**Final report Team 8 –**

**Opioid shipments Florida and opioid deaths Florida, Texas, Washington**

**Part I – For Nick**

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, as well as within the US.

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.

1. ***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 on opioid overdose deaths 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 (up to 2014 or 2015).

We will focus on the data for opioid overdose related deaths for all three states and opioid shipment data for the states of Florida and Washington, while Texas does 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. We chose to include control states in our analysis to account for the possibility of policy changes on the federal level affecting our target states more than their internal policy changes. By pooling the data from the comparison states, we should be able to make more confident statements on how much of the differences before and after the state’s policy changes were caused by those policy changes, and not by other effects, that affected the whole of the US in the same timeframe.

The comparison states were chosen as follows:

First for their known statistics on drug overdose mortality rate in 2005, based on data from the Centers for Disease Control (CDC): <https://www.cdc.gov/nchs/pressroom/sosmap/drug_poisoning_mortality/drug_poisoning.htm>

Our target state **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, so they were chosen as comparisons.

Our target state **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, so they were chosen as comparisons.

Our target state **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, so they were chosen as comparisons.

For all target states, 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.

Second, they were chosen for the fact that they did not implement legislation to limit opioid prescription until after our observation period had ended (2014), based on data from Ballotpedia: <https://ballotpedia.org/Opioid_prescription_limits_and_policies_by_state>

We examined our pre-selected comparison states for if and when they implemented policy changes. None of them implemented policy changes within our observation period up until 2015:

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.

1. ***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 to help the public understand the impact of years of prescription pill shipments on their communities. The entire data is a very large 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 variable for transaction date was not in the format that we wanted. So, it was converted 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 needed another dataset that includes information about population for each county in each state. We downloaded this dataset from the Census.gov website: <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 associated 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 stored in different files. Luckily, since all files have similar file names, a simple for-loop with year as the variable solved 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 observations. 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 the opioid death and the shipment datasets.

1. ***Summary statistics***

*Will need to fill in for final report.*

1. ***Analysis***

We plotted the relationship of opioid overdose deaths per capita for the years before and after the policy change in Florida (2010).

Chart, line chart

Description automatically generated

Figure 1: The rate of opioid related overdose deaths in Florida was increasing steeply from the year 2000-2010, when the policy change was implemented, then started declining until 2015.

As comparisons we plotted the same relationships for the three pooled control states we picked for Florida, Arizona, Colorado, and Louisiana.

Chart, line chart

Description automatically generated

Figure 2: The opioid related overdose death rates in the pooled comparison states was developing in a similar fashion to the one in Florida before Florida’s policy change but continued to increase after 2010.

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

Chart, line chart

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Figure 3: The rate of opioid related overdose deaths in Texas was increasing steeply from the year 2000-2007, when the policy change was implemented, then started declining slightly until 2015.

As comparisons we plotted the same relationships for the three control states we picked for Texas, Kansas, Mississippi and Wisconsin.

Chart, line chart

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Figure 4: The opioid related overdose death rates in the pooled comparison states was developing in a similar fashion to the one in Texas before Texas’ policy change but continued to increase after 2007.

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

Chart, line chart

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Figure 5: The rate of opioid related overdose deaths in Washington was increasing steeply from the year 2000-2012, when the policy change was implemented, then started rising less steeply until 2015.

As comparisons we plotted the same relationships for the three control states we picked for Washington, Arizona, Colorado and Oklahoma.

Chart, line chart

Description automatically generated

Figure 6: The opioid related overdose death rates in the pooled comparison states was developing in a similar fashion to the one in Washington before Washington’s policy change but continued to increase after 2010.

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

Chart, line chart

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Figure 7: The rate of opioid shipments in Florida was increasing steeply from the year 2000-2010, when the policy change was implemented, then started declining slightly until 2015.

As comparisons we plotted the same relationships for the three pooled control states we picked for Florida, Arizona, Colorado, and Louisiana.

Chart, line chart

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Figure 8: Opioid shipments were increasing less steeply in the pooled comparison states than in Florida, but instead of declining, they leveled out between 2010 and 2015.

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

Chart, line chart

Description automatically generated

Figure 9: Opioid shipments to Washington were increasing between 2006 and 2012 with a leveling out after the policy change.

As comparisons we plotted the same relationships for the three pooled control states we picked for Florida, Arizona, Colorado, and Louisiana.

Chart, line chart

Description automatically generated

Figure 10: The opioid shipments in the control states were increasing more steeply in the pooled comparison states than in Washington until 2012, then started increasing less steeply after 2012, similar to the trend in Washington.

1. ***Interpretation of analysis***

*Overdose Deaths:*

All our target states Florida, Texas and Washington were seeing steep increases in opioid overdose related death rates before they implemented policy changes and so were all pooled comparison states. After their policy changes, both Florida and Texas saw a slow decrease in opioid related death rates, while Washington saw a continued, but slightly less rapid increase in opioid related death rates after implementing its policy change.

Florida and Texas have a similar relationship to their comparison states; while their opioid related death rates started declining after their respective policy changes were implemented, the death rates in their comparison states kept rising steeply.

