Final report Team 8 –

Opioid shipments Florida and opioid deaths Florida, Texas, Washington

Part I – For Nick

https://www.overleaf.com/project/6189ad3e5ad679da0f6e2c46

1. Motivation for the project

   The United States has had an opioid addiction crisis since the early 2000s, initially caused by an over-prescription and over-use of painkillers and then perpetuated by illegal drug use of other opioids such as fentanyl.
   Policymakers in many states have tried to address these problems by implementing new legislation that tries to limit who can prescribe opioids and by trying to control the flow of opioids from other countries.
   This project is motivated by the need to evaluate the effects of such policies, so other states may follow successful examples and forego trying to implement policies that have proven unsuccessful in other states.

2. Motivation for the research design being used

   Our team is using the data from three states (Florida, Texas and Washington) for our analysis. All three states have data from before they implemented policy changes (in Texas in 2007, Florida in 2010, and Washington in 2012) aimed to reduce the impact of opioid addiction and data from several years after the policy took effect.
   We will focus on the data for opioid overdose related deaths for all three states and opioid shipment data for the state of Florida, as the other states do not have enough data available for analysis of drug shipments over the whole timeframe.

   Each of our target states will be compared to three different states that will function as controls. They were chosen:

   1. For their known statistics on drug overdose mortality rate in 2005: https://www.cdc.gov/nchs/pressroom/sosmap/drug_poisoning_mortality/drug_poisoning.htm

      Florida had an age-adjusted overdose death rate of 13.5.
      Arizona (rate: 14.1), Colorado (rate: 12.7), and Louisiana (rate: 14.7) all had similar age-adjusted mortality rates as Florida and are in relative geographical proximity.

      Texas had an age-adjusted overdose death rate of 8.5.
      Kansas (rate: 9.1), Mississippi (rate: 8.8), and Wisconsin (rate: 9.3) all had similar age-adjusted mortality rates as Florida and are in relative geographical proximity.

      Washington had an age-adjusted overdose death rate of 13.

Arizona (rate: 14.1), Colorado (rate: 12.7), and Oklahoma (rate: 13.8), all had similar age-adjusted mortality rates as Florida and are in relative geographical proximity.

We aimed to include at least one state with an age-adjusted opioid mortality rate above the target state and at least one state with a mortality rate below the target state.

2. For the fact that they did not implement legislation to limit opioid prescription until after our observation period had ended (2014): https://ballotpedia.org/Opioid_prescription_limits_and_policies_by_state

   Arizona implemented new policy on October 24, 2016,
   Colorado implemented new policy on August 1, 2017,
   Kansas has not implemented any policy changes thus far,
   Louisiana implemented new policy on June 12, 2017
   Mississippi has not implemented any policy changes thus far,
   Oklahoma implemented new policy on May 2, 2018
   Wisconsin has not implemented any policy changes thus far.

3. Details of the data used and how different datasets have been related to one another

Original dataset overdose deaths:
The Washington Post sifted through nearly 500 million transactions from 2006 through 2014 that are detailed in the Drug Enforcement Administration's (DEA) database and analyzed shipments of oxycodone and hydrocodone pills, which account for three-quarters of the total opioid pill shipments to pharmacies. The Post is making this data available at the county and state levels in order to help the public understand the impact of years of prescription pill shipments on their communities. The entire data is a huge file in .tsv format that is more than 80 GB containing 43 variables.

Issues related to data cleaning:
For a dataset this big, there are two ways of dealing with it: 1) Use the chunking technique in python to read in the data, creating a pandas object, then operate the data in a loop; 2) separate the data by each state, operate data on the states that we need, then concatenate them back together. Both methods were tried, however for the sake of completeness of the data, we decided to use the second method.

Variables that we care about:
- "BUYER_STATE": State of entity receiving shipments from reporter.
- "BUYER_COUNTY": County of entity receiving shipments from reporter.
- "TRANSACTION_DATE": Date shipment occurred

- "MME_Conversion_Factor": Morphine Milligram Equivalent, or how the specific drug compares to a morphine equivalent.
- "CALC_BASE_WT_IN_GM": DEA added field indicating the total active weight of the drug in the transaction, in grams.

