Estimating the Impact of Opioid Control Policies

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REPORT 1

Introduction

The purpose of this project is to analyze and combine large amounts of data regarding opioid prescriptions and drug overdose mortality to be able to estimate the impact of opioid control policies on opioid shipments and deaths. In addition, this project aims to encourage thoughtful exploration of the given data and the problem to find a third, relevant dataset necessary for estimating the impact of policy changes. In dealing with these three datasets on opioid prescriptions, opioid deaths, and the third dataset of choice, population data, we were also tasked with the challenge of data cleaning and wrangling. This included selecting columns of interest from a big dataset in an efficient way and merging cleaned datasets into one interpretable and usable dataset. Lastly, with a cleaned dataset, analysis can be done to examine the effect of opioid control policies in three states of interest by doing a pre-post analysis and a difference-in-difference analysis when comparing opioid shipments and overdose deaths.

In addition to the data cleaning, wrangling, and analysis aspects, this project also aims to encourage team collaboration through GitHub, including pull request and code reviews. Overall, this project focuses mostly on data cleaning and wrangling with the goals of analysis, successful writing of reports, and efficient team collaboration through GitHub as other motivations.

Data

For this project, we were provided two datasets that needed cleaning and reorganization to make a more usable dataset. The first dataset on opioid prescriptions is provided by *The Washington Post*. A significant portion of this dataset was not relevant to this study, and to help facilitate working with the large dataset, all columns except the necessary columns (state and county of drug buyer, transaction date, mme conversion factor for different drugs, the quantity of drugs, and the total amount of drug (in grams) bought). After dropping unnecessary columns, we extracted year information from the transaction data column, and computed the total morphine equivalent amount for each drug by multiplying the provided mme conversion factor by the total amount of drug (in grams). After these operations, we aggregated the total equivalent morphine, quantity of drug and grouped by state, year, and county (county is for further research if we have time).

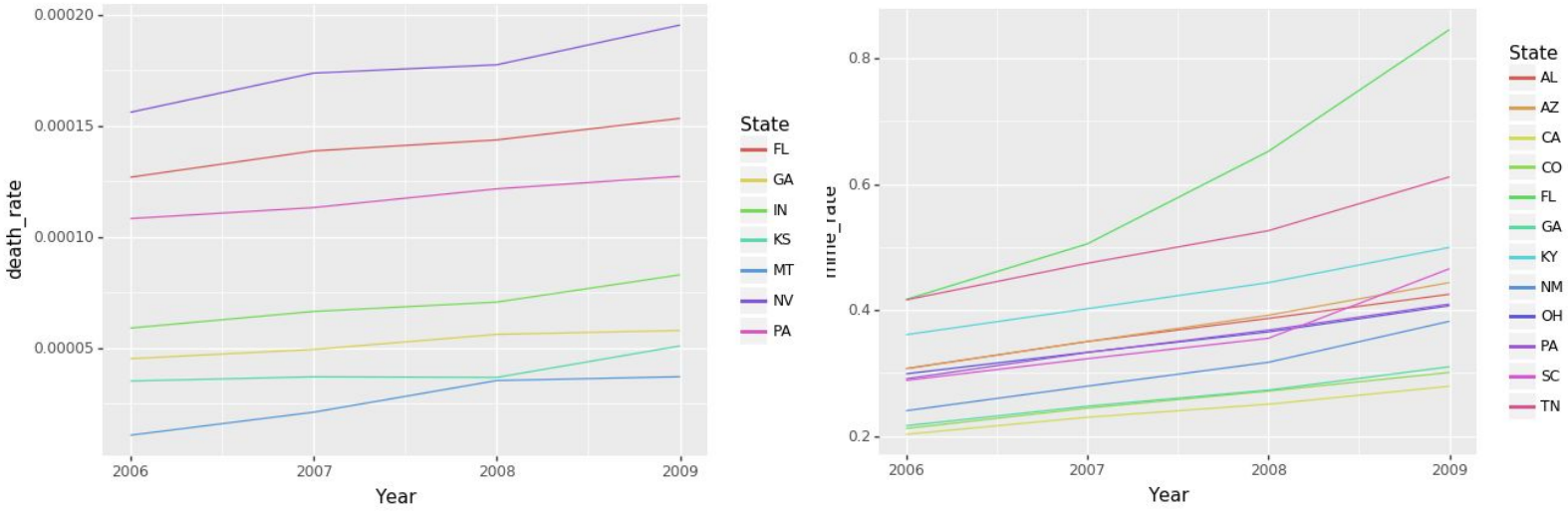
The second dataset on drug overdose mortality is provided by the US Vital Statistics records. This dataset includes information on all deaths for each county, but for our analysis, we only selected drug overdose deaths (aggregated from each specific group of drug overdose deaths) grouped by state. To do so, all data was downloaded and combined into one raw csv file. From this csv file, the two letter state code was separated from the county column into a new column. Subsetting only drug overdose death causes, we then grouped by state and year, summing the death counts. The resulting dataset consists of one row for each state and year with the corresponding drug overdose deaths for that state-year.

