Estimate the Impact of Opioid Control Policies (Non Technical Report)

Alex Bzdel, Charlotte Yuan, Zhonglin Wang, Annapurna Pandita

Motivation for Project

Opioid usage in the United States has increased substantially over the past two decades, leading to an increase in not only prescription opioid addiction, but also non-prescription, illegal opioids as well. In this project, we'd like to analyze various policies made to combat this crisis. Both the rate at which opioids are prescribed as well as the deaths attributed to overdoses will be taken into account. By looking at both of these variables, we are also able to determine whether a decrease in opioid prescriptions can lead to an increase in opioid prescriptions due to patients turning to their illegal, non-prescription counterparts.

Motivation for Research Design

Our analysis was grounded in causal inference in an effort to estimate the effectiveness of three policy interventions (Florida, 2009; Texas, 2004; Washington, 2012) and assess whether they have directly impacted the trend of:

1. Opioid prescription rates
2. Opioid overdose rates

We performed both pre-post and difference-in-difference analyses for all three states to see if a trend line changes directly before and after a policy implementation and compared it with comparison states. By isolating the problem domain to these specific, controlled domains, we're able to confidently derive whether a policy has changed our variable over time.

Data Overview

Summary Statistics - Opioid Shipments

Washington

	Opioid Shipment per 100k Residents - Washington	Opioid Shipment per 100k Residents - Control States
count	4.000000	4.000000
mean	226.709481	245.127968
std	27.298342	10.168062
min	197.901727	235.799681
25%	209.262134	239.019994
50%	224.198237	242.761573
75%	241.645584	248.869547
max	260.539723	259.189045

Florida

	Opioid Shipment per 100k Residents - Florida	Opioid Shipment per 100k Residents - Control States
count	6.000000	6.000000
mean	100.118842	122.946454
std	25.614809	13.878212
min	68.128873	103.537660
25%	81.236070	113.919150
50%	101.636942	124.809510
75%	115.675299	130.592925
max	134.519765	141.712283

Summary Statistics - Drug Overdose Deaths

Texas

	Overdoses per 100k Residents - Texas	Overdoses per 100k Residents - Comp States
count	7.000000	7.000000
mean	10.340820	16.994631
std	1.555099	1.020954
min	8.102934	15.332948
25%	9.454362	16.410762
50%	10.315215	16.961625
75%	11.112507	17.855982
max	12.833851	18.134355

Washington

	Overdoses per 100k Residents - Washington	Overdoses per 100k Residents - Comp States
count	7.000000	7.000000
mean	9.974384	10.533942
std	0.940849	0.746642
min	8.615240	9.979069
25%	9.393438	10.053282
50%	10.122058	10.124154
75%	10.404292	10.803461
max	11.487930	11.920887

Florida

	Overdoses per 100k Residents - Florida	Overdoses Per 100K Residents - Control States
count	7.000000	7.000000
mean	10.707491	14.516717
std	0.984322	0.916776
min	9.046919	13.344370
25%	10.263142	13.915883
50%	10.589778	14.318559
75%	11.406635	15.053090
max	11.976183	16.016143

We provide a comparison table for the three states and their comparison states:

Florida - Georgia, Alabama, Mississippi, South Carolina, Tennessee (Year: 2007 - 2013)

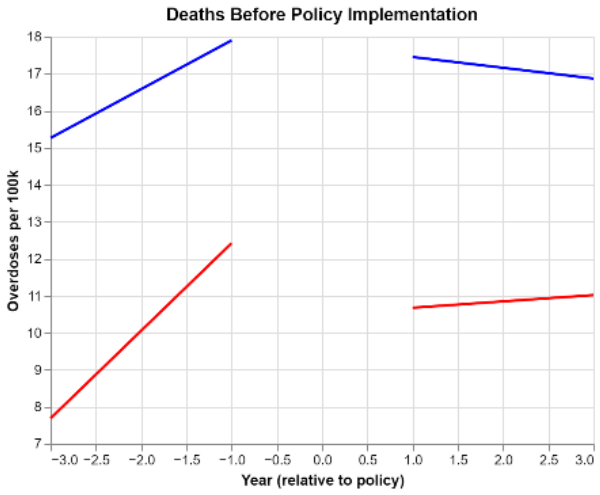
Texas - Oklahoma, Louisiana, New Mexico, Arkansas, Kansas (Year: 2004 - 2010)

Washington - Oregon, Idaho, Montana, Nevada, Wyoming (Year: 2009 - 2012)

Analysis and Interpretation

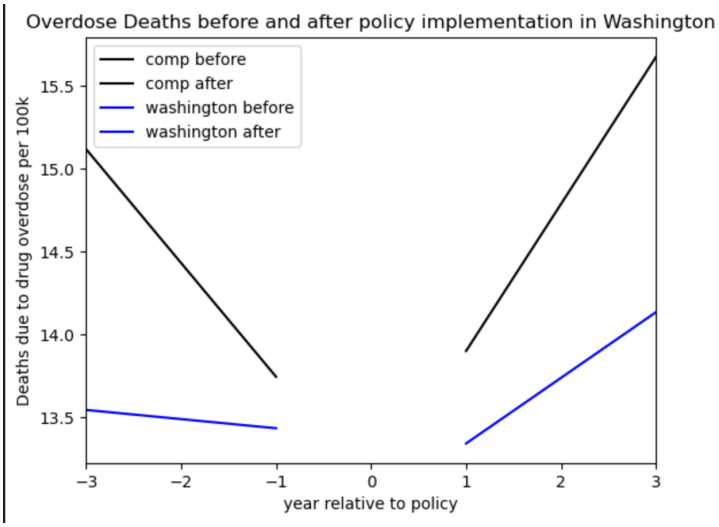
Since the Pre-Post is more likely a preliminary check, we didn't include those visualizations in the report for policy-maker. Difference-in-Difference provides more information and is closer to the details we want to illustrate and present.