Washington once again shows a slightly different trend, where its opioid overdose related death rate kept increasing at a lower level than before the policy change took effect and the same seems to have happened to the pooled comparison states.

This seems to generally show effectiveness of the policy changes in curbing opioid overdose related deaths in the states that implemented them.

*Opioid Shipments:*

Opioid shipments for the state of Florida were increasing in the years before the policy change and started decreasing steeply after the policy change. The increase in shipments for Florida’s control states was not as steep before 2010 and kept increasing at a relatively low rate between 2010 and 2015. While there was a less steep increase in shipments in Washington before the policy change, the shipments did not start declining after 2012 but they seemed to stabilize at a lower level. In the pooled comparison states for Washington, there was a marked decline in opioid shipment rates after 2012. There was a national trend for a leveling out in opioid prescriptions after two major papers raised awareness in the medical community1, 2 in 2009 and 2010 and there was a 13.1% decline in prescriptions nationally between 2012-20153, which may be what is reflected in the decline in shipments in Washington’s comparison states.

Florida had a very steep incline in opioid shipment rates before it changed its policies and then saw a clear decline, while its comparison states continued to see increasing shipment rates, which indicates that the policy change in Florida was successful in curbing opioid shipments. In Washington the data is not as clear as this, with shipment rates leveling out but not showing the clear decline that its pooled comparison states saw in the same timeframe. There may be factors at play in Washington that were not taken into account in our analysis but which set Washington apart from the three comparison states that we selected (e.g. migration within the US of people who were prescribed opioids in Washington instead of other states, a difference in population makeup (maybe more older people in Washington that require opioid prescriptions, moving a drug from a lower to a higher tier in the DEA schedule4).

*Limitations*

It is important to keep in mind that while analyzing the outcomes of policy changes on a state level is very relevant, it would also be helpful to do the same analyses on a national level, to be able to tease out more general versus more localized effects. There are many strategies that can be and have been adopted including raising awareness in the medical community over opioid prescriptions, which may affect opioid shipments to pharmacies more than a policy change might, there could be changes to drug enforcement policies or to opioid buyback programs5.

In addition, this data is solely focused on the USA and several of its states, but it might be relevant to take into account how illicit drug use might be fueled by changes in policies in Mexico, Middle- or South America.

**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.

1. ***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 (such as federal changes to opioid policies or DEA enforcement), 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.

1. ***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*). Washington also saw an increase of opioid overdose related deaths before a policy change was implemented in 2012 but no decrease afterwards, though the death rates did increase at a lower rate.

Chart, line chart

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

For Florida and Texas, we see an increase in opioid related death rates before the policy changes, and we also see a clear decrease of death rates after these states made policy changes regarding opioid prescription practices. At the same time, the opioid overdose related death rates continued to increase in the pooled comparison states for Florida and Texas (*Figure 2*). The comparison states for Washington showed a very similar trend to Washington after its policy change with a slower increase in overdose related death rates after 2012.

Chart, line chart

Description automatically generated

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

The opioid shipments to Florida and Washington were increasing up to the time that their respective policy changes were implemented and started decreasing immediately after the policy change in Florida while in Washington shipment rates leveled out after the policy change (*Figure 3*).

Chart, line chart

Description automatically generated

Figure 3: Opioid shipment data for Florida and Washington in the top row. Note the steep increase before the policy change in Florida in 2010 and the notable decrease after that policy change took effect, while there was no clear change in the comparison states (bottom left). For Washington the policy change seems to have led to a leveling out of opioid shipments after its policy change in 2012. The comparison states for Washington saw a much steeper decline in opioid shipments in the same timeframe (bottom right).

1. ***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 decrease or slower increase of opioid related death rates after they implemented their policy changes.

At the same time, opioid related deaths in the pooled comparison states continued to increase at different rates, which would point to a good efficacy of the measurements implemented in Florida and Texas, and to a lesser degree in Washington.

The opioid shipment data is clear for both of the states where enough data was available (Florida and Washington): the shipments were increasing before the policy change and immediately started decreasing or leveling out after the policy change, which indicates good efficacy of the measures implemented.

Taking all of this into account, the policy changes in Florida and Texas seem to have had high success and may be worth emulating on a state or even federal level. The fact that the trends in Washington were not as clear may be due to the fact that their policy change was implemented later than in Florida and Texas, when national trends of opioid deaths and prescriptions (which are associated with shipments to pharmacies) were already declining.

When considering policy changes, it might be prudent to take into account other factors that may have influenced the opioid related death and shipment 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.

**References:**

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**3** Guy GP Jr., Zhang K, Bohm MK, et al. Vital Signs: Changes in Opioid Prescribing in the United States, 2006–2015. MMWR Morb Mortal Wkly Rep 2017;66:697–704. DOI: <http://dx.doi.org/10.15585/mmwr.mm6626a4>

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**5** Soelberg CD, Brown RE Jr, Du Vivier D, Meyer JE, Ramachandran BK. The US Opioid Crisis: Current Federal and State Legal Issues. Anesth Analg. 2017 Nov;125(5):1675-1681. doi: 10.1213/ANE.0000000000002403. PMID: 29049113.