The third dataset that we decided to use was population data provided by The National Historical Geographic Information System (NHGIS). For this project, we chose to add population data in order to be able to compare the number of deaths/shipments relative to the

population of each state, rather than just comparing the raw numbers. The base dataset we use has population data from 2006 to 2012. We add population data from 2003 to 2005 and 2013 to 2015 to the base dataset for future analysis with county, state, and year information ('year', 'state', 'county', 'STATEA', 'COUNTYA', 'countyfips', 'population'). Because the years 2013 and 2014 were missing, data was interpolated using information from 2012 and 2015. For example, pop_2013 = (pop_2015 - pop_2012) / 3 + pop_2012. Some county data was missing, but because we aggregated by state, the difference is minimal. The resulting population data includes information from 2003 to 2015 by county. We then group this county-level data by state and year, and sum on population, resulting in a final population dataset from 2003 to 2015 by state and year.

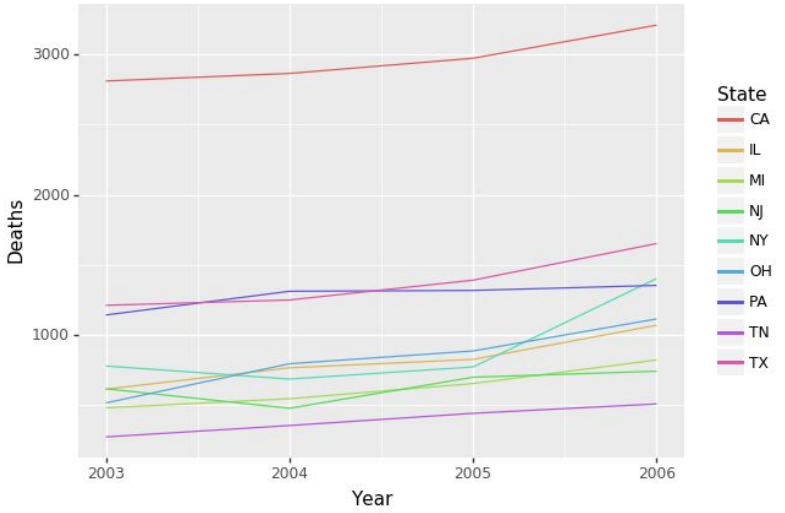
With the opioid shipments, overdose deaths, and population datasets, we then merged these three datasets on state and year. The resulting dataset has one row for each state and year with information on opioid shipments, overdose deaths, and state population. Opioid deaths and shipments were then calculated per capita by dividing the amount of each by the state population in that year. The final dataset has 670 rows and 7 columns (state, year, mme, population, deaths, deaths per capita, and mme per capita).

Analysis

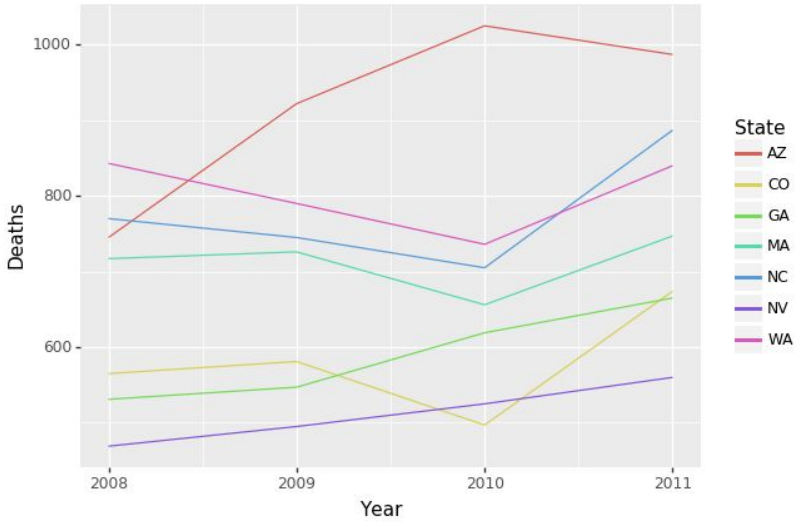


In order to assess the effectiveness of opioid policies implemented in Florida in 2010, we aimed to identify 3 states that have similar trends in opioid overdose deaths and shipments per capita for the previous three years, 2006 through 2009. To do so, we subsetted data within a range (½ minimum to 3/2 maximum) of deaths and shipments per capita from 2003 to 2009. We then plotted a selection of these states to visualize trends and choose 2 sets of 3 states with similar trends in each opioid deaths and shipments per capita. Based on these plots, three states with similar trends in overdose deaths per capita compared to Florida are Nevada, Pennsylvania, and Indiana. Likewise, three states with similar trends in opioid shipments per capita compared to Florida are Georgia, California, and New Mexico. This same process was done to identify states with similar trends in overdose deaths relative to Texas and Washington. An opioid policy was implemented in Texas in 2007 , so we examined opioid deaths per capita from 2003 to 2006.

Based on the plots, we identified Pennsylvania, Ohio, and Illinois as three states with similar trends in opioid deaths per capita from 2003 to 2006.



Likewise, an opioid policy was implemented in 2012 in Washington, we examined opioid deaths per capita from 2008 to 2011. Based on the plot of opioid deaths per capita for a select number of states in this time frame, North Carolina, Massachusetts, and Colorado have similar trends in opioid deaths per capita.



