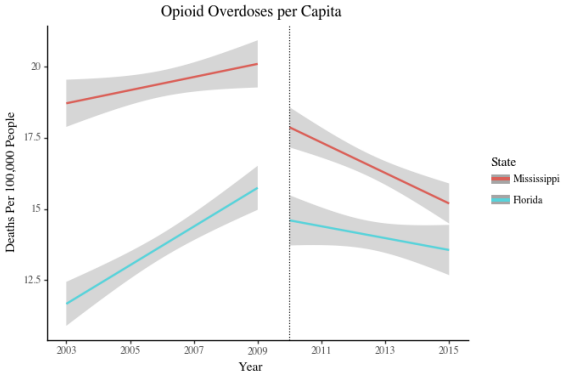
OPIOID SHIPMENT DD ANALYSIS, FLORIDA VS. COMPARISON STATES

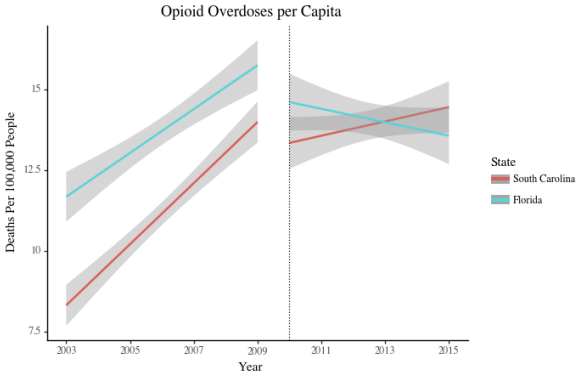


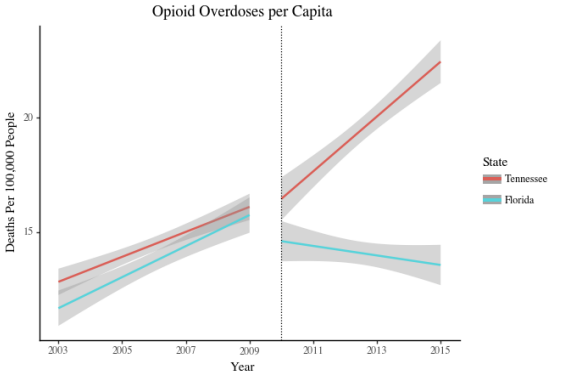
OPIOID OVERDOSES DD ANALYSIS, FLORIDA VS. COMPARISON STATES



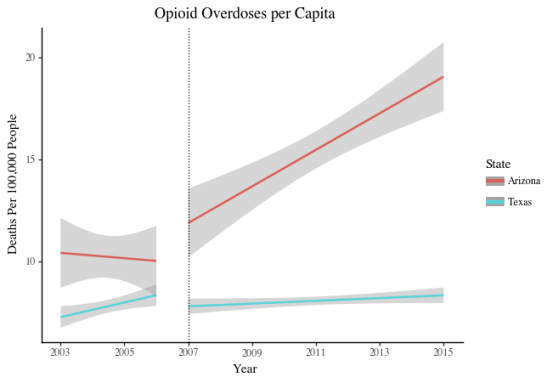


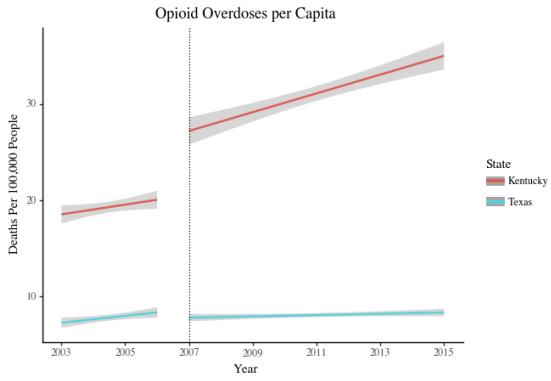


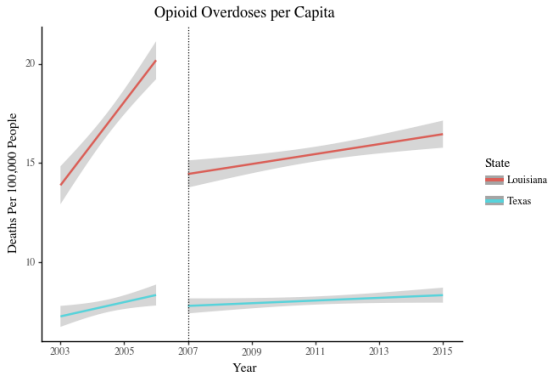


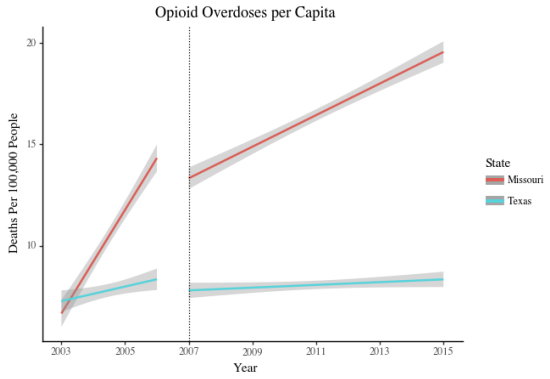


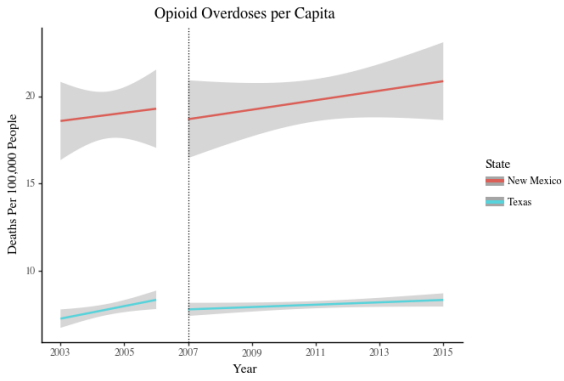
OPIOID OVERDOSES DD ANALYSIS, TEXAS VS. COMPARISON STATES


Opioid Overdoses per Capita
Deaths Per 100,000 People
Year
State
Arizona
Texas


Opioid Overdoses per Capita
Deaths Per 100,000 People
Year
State
Kentucky
Texas


Opioid Overdoses per Capita
Deaths Per 100,000 People
Year
State
Louisiana
Texas


Opioid Overdoses per Capita
Deaths Per 100,000 People
Year
State
Missouri
Texas


Opioid Overdoses per Capita
Deaths Per 100,000 People
Year
State
New Mexico
Texas

OPIOID OVERDOSES DD ANALYSIS, WASHINGTON VS. COMPARISON STATES