Texas Overdoses



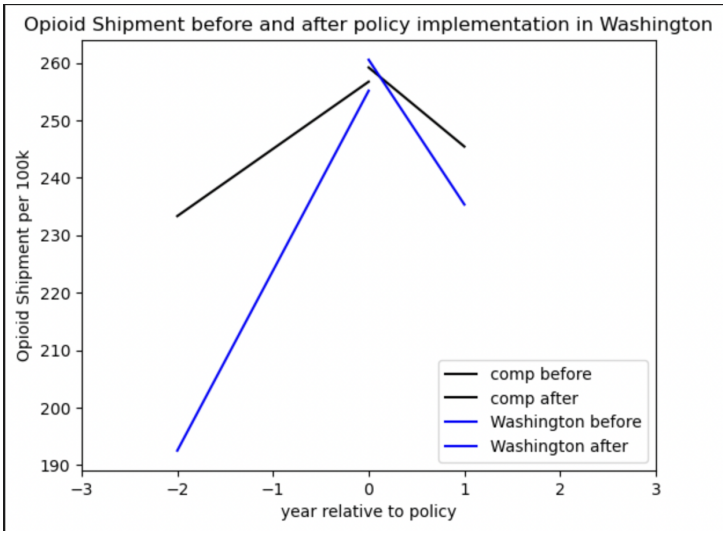
As a preliminary check, we must look to see that the pre-policy lines are somewhat parallel. In this case, they are, so we can assume the conditions of a diff-in-diff are met. In our comparison states, we see a *decrease* in overdose deaths after the *Texas* policy implementation. Therefore, we cannot attribute this trend change to Texas' policy in 2004. There must be some other policy or intervention at play.

Washington Overdoses



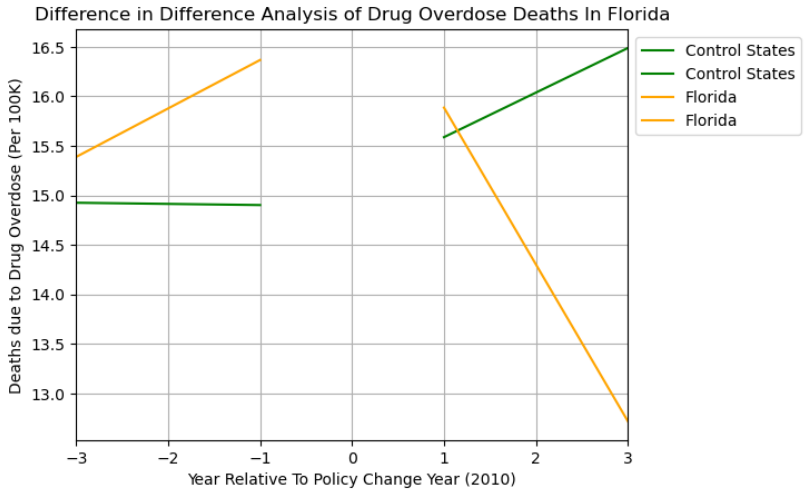
As a preliminary check, we are able to see that the pre-policy lines are not parallel and Washington had a lower decreasing rate compared to other states. According to our diff-in-diff analysis, Washington's overdose deaths had a slower decrease (before policy) and decrease rate (after policy implementation) compared to our comparison states, Therefore, we cannot attribute this trend change to Washington's policy implementation in 2012. There must be some other policy or intervention at play.

Difference-in-Difference: Washington Prescriptions



As a preliminary check, we are able to see that the pre-policy lines are not parallel and Washington had a steeper increasing uptrend compared to other states. According to our diff-in-diff analysis, Washington's Opioids shipment per 100,000 had a steeper increase (before policy) and a steeper decrease rate (after policy implementation) compared to our comparison states, Therefore, we cannot attribute this trend change to Washington's policy implementation in 2012. There must be some other policy or intervention at play.

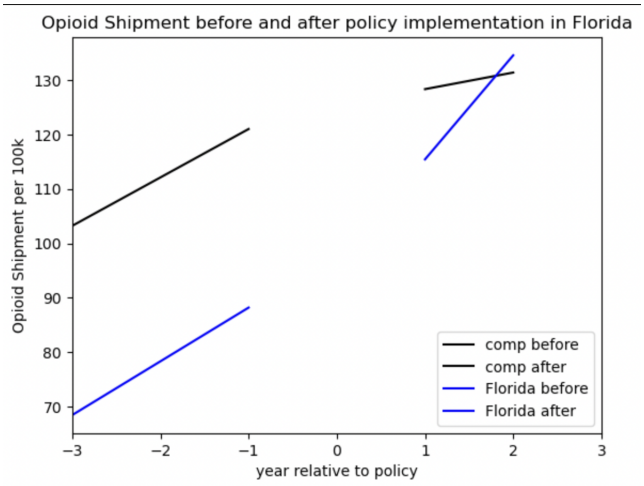
Difference-in-Difference: Florida Overdoses



Since the pre-policy lines are somewhat parallel, the conditions of conducting a difference-in-difference analysis are met. In the neighboring states of Florida, an increase can be seen in deaths due to drug overdose after the Florida policy implementation. But a decrease in deaths due to

drug overdose can be seen in Florida. Therefore, this trend change in Florida can be attributed to Florida's policy change in 2010.