For Florida, as well as the control states Arizona, Colorado and Louisiana, we first subset the data based on the variables we need: 1) the buyer's state and county, 2) the date for the shipment. In addition, we need a variable to represent the quantity of the opioid shipment. This variable can be calculated by using Morphine Milligram Equivalent (MME) multiplied by the total weight of the drug. Thus, we keep these two variables too.
Next, the validity of the variables needed to be checked. Wherever there were missing variables, they were checked before dropping to ensure useful information was not mistakenly discarded.
The TRANSACTION_DATE was not in the format that we wanted. So it was converted to to the python date variable and the year for each transaction was extracted from that.

Finally, the data frame was grouped by county and year level (identical to our overdose death data and population data). The quantity of the opioid shipment was calculated, naming the result "MME", and the data was subset for the last time using variables that we wanted to keep for merging. The merge was achieved via a function concatenating the data sets together and merging them to the death-rate-population data.

Additional dataset for overdose deaths:
Since our final plot's metrics are calculated per capita, we need another dataset that includes information about population for each county in each state. We downloaded this dataset from:
https://urldefense.com/v3/__http://Census.gov__;!!OToaGQ!6efKOCd1I6x8GrQkrOtL9p43O7hmImrdAbUPGypskBI4AfSKO-lQoLG6cJTu3jPAfj7tMQ$, and it contains intercensal estimates of population.

To be more specific, each dataset contains 10 years of data for each county, and the "county_name" column also includes its state name. In order to merge the population dataset with the overdose death one, a little string manipulation needed to be performed on the "county_name" column so that it could match the primary key from the overdose death dataset.
After merging, the overdose death dataset will contain the "population" for each observation, so that we can easily calculate overdose death per capita.

Issues related to data cleaning:
For merging the overdose death dataset, the first problem we encountered was that each year's data was store in different files. Luckily, since all files have similar file names, a simple for-loop with year as the variable could solve this problem. After loading the data, we first performed a basic data validity check for null or abnormal values. Then,

while checking for missing values, we noticed that the number of unique counties in the dataset does not match the actual county number. The difference was caused by the fact that there was no overdose death reported in several counties for that year. Finally, for this dataset, we selected the “County” column as out primary key, “Year”, “Drug/Alcohol Induced Cause”, and “Death” for future use.

The data from the official US Census website in the range from 2000 to 2019 was split into two 10-year time periods, and the data for each state were stored in separate files. After manually downloading each target state’s data, we found out that each file contained several documentation rows and columns that were not of interest to us, like income summary. We first thought that we could manually modify these files by deleting certain parts of the data, but it was not reasonable to repeat the same process for over 20 files. So, we wrote some automated scripts to modify the data format in these files and to only leave county-year observation. Another problem we encountered was that the dataset from 2000 to 2009 was stored in the xls format, so in our automated scripts, we had to have two functions for both xls and xlsx format.

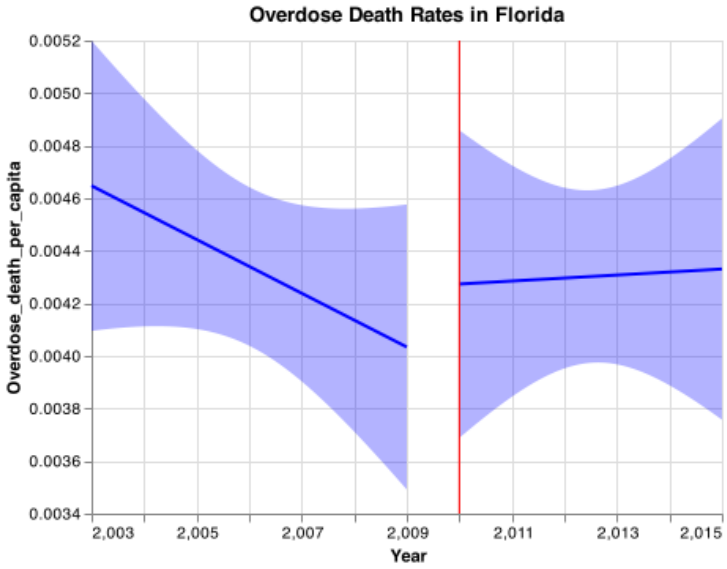
Shipment data:
The shipment data was part of the original dataset as described above. Merging was challenging due to variable names being different between datasets.