In summary, the following table describes the comparison states for future analysis:

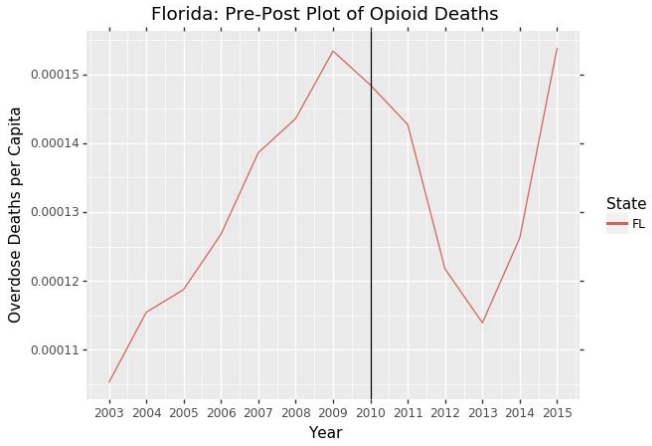
Opioid Policy State	Policy Implementation Year	Overdose Death Comparison States	Opioid Shipments Comparison States
Florida	2010	Nevada	Georgia

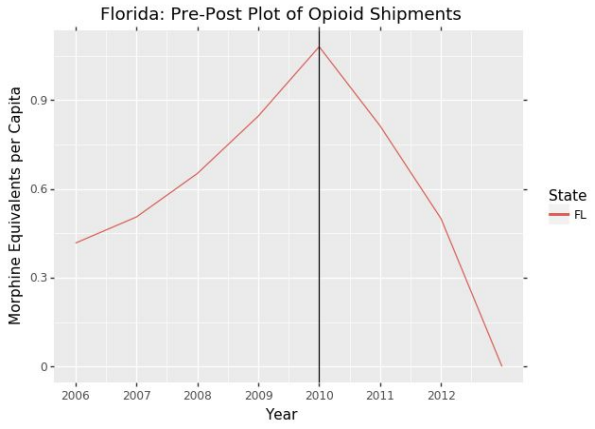
		Pennsylvania	California
		Indiana	New Mexico
Texas	2007	Pennsylvania	
		Ohio	
		Illinois	
Washington	2012	North Carolina	
		Massachusetts	
		Colorado	

Results

Florida: Overdose Deaths and Opioid Shipments

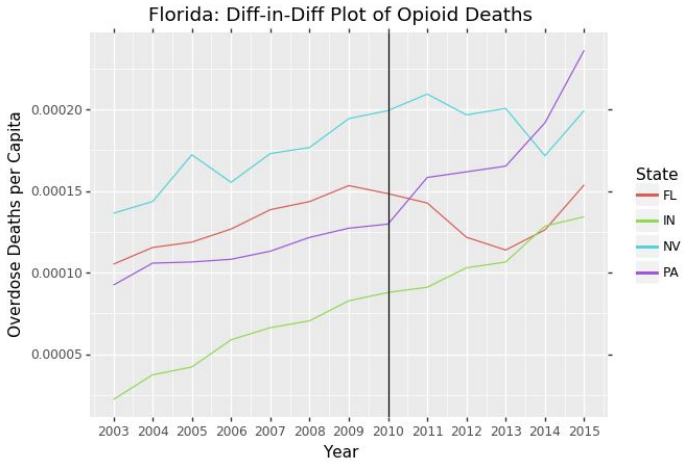
First, we performed a pre-post analysis where we compare the opioid deaths (left) and shipments (right) before and after policy implementation in 2010, indicated by the horizontal line at year 2010. By comparing the trend in overdose deaths and opioid shipments, we can determine if the policy decreased deaths and/or shipments. Initially, it appears that the opioid policy implements in 2010 in Florida decreased deaths per capita, but in 2013, the overdose deaths per capita again increase. However, the decreasing trend in opioid shipments after 2010 is evident, and it is possible that the opioid policy was effective in decreasing opioid shipments in Florida.





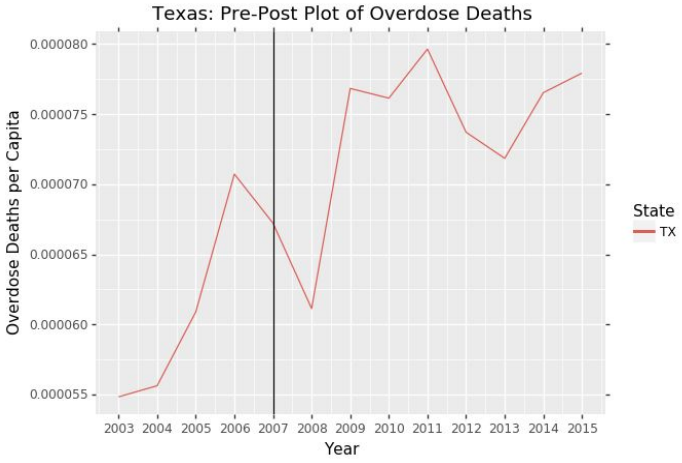
Because pre-post analysis does not account for external factors that could also affect overdose deaths and opioid shipments, we also perform a difference in difference analysis, comparing Florida (red) to the three previously identified comparison states for both overdose deaths (left) and opioid shipments (right). While Florida previously showed a similar trend in