Difference-in-Difference: Florida Prescriptions



Since the pre-policy lines are somewhat parallel, the conditions of conducting a difference-in-difference analysis are met. In the neighboring states of Florida, an increase can be seen in Opioids shipment per 100,000 after the Florida policy implementation. However, a steeper uptrend in Opioids shipment per 100,000 can be seen in Florida. Therefore, this trend change in Florida can be attributed to Florida's policy change in 2010.

Conclusion

The difference in difference analysis of opioid shipments and drug overdose deaths in Florida, Texas and Washington and their neighboring states have given us a clear insight into the impact of policy changes on opioid shipments and drug overdose deaths. We can see that the positive changes due to policy implementation in these states may not be too significant as expected. Exception can be made for the result of the difference in difference analysis of drug overdoses in Florida after the implementation of policy. A steep increase can be observed. But overall, the reasons for the less impact of the policies need further investigation.

Estimate the Impact of Opioid Control Policies (Technical Report)

Alex Bzdel, Charlotte Yuan, Zhonglin Wang, Annapurna Pandita

Motivation for Project

Opioid usage in the United States has increased substantially over the past two decades, leading to an increase in not only prescription opioid addiction, but also non-prescription, illegal opioids as well. In this project, we'd like to analyze various policies made to combat this crisis. Both the rate at which opioids are prescribed as well as the deaths attributed to overdoses will be taken into account. By looking at both of these variables, we are also able to determine whether a decrease in opioid prescriptions can lead to an increase in opioid prescriptions due to patients turning to their illegal, non-prescription counterparts.

Motivation for Research Design

Our analysis will be grounded in causal inference in an effort to find out if a given policy has directly impacted the trend of:

1. Opioid prescription rates
2. Opioid overdose rates

Both pre-post and difference-in-difference utilize single-variable regression-based approaches that see if a trend line changes directly before and after a policy implementation. By isolating the problem to these specific, controlled constraints, we're able to confidently derive whether a policy has changed our variable over time.

Details of the Data

Our final analysis revolves around two main sources of data for each set of states (Texas, Florida, Washington):

1. Prescription drug shipments
2. Overdose death statistics

The sources for the raw data above can be found in our GitHub repo under 00_source_data. Through a series of cleaning steps, we aggregated this data yearly for overdose data and monthly for prescription data (due to the granularity of the data when retrieved).

Additionally, we wanted to normalize overdose deaths over county population (and therefore analyzed overdose deaths per 100k residents). This was done by creating a unique FIPS ID based on a concatenation of county and state FIPS IDs (source of these FIPS also found in 00_source_data). We went on to join these unique FIPS numbers to our overdose and prescription datasets separately. Joining these FIPS numbers correctly was a challenge at first due to inconsistencies in how each dataset labeled counties and states, but we were able to get this done after cleaning these fields accordingly.

One of our issues when adding in FIPS numbers had to do with some counties being present in our FIPS data (eg. Populations of every state and county across the years), but not present in either our overdose or prescription datasets. The first issue we noticed was simple name inconsistencies in counties. For example, “Franklin” in one dataset may be labeled “FRANKLIN COUNTY” in the one we need to join it to.

Our first step was to make every county completely lowercase. Then, we looked to solve the parish/county inconsistency outlined above. To do this, we removed the words “county” and “parish” from every record in our county column. The only time this caused ambiguity was with one county name appearing in two states: “La Salle County '' and “La Salle Parish” in another. However, since we joined the FIP number based on county and state, we conclude that we can safely ignore this issue. Finally, we expanded and changed some county names that appeared differently in our different datasets (saint to st, desoto to de soto, etc.).

After following these steps, we still found that some counties were not merging from our FIPS data to our overdose and prescription datasets. In both cases, they were missing from the latter datasets (FIPS data has data from every county in the US). To check if this was an acceptable abnormality, we randomly sampled 10 counties from our prescription dataset and searched their names (and multiple

variations/other spellings/breaking points in the words) in our FIPS dataset as well as Google to ensure we were not missing any secondary names or spellings for the same county. We only had four missing records in our overdose data, so we just checked every county in this case.

We were not able to find any records from our sample in either dataset, so we concluded that these values were simply missing from their respective datasets. Therefore, our right only merge indicator is acceptable as we still ascertained a comprehensive set of counties in our data.

Summary Statistics - Opioid Shipments

Washington

	Opioid Shipment per 100k Residents - Washington	Opioid Shipment per 100k Residents - Control States
count	4.000000	4.000000
mean	226.709481	245.127968
std	27.298342	10.168062
min	197.901727	235.799681
25%	209.262134	239.019994
50%	224.198237	242.761573
75%	241.645584	248.869547
max	260.539723	259.189045

Noteworthy Points:

- Mean number of opioid shipments for neighboring states (245) is higher than that of Washington (227) with a slightly higher standard deviation.
- Minimum number of opioid shipments for neighboring states (236) is higher than that of Washington (198).
- Maximum number of opioid shipments for neighboring states (259) is almost equivalent to that of Washington (261).