4. Summary statistics

Will need to fill in for final report.

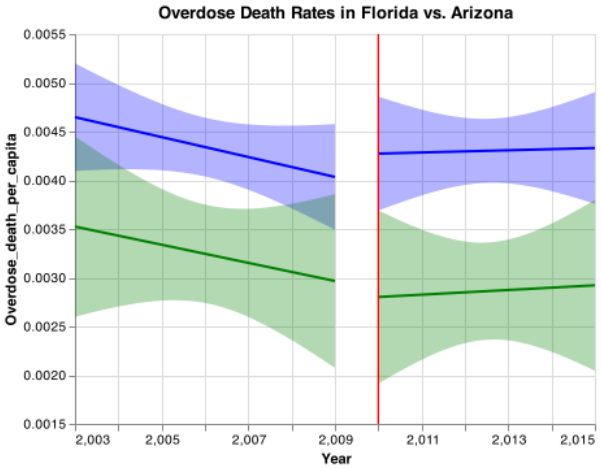
5. Analysis

We plotted the relationship of opioid overdose deaths per capita for the years before and after the policy change in Florida (2010). The state of interest is always depicted in blue/purple, the comparison states in different colors:

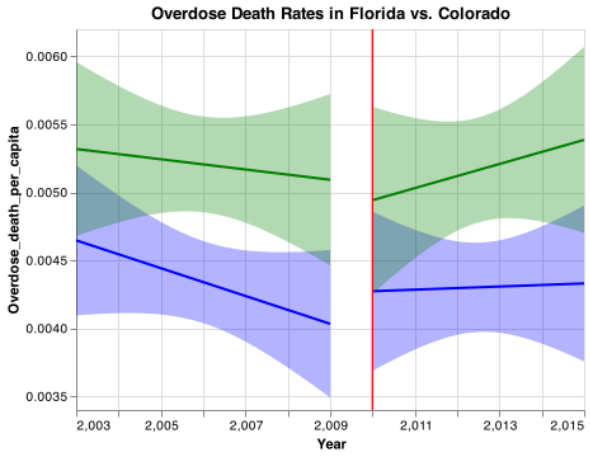


As comparisons we plotted the same relationships for the three control states we picked for Florida.

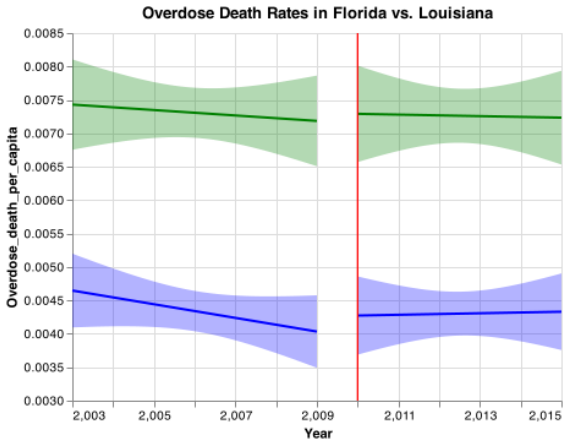
Arizona:



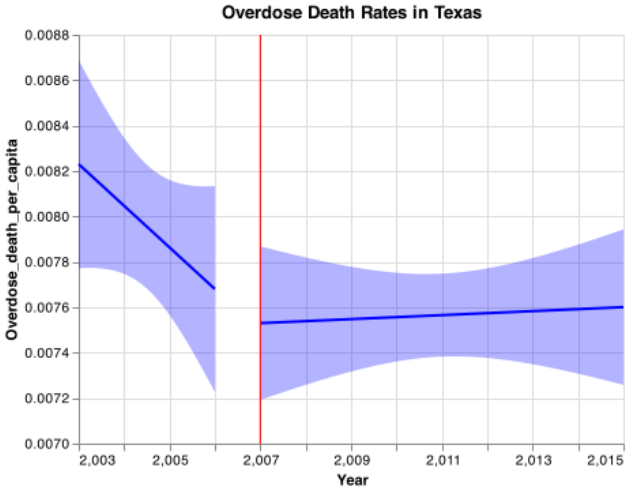
Colorado:



Louisiana:

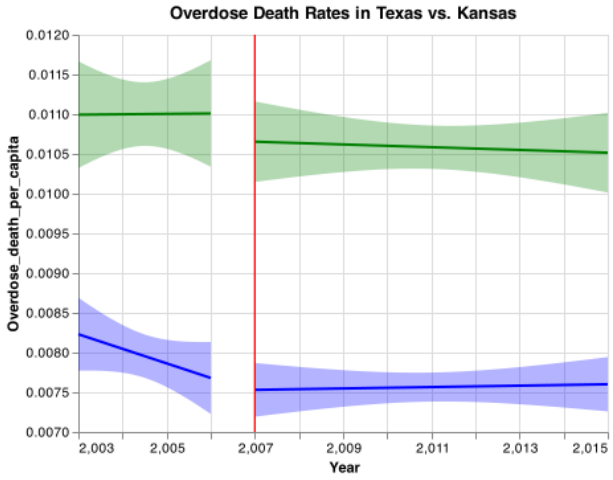


We plotted the relationship of opioid overdose deaths per capita for the years before and after the policy change in Texas:

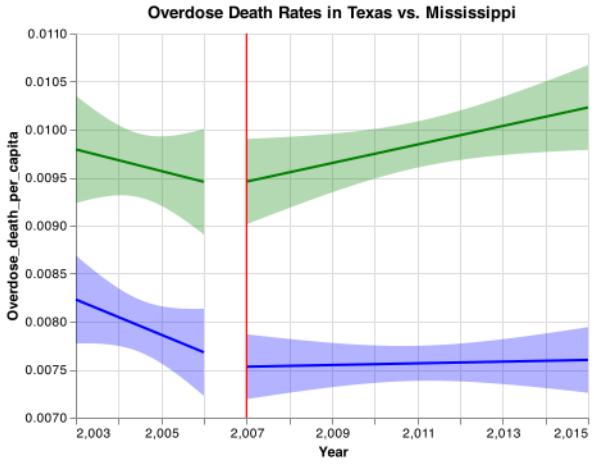


As comparisons we plotted the same relationships for the three control states we picked for Texas.

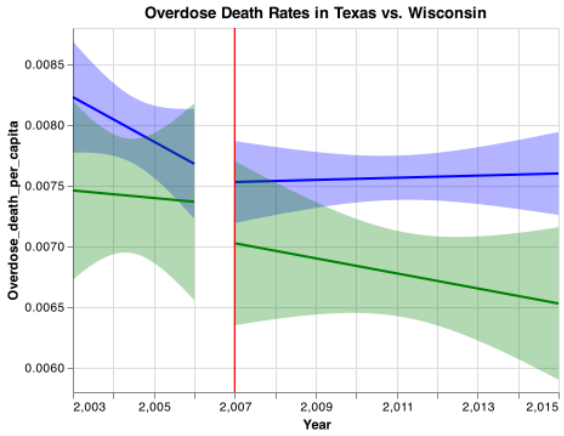
Kansas:



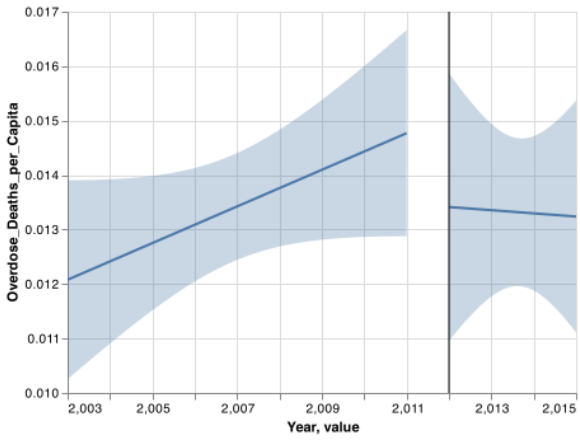
Mississippi:



Wisconsin:

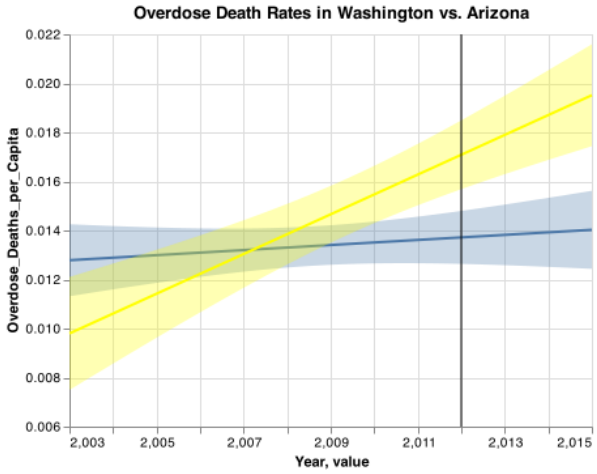


We plotted the relationship of opioid overdose deaths per capita for the years before and after the policy change in Washington:

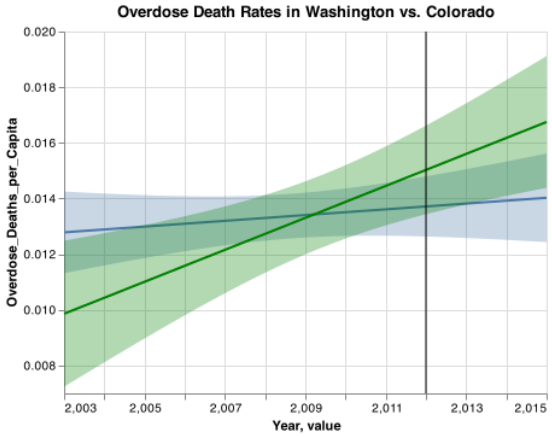


As comparisons we plotted the same relationships for the three control states we picked for Washington.

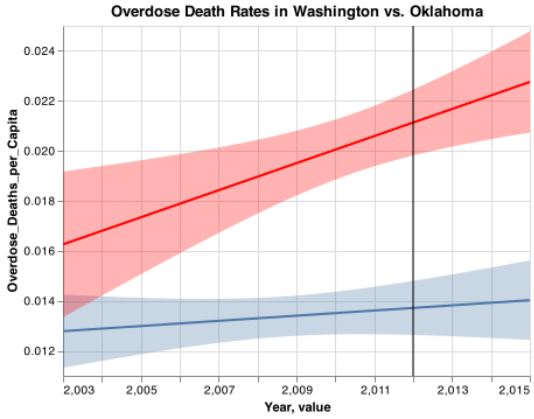
Arizona:



Colorado:



Oklahoma:



We plotted the relationship of opioid shipments per capita for the years before and after the policy change in Florida:

6. Interpretation of analysis

Florida:

For the state of Florida, the plots show a decline in opioid-related overdose deaths between 2003 and 2009, before the policy change in 2010. After the policy change the overdose related death rate seems to stabilize on a slightly higher level than the rate of 2009 with a very slight increase toward 2015 (last available data).
A very similar trend is observed for Arizona over the same time period, with a decline before the policy change in Florida and a leveling out from 2011 with a slight increase of death rates towards the end of the observation period in 2015. Overall, the death rates for Florida were higher than those for Arizona both before and after the policy change.

For the comparison state of Colorado, the decline in opioid related death rates was not as clear before 2010 and in the period of 2011-2015, where Florida and Arizona saw a leveling out of death rates, a clear increase in opioid related deaths was observed in Colorado. Overall, the death rates for Florida were lower than those for Colorado both before and after the policy change.