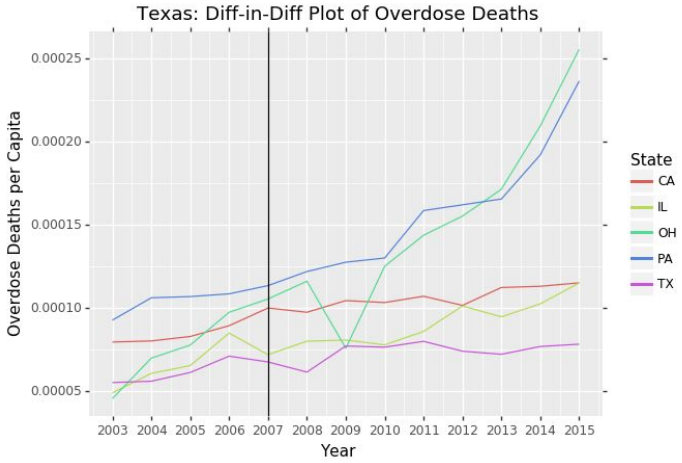
opioid deaths per capita prior to policy implementation, after policy implementation, it appears that the overdose deaths per capita decrease in Florida relative to other states whose trends continued to increase. Similarly, relative to other comparison states for opioid shipments, the number of opioid shipments per capita in Florida show a clear, sharp decrease while opioid shipments in the other comparison states remain about the same. Thus, based on these difference-in-difference plots, it is likely that the opioid policy implemented in Florida in 2010 was effective at decreasing overdose deaths and opioid shipments per capita.



Texas: Overdose Deaths

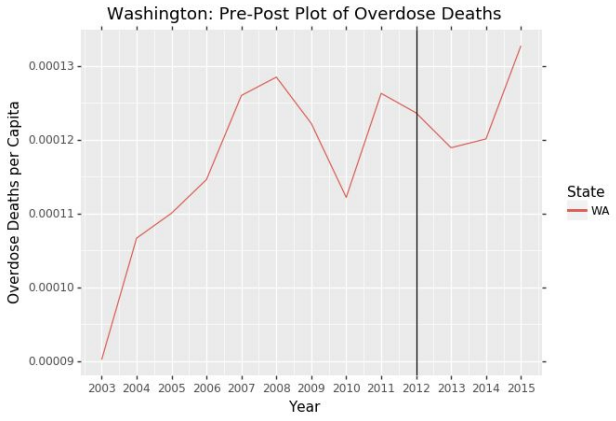
We proceed with the same process of a pre-post analysis followed by a difference in difference analysis to examine the effects of opioid policies on overdose deaths in both Texas and Washington. In plotting the overdose deaths per capita in Texas before and after policy implementation in 2007, we can see that after policy implementation, overdose deaths temporarily decreased then increased again. Relative to other non-policy states with similar trends in overdose deaths before 2007, the trend in overdose deaths per capita in Texas remains approximately the same. While the overdose deaths per capita increase significantly in some states, it remains about the same after policy implementation in Texas. Based on these plots, it is inconclusive as to whether the opioid policy in Texas decreased overdose deaths per capita, but it is possible that it may have prevented a sharper increase, as seen in other states.

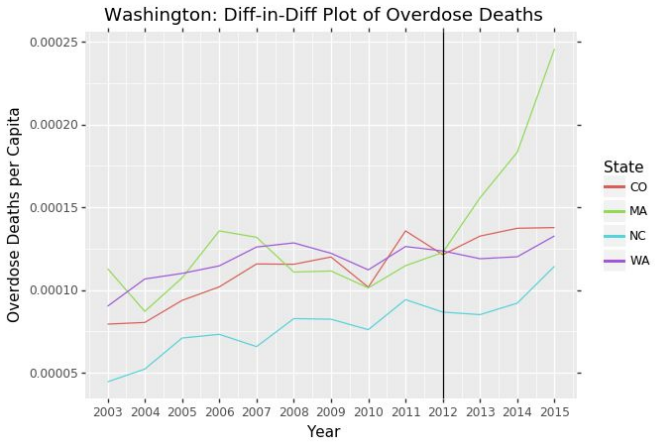




Washington: Overdose Deaths

Again, we aim to determine if the opioid policy implemented in Washington in 2012 decreased overdose deaths per capita. Our pre-post plot (left) shows that there may have been a slight decrease followed by an increase. Comparing the overdose deaths per capita in Washington to non-policy states, it appears that the trend in overdose deaths in Washington remains approximately the same after policy implementation. However, because the slope remains relatively flat after 2012, it is possible that the opioid policy prevented further increases in opioid deaths, as seen in other non-policy states





All in all, the opioid policy implemented in Florida seems to be the most effective at decreasing overdose deaths and opioid shipments per capita. Not only did the actual value of overdose deaths and opioid shipments per capita decrease, but also relative to non-policy states, the trend in Florida in both deaths and shipments per capita decreased. However, changes are less evident in overdose deaths in Texas and Washington. In both states, the overdose deaths per capita remain about the same after policy implementation. It is possible that the trends in overdose deaths per capita do not increase in Texas and Washington as much as in non-policy states.