Florida

	Opioid Shipment per 100k Residents - Florida	Opioid Shipment per 100k Residents - Control States
count	6.000000	6.000000
mean	100.118842	122.946454
std	25.614809	13.878212
min	68.128873	103.537660
25%	81.236070	113.919150
50%	101.636942	124.809510
75%	115.675299	130.592925
max	134.519765	141.712283

Noteworthy Points:

- Mean number of opioid shipments for neighboring states (123) is higher than that of Florida (100) with a slightly higher standard deviation.
- Minimum number of opioid shipments for neighboring states (104) is higher than that of Florida (68).
- Maximum number of opioid shipments for neighboring states (142) is quite close to that of Florida (134).

Summary Statistics - Overdose Data

Texas

	Overdoses per 100k Residents - Texas	Overdoses per 100k Residents - Comp States
count	7.000000	7.000000
mean	10.340820	16.994631
std	1.555099	1.020954
min	8.102934	15.332948
25%	9.454362	16.410762
50%	10.315215	16.961625
75%	11.112507	17.855982
max	12.833851	18.134355

Noteworthy Points:

- Mean number of drug overdose deaths for comparison states (16) is higher than that of Texas (10) with a slightly higher standard deviation.
- Minimum number of drug overdose deaths for comparison states (15) is higher than that of Texas (8).
- Maximum number of drug overdose deaths for comparison states (12) is higher than that of Texas (18).

Washington

	Overdoses per 100k Residents - Washington	Overdoses per 100k Residents - Comp States
count	7.000000	7.000000
mean	9.974384	10.533942
std	0.940849	0.746642
min	8.615240	9.979069
25%	9.393438	10.053282
50%	10.122058	10.124154
75%	10.404292	10.803461
max	11.487930	11.920887

Noteworthy Points:

- Mean number of drug overdose deaths for comparison states (11) is slightly higher than that of Washington (10) with a slightly higher standard deviation.
- Minimum number of drug overdose deaths for comparison states (10) is slightly higher than that of Washington (9).
- Maximum number of drug overdose deaths for comparison states (12) is slightly higher than that of Washington (11).

Florida

	Overdoses per 100k Residents - Florida	Overdoses Per 100K Residents - Control States
count	7.000000	7.000000
mean	10.707491	14.516717
std	0.984322	0.916776
min	9.046919	13.344370
25%	10.263142	13.915883
50%	10.589778	14.318559
75%	11.406635	15.053090
max	11.976183	16.016143

Noteworthy Points:

- Mean number of overdose deaths for Florida (11) is lower than that of its neighboring states (15).
- Minimum number of overdose deaths for comparison states (13) is higher than that of Florida (9).
- Maximum number of overdose deaths for comparison states (16) is higher than that of Florida (12).

Analysis and Interpretation

Pre-post: General Overview

In our pre-post analysis, we look to compare a state to itself before and after an implementation of a policy. What we're trying to see here is whether a given state looked as it did prior to said policy. If it looks the same, we conclude that the policy had no effect. However, if we see a decrease (or even a decrease of the rate of increase) of our target variable, we may be able to conclude that a policy has made a difference.

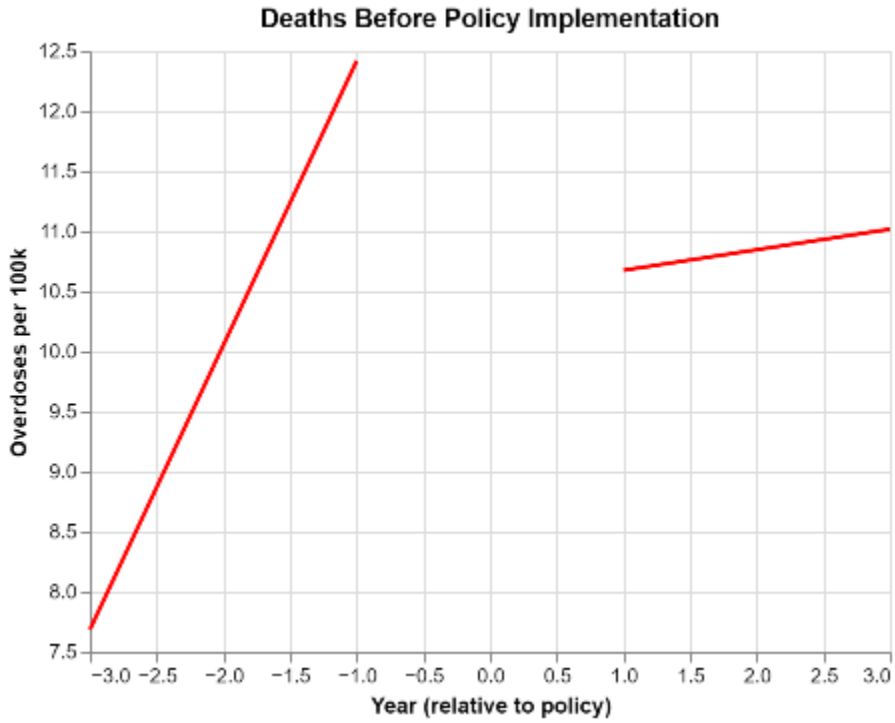
However, this approach is not robust to changes across larger populations (like the entire United States). Perhaps a nationwide policy or other intervention had also gone into effect, causing us to falsely attribute a change to the more local policy.