The death rates in Louisiana were on a very slight decline between 2003 and 2009 as well and stayed even more level than those of Florida and Arizona between 2011 and 2015. Overall, the death rates for Florida were much lower than those for Louisiana both before and after the policy change.

Texas:

For the state of Texas, the plots show a decline in opioid-related overdose deaths between 2003 and 2006, before the policy change in 2007. After the policy change the overdose related death rate seems to stabilize on a slightly lower level than the rate of 2006 with a very slight increase toward 2015 (last available data).

Kansas had different trends over the same time period, with no decline before the policy change in Texas and a very slight decline from 2007 until 2015. Overall, the death rates for Texas were lower than those for Kansas both before and after the policy change.

For the comparison state of Mississippi, the decline in opioid related death rates was similar before 2007 but in the period of 2007-2015, where Texas saw a leveling out of death rates, a clear increase in opioid related deaths was observed in Mississippi. Overall, the death rates for Texas were lower than those for Mississippi both before and after the policy change.

The death rates in Wisconsin were on a very slight decline between 2003 and 2006 as well and showed a clear decrease between 2007 and 2015. Overall, the death rates for Texas were slightly higher than those for Wisconsin both before and after the policy change.

Washington:

For the state of Washington, the plots show an increase in opioid-related overdose deaths between 2003 and 2011, before the policy change in 2012. After the policy change the overdose related death rate seems to stabilize on a slightly lower level than the rate of 2011 with a very slight increase toward 2015 (last available data).

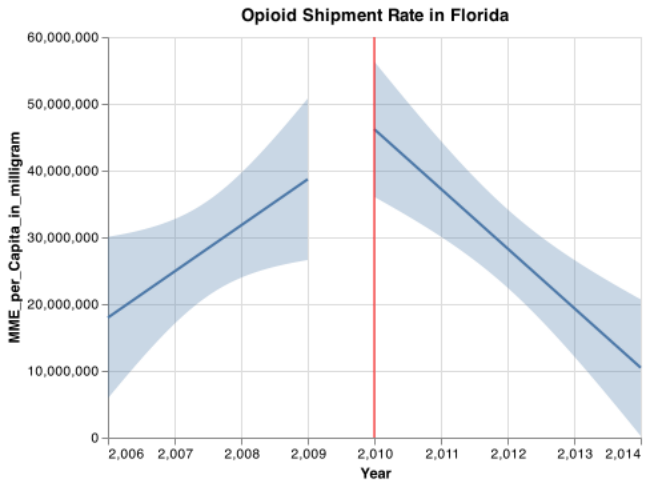
For Arizona over the same time period, there was a relatively steep increase in rate of overdose related deaths before the policy change in Washington and this increase continued after 2012. Overall, the death rates for Washington were higher than those for Arizona in the early 21st century but got surpassed between 2007 and 2008, and the rates for Washington were lower than for Arizona both before and after the policy change.

For the comparison state of Colorado, the trends were very similar to those in Arizona with an increase in opioid related deaths before and after the policy change in Washington and with opioid related death rates in Colorado surpassing those in Washington between 2009 and 2010.

The death rates in Oklahoma, the trends were very similar to those in Arizona and Colorado with an increase in opioid related deaths before and after the policy change in Washington and with opioid related death rates in Colorado higher than those in Washington throughout the whole time period of observation from 2003-2015.

Opioid Shipments:

Opioid shipments for the state of Florida were increasing in the years before the policy change and started decreasing after the policy change.



The response to policy changes related to opioid prescription practices in the states that were analyzed was relatively homogenous; all states saw a leveling out of opioid related death rates after they implemented their policy changes.

The trends for opioid related death rates were not as homogenous for the comparison states though, and recommendations for or against policy changes is difficult should not really be made based on this data alone.

Some of the comparison states saw steep increases in opioid related death rates (e.g. Colorado and Mississippi) but others saw a leveling-out or even decline in spite of the fact that they had made no policy changes to opioid prescription practices (e.g. Kansas and Wisconsin).