REPORT 2

Introduction

The purpose of this project is to analyze the effect of the implementation of opioid policies on opioid shipments and deaths. In order to do so, we analyze the number of opioid shipments and deaths *before* policy implementation and compare it to the number of opioid shipments and deaths *after* policy implementation. This pre-post analysis highlights the change in opioid shipments and deaths. While we would like to assume that this difference is likely due to the implementation of the opioid policy, other outside factors may have contributed to a certain observed change. To help account for this, we also study the difference in opioid shipments and deaths in states *with* policy implementation in comparison to the difference in opioid shipments and deaths in states *without* policy implementation. By also including this difference-in-difference analysis, we can examine how changes in a certain state with opioid policies compared to changes in other states without opioid policies.

Overall, these two methods of analysis, pre-post and difference-in-difference, allow us to study the effects of opioid policies on opioid shipments and deaths. More specifically, this analysis can be used to help determine if the opioid policy implemented in Florida in 2010 was effective in decreasing both opioid shipments and deaths. Likewise, we can also examine the effect of the opioid policies implemented in Texas in 2007 and Washington in 2012 successfully decreased opioid deaths.

Data

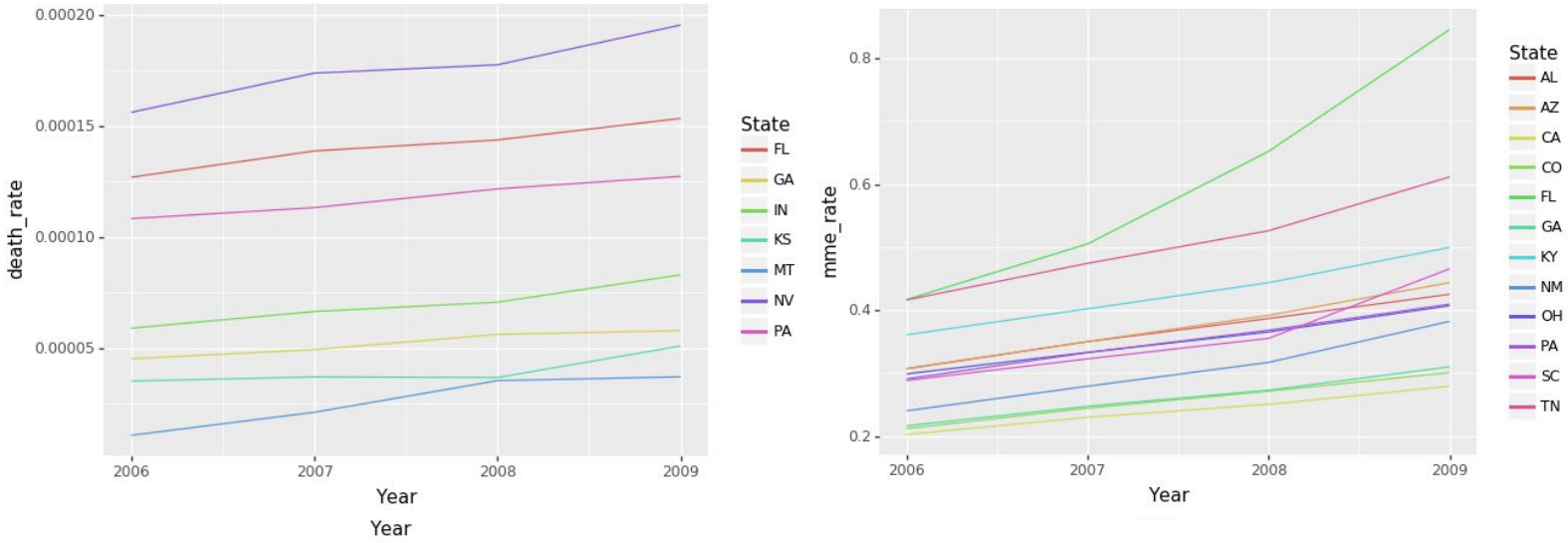
For this analysis, three datasets on opioid shipments, overdose deaths, and population were necessary to gather information on opioids before and after policy implementation. The first dataset on opioid shipments was recently published by *The Washington Post* and includes information on all opioid shipments into the United States. For this analysis, we focus on the opioids shipped into each state for each year, and convert the weight in grams of a specific opioid into a morphine equivalent using a conversion factor provided by the Drug Enforcement Administration (DEA). This converts different opioids in different formats to the same scale, enabling comparison of opioid shipment amounts. The second dataset on mortality is provided by the US Vital Statistics records. From this dataset, we isolate specifically drug overdose deaths for each state and year. Lastly, the state population data is provided by The National Historical Geographic Information System (NHGIS) and is broken down by state and year.

With these three datasets, we have state and year level information on opioid shipments from 2006 to 2012, drug overdose deaths from 2003 to 2015, and population from 2003 to 2015. We then calculate the overdose deaths and opioid shipments per capita by dividing the overdose deaths and morphine equivalents by the state population for each year.