Difference-in-Difference: General Overview

Our diff-in-diff analysis looks to address the aforementioned problem in our pre-post analysis. This method involves comparing our target state to the average of a few other comparison states to see if our trend continues on a broader scale. There are a few different methodologies on how to pick these states – in our case, we looked at our target state's five closest neighbors. This allows us to see if our policy led to changes locally, or if we see the same trend across comparison states.

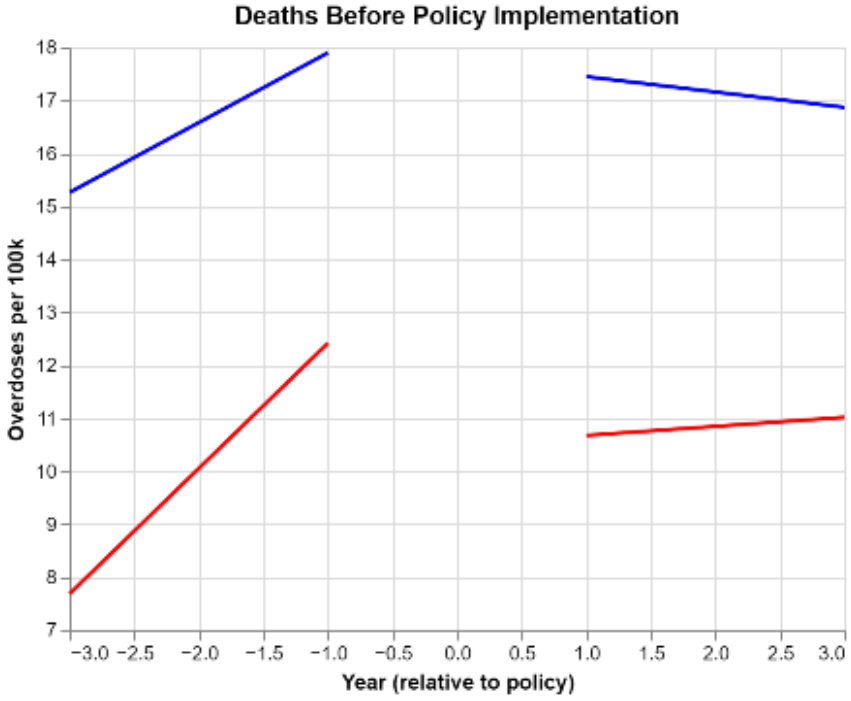
In order for this approach to work, we need to see that the target and comparison states exhibit similar trends prior to the policy change. Additionally, one weakness here is that our choice of comparison states will always be somewhat subjective. There is no perfect number of states or reason to choose another state, so as analysts we must work with the best assumptions we can.

Pre-post: Texas Overdoses



In Texas, our pre-post analysis suggests that the policy change likely made a difference. While we do not see an explicit decrease in opioid deaths, we see a substantial flattening of the upwards trend that occurs before the implementation.

Difference-in-Difference: Texas Overdoses



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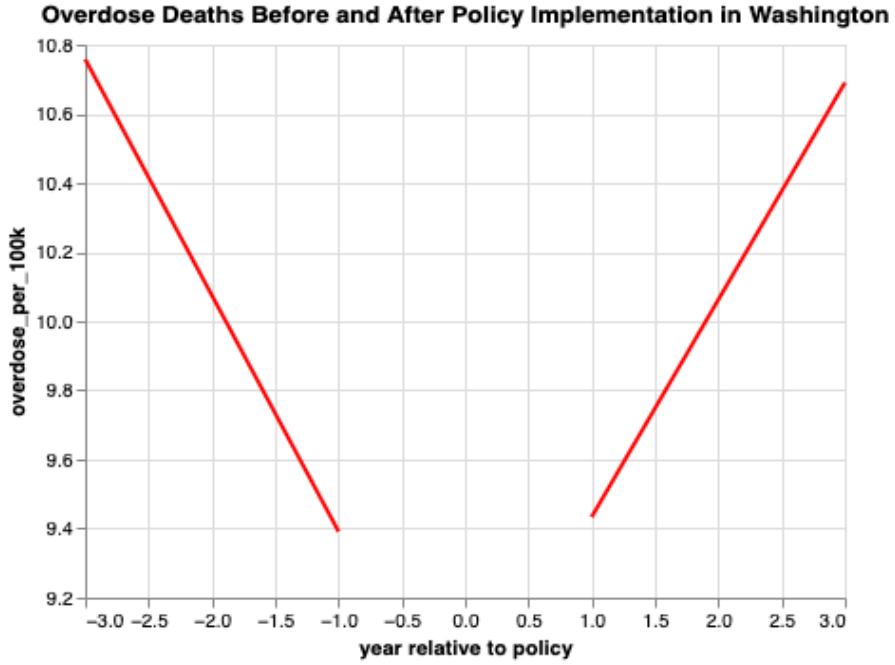
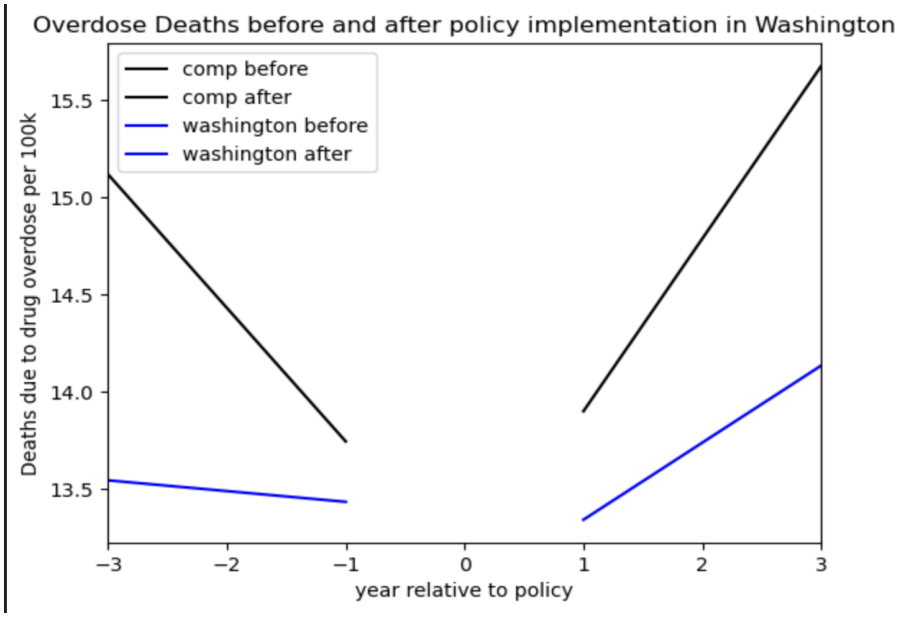
As a preliminary check, we must look to see that the pre-policy lines are somewhat parallel. In this case, they are, so we can assume the conditions of a diff-in-diff are met. In our comparison states, we see a *decrease* in overdose deaths after the *Texas* policy implementation. Therefore, we cannot attribute this trend change to Texas' policy in 2004. There must be some other policy or intervention at play.