Part II – For Policymaker

1. Motivation for the project

The United States has had an opioid addiction crisis since the early 2000s, initially caused by an over-prescription and over-use of painkillers and then perpetuated by illegal drug use of other opioids such as fentanyl.

Many states have tried to address these problems by implementing new legislation that tries to limit who can prescribe opioids and by trying to control the flow of opioids from other countries.

This project is motivated by the need to evaluate the effects of such policies, so policymakers in other states may follow successful examples and forego trying to implement policies that have proven unsuccessful in other states.

2. Overview of the data being used

To analyze the effects of policy changes on opioid related deaths and opioid shipments, three states were evaluated. Florida implemented a policy change in 2010, Texas implemented a policy change in 2007 and Washington did so in 2012.

To control for other factors that may have influenced opioid related death rates, each of the states of interest was compared to three other states, with similar overdose deaths in 2005. These comparison states did not implement policy changes to curb opioid prescriptions or implemented them after 2015, which is when our observation data ends.

3. Analysis

To visualize the changes in opioid related death rates before and after the policy changes, plots were created to show the trends before and after the policy changes in each of the three states of interest and in their comparison states.

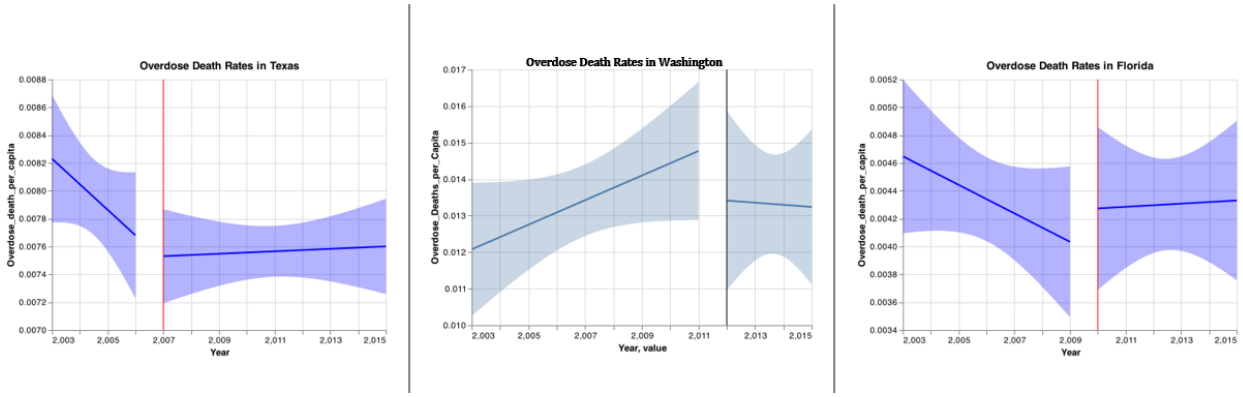


Figure 1: Overdose death rates in Texas, Washington, and Florida before and after their respective policy changes (marked by vertical red or black line), including confidence intervals.

For Florida and Texas we see a decline in opioid related death rates even before the policy changes, and we also see a clear leveling out of death rates after these states made policy changes regarding opioid prescription practices.

Some of the comparison states (Arizona and Louisiana) for Florida behaved in a similar fashion, even though they did not implement policy changes. The comparison state of Colorado saw a steep increase of opioid related death rates after Florida had made its policy change and seen a leveling out of death rates.