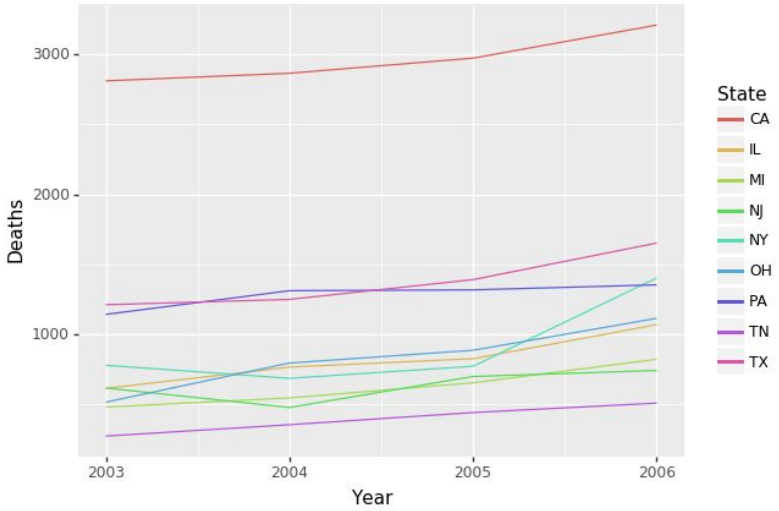
Analysis

In order to assess the effectiveness of opioid policies on opioid deaths and shipments in Florida and opioid deaths in Texas and Washington, we identified three states with similar trends in opioid deaths/shipments per capita for each opioid policy state. By plotting trends in opioid deaths and shipments per capita in the four years preceding the implementation of opioid policy, we can visually identify states with similar trends.

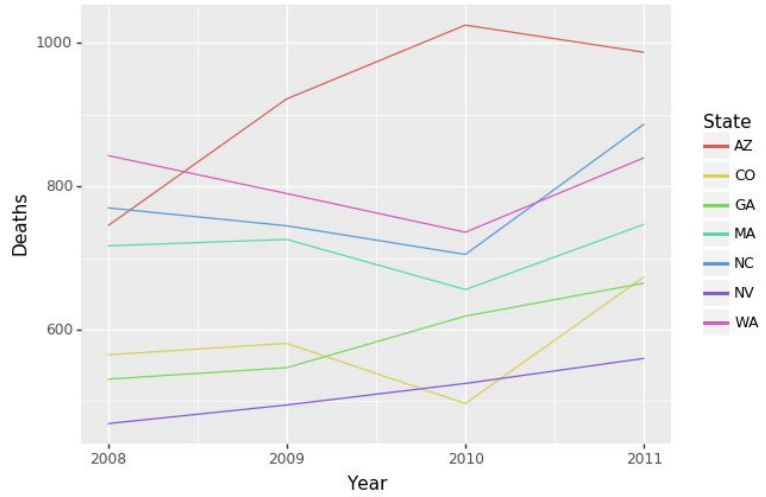
In 2010, an opioid policy was implemented in Florida. Thus, we wanted to examine trends in opioid shipments and deaths per capita from 2006 to 2009 in Florida. Based on the following plots, we can see that states with similar trends in overdose deaths per capita from 2006 to 2009 include Nevada, Pennsylvania, and Indiana. Likewise, states with similar opioid shipments per capita include Georgia, California, and New Mexico.



Likewise, an opioid policy was implemented in Texas in 2007 , so we examined opioid deaths per capita from 2003 to 2006. Based on the plots, we identified Pennsylvania, Ohio, and Illinois as three states with similar trends in opioid deaths per capita from 2003 to 2006.



Lastly, an opioid policy was implemented in 2012 in Washington. We examined opioid deaths per capita from 2008 to 2011. Based on the plot of opioid deaths per capita for a select number of states in this time frame, North Carolina, Massachusetts, and Colorado have similar trends in opioid deaths per capita.



The following table summarizes the comparison states for both opioid deaths and shipments (if applicable) for each of the three states of interest:

Opioid Policy State	Policy Implementation Year	Overdose Death Comparison States	Opioid Shipments Comparison States
Florida	2010	Nevada	Georgia
		Pennsylvania	California
		Indiana	New Mexico
Texas	2007	Pennsylvania	
		Ohio	
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Results

Florida: Overdose Deaths and Opioid Shipments

First, we compare the opioid deaths (left) and shipments (right) before and after policy implementation in 2010, indicated by the horizontal line at year 2010. By comparing the trend in overdose deaths and opioid shipments, we can determine if the policy decreased deaths and/or shipments. Initially, it appears that the opioid policy implements in 2010 in Florida decreased