Pre-post: Washington Overdoses



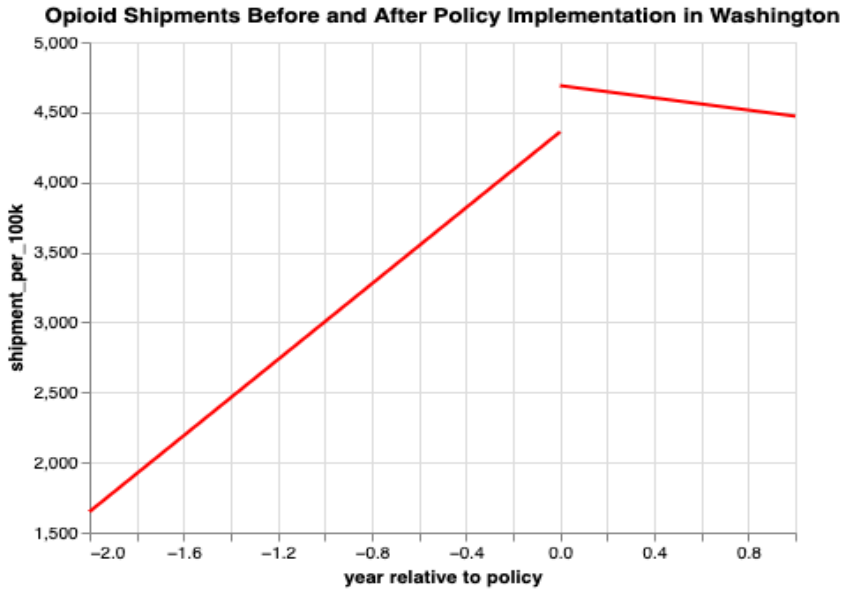
We did not see an effective policy implementation in Washington from the pre-post analysis. Drug overdoses decreased before the policy change, then started to increase again.

Difference-in-Difference: Washington Overdoses



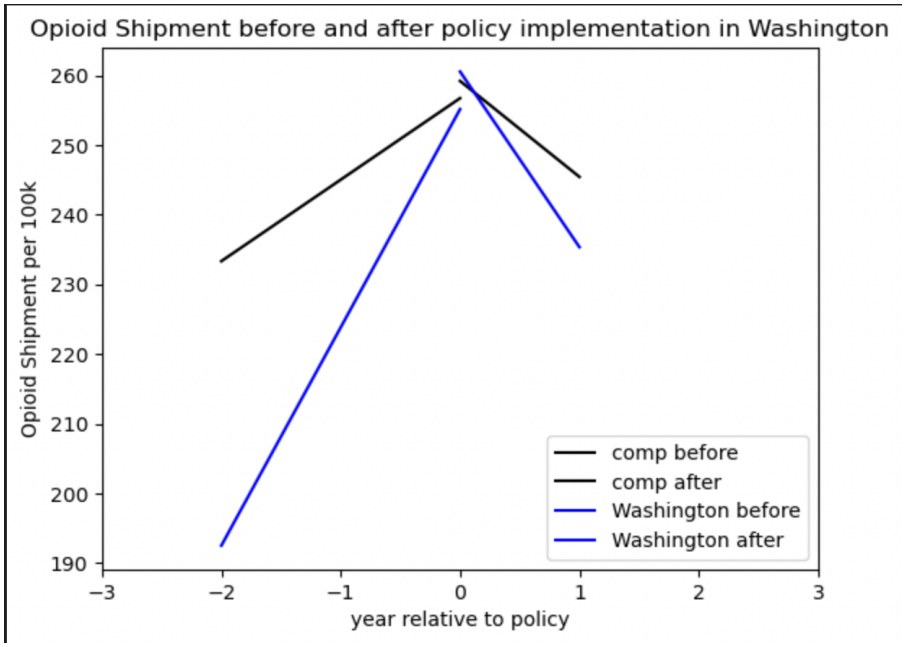
As a preliminary check, we are able to see that the pre-policy lines are not perfectly parallel, but still exhibit marginally similar trends. According to our diff-in-diff analysis, Washington's overdose deaths had a slower decrease (before policy) and decrease rate (after policy implementation) compared to our comparison states, Therefore, we cannot attribute this trend change to Washington's policy implementation in 2012. There must be some other policy or intervention at play.