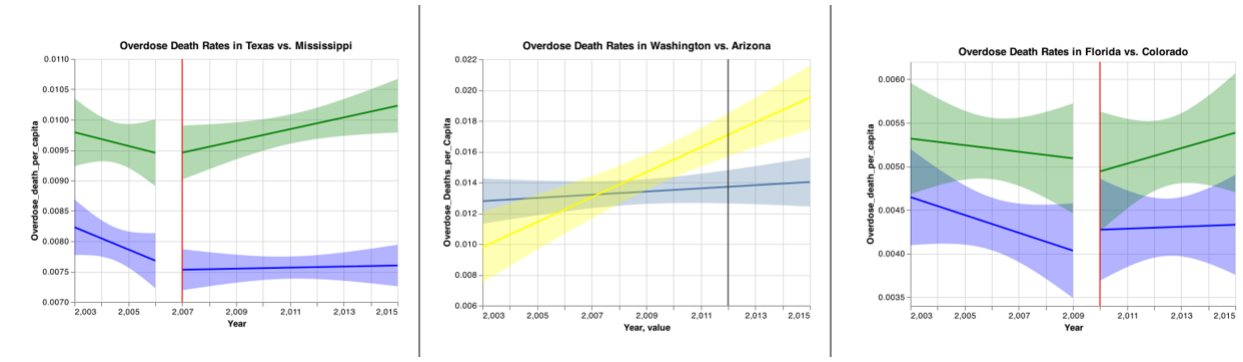


Figure 2: Overdose deaths in each of the target states compared to one of the comparison states that had an increase in overdose death rate after the target state implemented its policy change.

The comparison states for Texas did not behave in a similar fashion, before and after Texas implement its policy changes. The death rates for Kansas showed almost no change, even though no policy changes were implemented. The death rates for Mississippi showed a steep increase in death rates over the same time period in which Texas saw a leveling-out of opioid related deaths, while Wisconsin saw a clear decline in death rates over the same time period even though no policy changes were implemented.

The opioid shipments to Florida were increasing up to the time that the policy change was implemented and started decreasing immediately after the policy change:

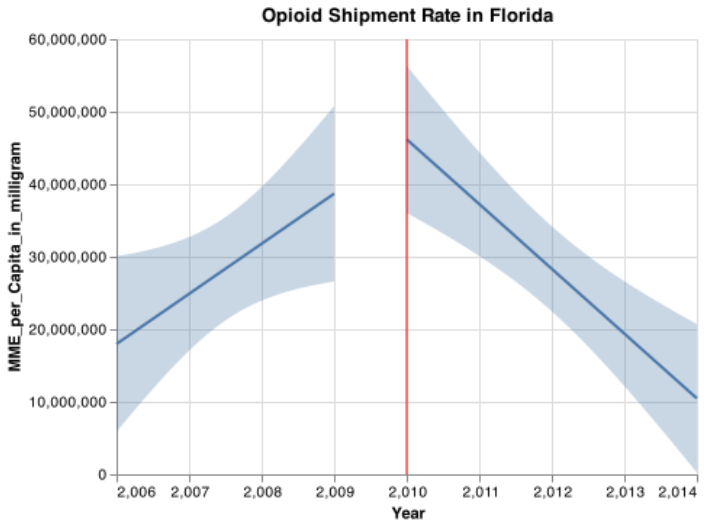


Figure 3: Opioid shipment data for Florida. Note the steep increase before the policy change in 2010 and the notable decrease after that policy change took effect.

4. Interpretation of that analysis

The response to policy changes related to opioid prescription practices in the states that were analyzed was relatively homogenous; all states saw a leveling out of opioid related death rates after they implemented their policy changes.

The trends for opioid related death rates were not as homogenous for the comparison states though, so making a clear recommendation for or against policy changes is difficult.

Some of the comparison states saw steep increases in opioid related death rates (e.g. Colorado and Mississippi) but others saw a leveling-out or even decline in spite of the fact that they had made no policy changes to opioid prescription practices (e.g. Kansas and Wisconsin).

The opioid shipment data is clear for the one state that was analyzed (Florida): the shipments were increasing before the policy change and immediately started decreasing after the policy change. Since there are no comparison states for this analysis, this might be a general trend for states bordering the Gulf of Mexico though, so no absolute conclusions can be drawn from this fact either.

When considering policy changes, it might be prudent to take into account other factors that may have influenced the opioid related death rates, such as changes to government funded assistance programs for the treatment of addiction, the expansion of Medicare or changing opioid production and distribution networks.