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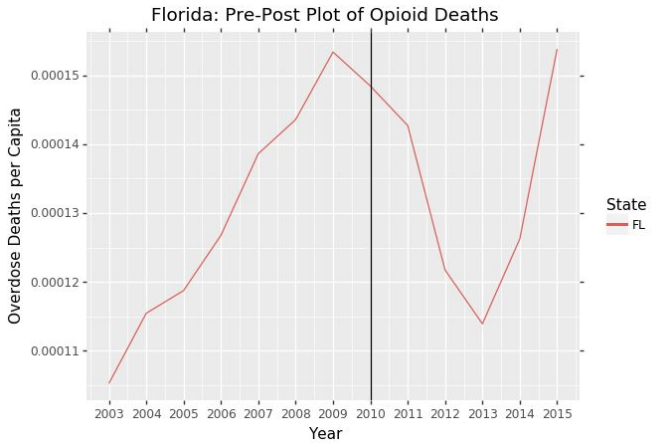
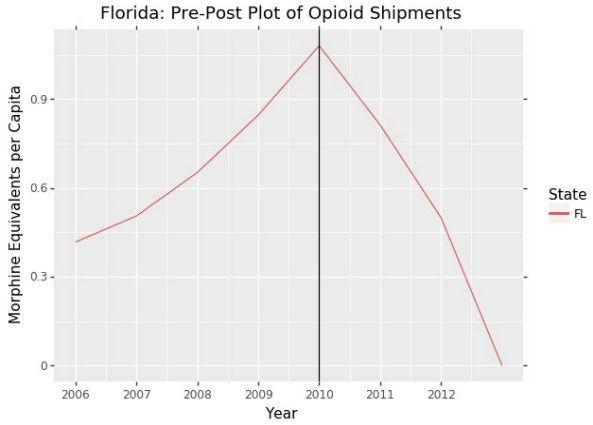
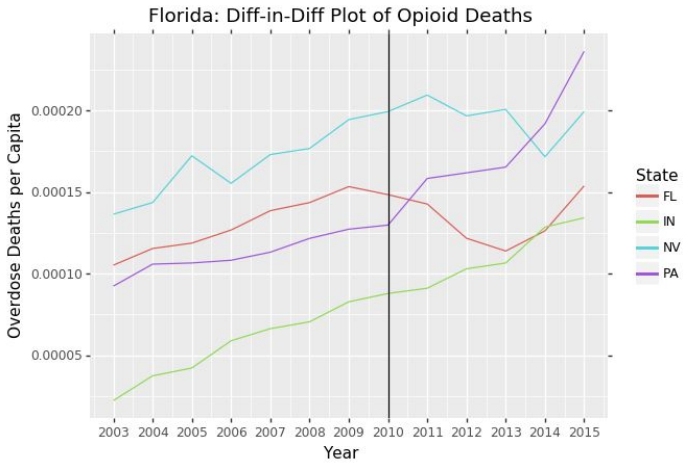


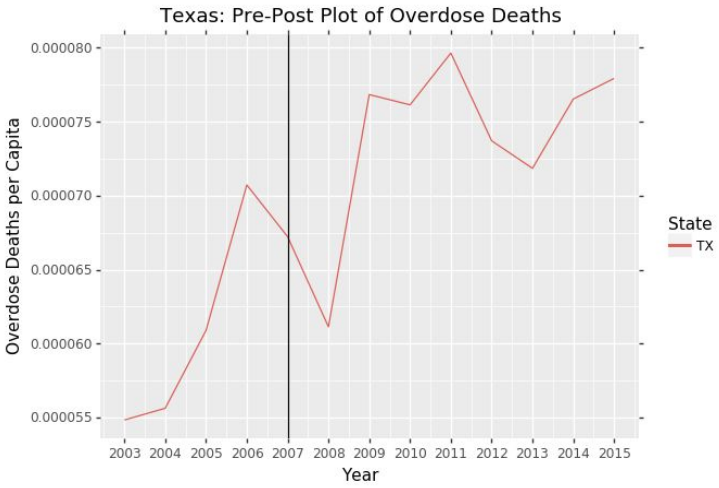


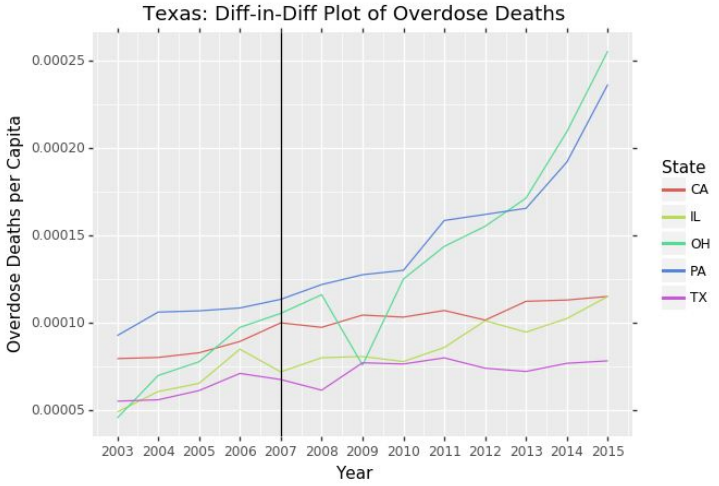
Because pre-post analysis does not account for external factors that could also affect overdose deaths and opioid shipments, we also compare Florida to the three previously identified comparison states for both overdose deaths (left) and opioid shipments (right). While Florida previously showed a similar trend in opioid deaths per capita prior to policy implementation, after policy implementation, it appears that the overdose deaths per capita decrease in Florida relative to other states whose trends continued to increase. Similarly, relative to other comparison states for opioid shipments, the number of opioid shipments per capita in Florida show a clear, sharp decrease while opioid shipments in the other comparison states remain about the same. Thus, based on these difference-in-difference plots, it is likely that the opioid policy implemented in Florida in 2010 was effective at decreasing overdose deaths and opioid shipments per capita.