Pre-post: Washington Prescriptions



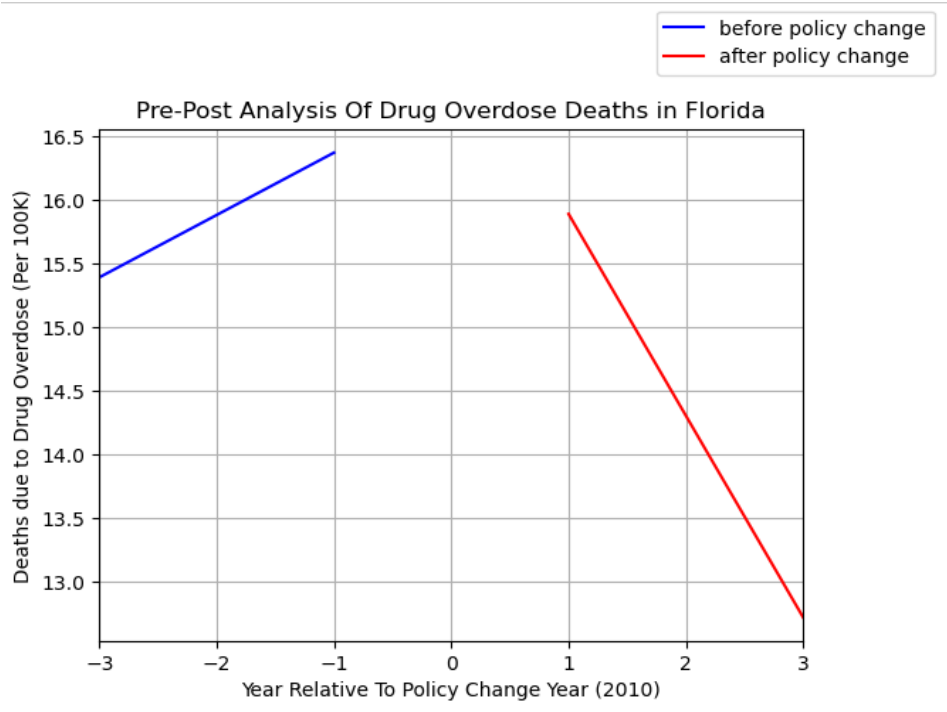
Opioid shipments continued to increase before policy implementation in Washington, then dropped slightly after the policy change. This can be confirmed further by doing a difference-in-difference analysis to capture the trend of opioid shipments over the years.

Difference-in-Difference: Washington Prescriptions



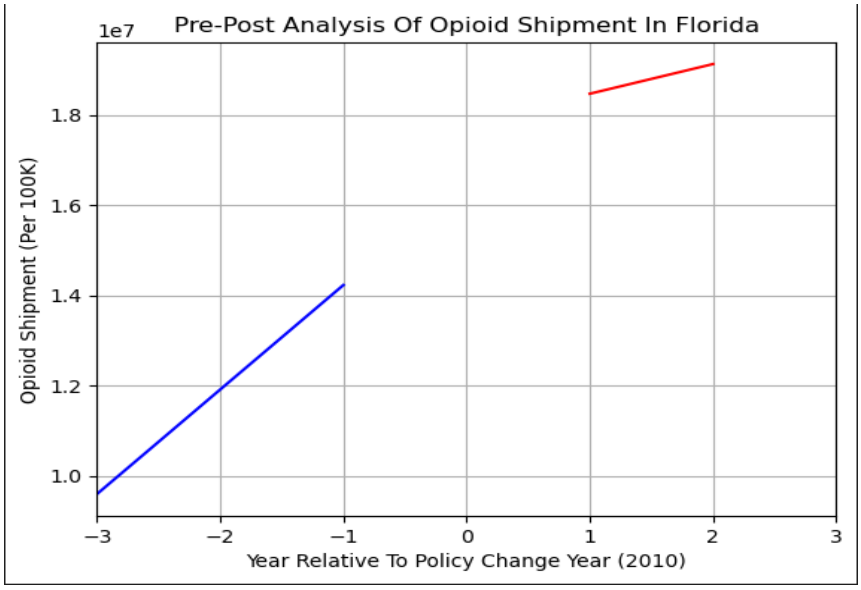
As a preliminary check, we are able to see that the pre-policy lines are not parallel and Washington had a steeper increasing uptrend compared to other states. According to our diff-in-diff analysis, Washington's Opioids shipment per 100,000 had a steeper increase (before policy) and a steeper decrease rate (after policy implementation) compared to our comparison states, Therefore, we cannot attribute this trend change to Washington's policy implementation in 2012. There must be some other policy or intervention at play.

Pre-post: Florida Overdoses



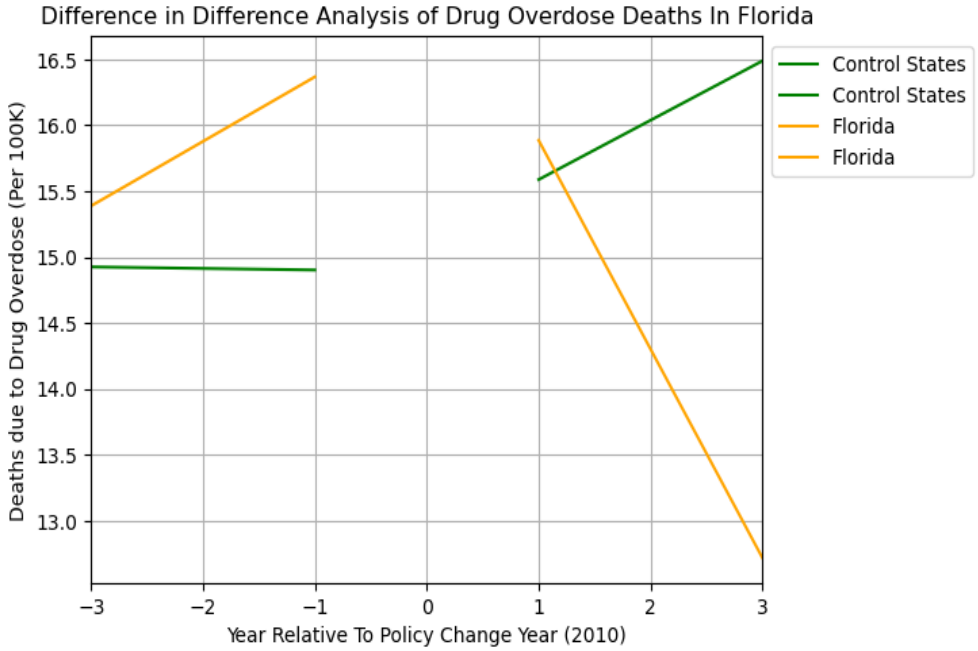
An effective policy implementation has been observed in Florida from the pre-post analysis. Deaths due to drug overdoses were increasing right before the policy change. After the policy change in 2010, deaths due to drug overdose have decreased.

Pre-post: Florida Prescriptions



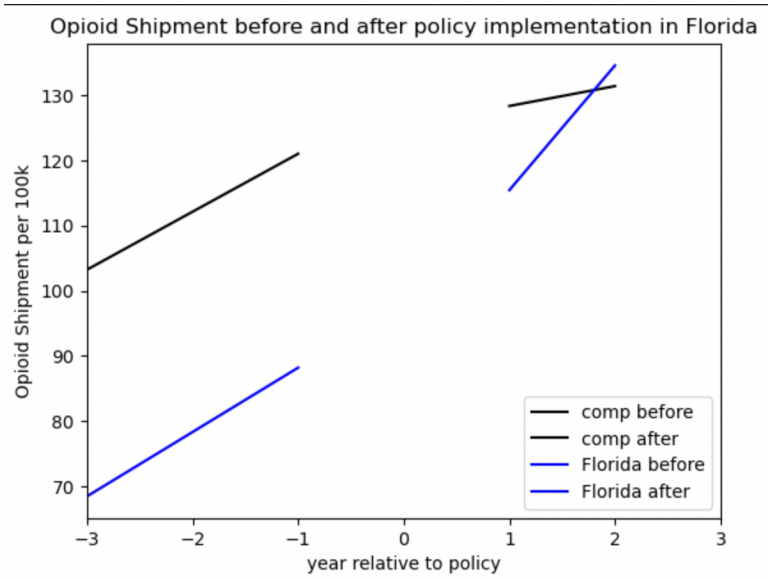
As per the pre-post analysis Florida's opioid shipment per 100,000 had a steeper increase (before policy) and a marginal increase rate (after policy implementation). It might be concluded that the implementation of the policy change reduced the rate of increase of opioid shipment in Florida. But this needs to be delved into further (perhaps, Google search).

Difference-in-Difference: Florida Overdoses



Since the pre-policy lines are somewhat parallel, the conditions of conducting a difference-in-difference analysis are met. In the neighboring states of Florida, an increase can be seen in deaths due to drug overdose after the Florida policy implementation. But a decrease in deaths due to drug overdose can be seen in Florida. Therefore, this trend change in Florida can be attributed to Florida's policy change in 2010.

Difference-in-Difference: Florida Prescriptions



Since the pre-policy lines are parallel, the conditions of conducting a difference-in-difference analysis are met. In the neighboring states of Florida, an increase can be seen in Opioids shipment per 100,000 after the Florida policy implementation. However, a steeper uptrend in Opioids shipment per 100,000 can be seen in Florida. Therefore, this trend change in Florida can be attributed to Florida's policy change in 2010.

Conclusion

Both pre-post and difference in difference analysis of opioid shipments and drug overdose deaths in Florida, Texas and Washington have given us a clear insight into the impact of policy changes on opioid shipments and drug overdose deaths. In states like Florida, the policy changes have apparently made a more positive impact. In states like Texas and Washington, not much of a positive impact can be seen. This needs to be researched further.