Texas: Overdose Deaths

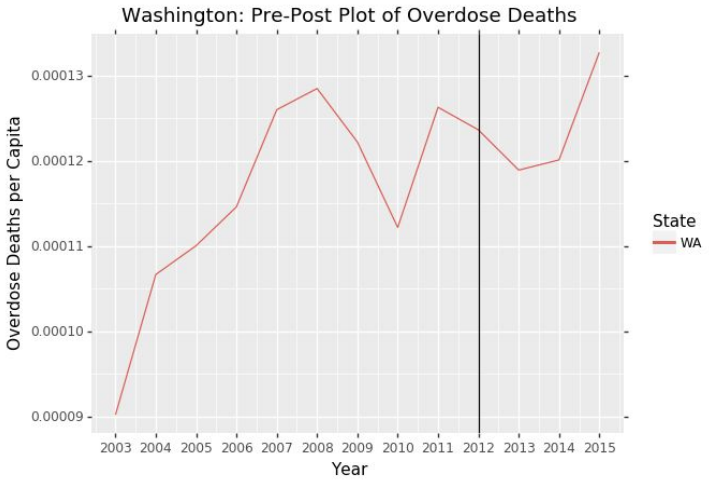
We proceed with the same process of a pre-post analysis followed by a difference in difference analysis to examine the effects of opioid policies on overdose deaths in both Texas and Washington. In plotting the overdose deaths per capita in Texas before and after policy implementation in 2007, we can see that after policy implementation, overdose deaths temporarily decreased then increased again. Relative to other non-policy states with similar trends in overdose deaths before 2007, the trend in overdose deaths per capita in Texas remains approximately the same. While the overdose deaths per capita increase significantly in some states, it remains about the same after policy implementation in Texas. Based on these plots, it is inconclusive as to whether the opioid policy in Texas decreased overdose deaths per capita, but it is possible that it may have prevented a sharper increase, as seen in other states.

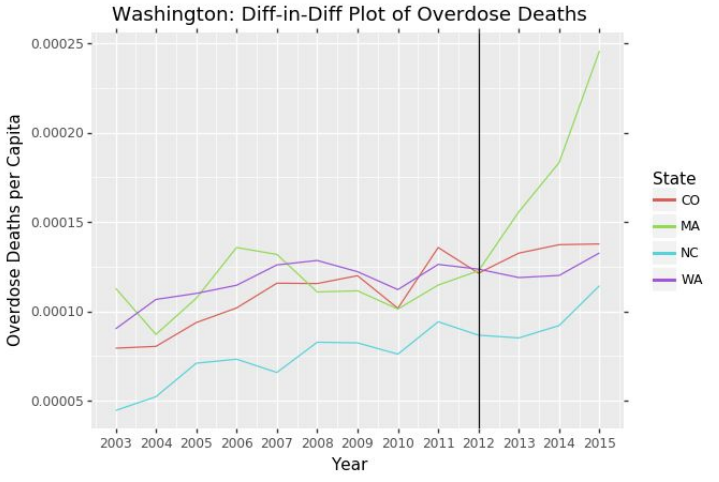




Washington: Overdose Deaths

Again, we aim to determine if the opioid policy implemented in Washington in 2012 decreased overdose deaths per capita. Our pre-post plot (left) shows that there may have been a slight decrease followed by an increase. Comparing the overdose deaths per capita in Washington to non-policy states, it appears that the trend in overdose deaths in Washington remains approximately the same after policy implementation. However, because the slope remains relatively flat after 2012, it is possible that the opioid policy prevented further increases in opioid deaths, as seen in other non-policy states





All in all, the opioid policy implemented in Florida seems to be the most effective at decreasing overdose deaths and opioid shipments per capita. Not only did the actual value of overdose deaths and opioid shipments per capita decrease, but also relative to non-policy states, the trend in Florida in both deaths and shipments per capita decreased. However, changes are less evident in overdose deaths in Texas and Washington. In both states, the overdose deaths per capita remain about the same after policy implementation. It is possible that the trends in overdose deaths per capita do not increase in Texas and Washington as much as in non-policy states.

One major limitation of this analysis is that overdose data is only available through 2015. This is particularly relevant for the analysis on Washington, as the opioid policy was implemented in 2012 in Washington, leaving only a few years to analyze after policy implementation. Second, this analysis method does not really account for other external changes or factors that could influence overdose deaths or opioid shipments. While comparing the change in policy states to the change in non-policy states somewhat helps account for this, it is possible that there are still remaining confounding factors not captured by these analysis plots.

Despite these limitations, this method of analysis is beneficial as it clearly shows trends before and after policy implementation. Using graphics rather than numerical explanations helps make results more interpretable and meaningful. Second, visualizing trends over time is clear and easy through these plots, as we can examine how the overdose deaths and opioid shipments change over time. Lastly, this method is very flexible and generalizable, as new states can easily be added or changed for comparison.

REPORT 1
FOR NICK

- The motivation for the project
- The motivation for the research design being used
- Details of the data used and how different datasets have been related to one another
- Summary statistics for your data
- Your analysis
- Your interpretation of that analysis.

REPORT 2
FOR POLICY MAKER

- The motivation for the project,
- Overview of the data being used,
- Your analysis (presented for a non-statistician),
- Your interpretation of that analysis (again, laying out strengths and weaknesses without using statistical jargon).