Statistician report

NOVEMBER 12, 2020

HIGH TIME FOR BETTER DRUG LEGISLATION

ESTIMATING THE IMPACT OF OPIOID LEGISLATION IN WA, TX, AND FL

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Motivation for the project

Over the past two decades, prescription opioid addiction and overdose deaths, resulting from the increased prescription and abuse of opioids pain medication, has wreaked havoc on communities across the Unites States. These problems have become one of the most pressing health concerns in the country. To decrease the severity of the problem at hand, many states have begun implementing policies with the goal of restricting the flow of prescription opioids. The goal of this analysis is to estimate the effectiveness of three such policy interventions implemented in Florida, Texas, and Washington state. To assess the effectiveness of each policy, the per capita volume of prescription opioids imported, and the per capita volume of fatal drug overdoses will be examined using *Pre-Post Comparison* and *Difference-in-Difference* analyses.

Research Design

In 2010, Florida enacted policy that required registration of plain clinics that treat pain with controlled substances – like opioids. In addition, during the second half of the year, the state legislature prohibited physicians from dispensing schedule II or III drugs from their offices and activated regional strike forces to address the emergency. To measure the impact of this policy we will analyze annual trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Florida before and after 2010.

In 2007, the Texas Medical Board adopted regulations on treating pain with controlled substances that required thorough reviews of any applications for opioid prescriptions and required physicians to conduct periodic reviews of ongoing opioid treatments. To measure the impact of this policy we will analyze trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Texas before and after 2010. Since opioid shipment data only runs from 2006 to 2012, we will analyze Texas opioid shipment data by month.

In 2012, the Washington Department of Health adopted rules regulating the prescription of opioids for pain treatment, with the goal of reducing patient consumption of opioids. To measure the impact of policy intervention, we will analyze trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Washington before and after 2012. Since opioid shipment data only runs from 2006 through 2012, we will analyze Washington's opioid shipment data by month.

To implement *Difference-in-Difference comparison*, we chose control states (no policy change) that were similar in geographic location, political affiliation, or demographic composition to the state of interest. The rationale behind our decision stemmed from the belief that similar geographic location would account for the potential regional factors like seasonal depression in PNW or the work on non-profits that operate regionally, while similar political views would account for drug policies and addiction resources already in place before policy enactment (stricter regulations in more conservative states), and similar demographic composition would account for the cultural variation within a state (i.e., indigenous American communities have been especially hard hit by the opioid epidemic). All the control states we selected fulfilled at least two of the three criteria mentioned above. For Florida, we will look at Louisiana, Mississippi, and South Carolina; for Texas, we will look at Arkansas, New Mexico, and Kansas; for Washington, we will look at Colorado, Oregon, and California.

Drug Overdose Death

State	Policy Enactment Year	Timeframe	Level
Florida	2010	2007-2013	State-County-Year
Texas	2007	2004-2010	State-County-Year
Washington	2012	2009-2015	State-County-Year

Opioids Shipment

State	Policy Enactment Year	Timeframe	Level
Florida	2010	2008-2012	State-County-Year
Texas	2007	2006-2008	State-County-Month
Washington	2012	2010-2012	State-County-Month

Data and dataset relationships

Datasets used

The datasets used in the analysis are the DEA Pain Pill Database's opioid shipment data, the US Vital Statistics' mortality data, and the US Census Bureau's 2000-2010 and 2010-2019 population estimates (which we believe to be the most accurate prediction of state and county level population in non-census years). The true census population, not an estimate, was used for 2010.

Overdose death data preparation

The US Vital Statistics labels counties with overdose deaths less than 10 as 'Missing' or eliminate the entire county-year observation if there is no certain category of death reported in that county. To ensure all counties were present across the years we analyzed, we replaced missing values with a value between 0 and 10, proportional to the size of that county's population. For counties with extremely low population, like Loving County in Texas (<150), we also replace the overdose death proportion with the average of the rest of the counties in the same state. To calculate the volume of fatal drug overdoses, we collapsed four overdose death categories into one, aggregating the total number of deaths. Categories collapsed include drug poisonings (overdose), Unintentional (X40-X44), Undetermined (Y10-Y14), Suicide (X60-X64), and Homicide (X85). The combined counts of fatal overdoses were then used to calculate the per capita volume of overdose deaths for each unique state-year-county combination.

$$Overdose\_Prop = Overdose\_Deaths/Total\_Population$$

Two more columns were also added to our dataset, one contained an identifier for states in which policies were implemented and the other to denote whether the data in question was to be analyzed as pre- or post-policy implementation.

Opioid shipment and US Census dataset relationships

The data for opioid shipments involved merging a truncated version of the Pain Pill dataset with the Census estimates. The information extracted from the Pain Pill dataset was buyer *state, buyer*

county, year, and *weight imported*. Information extracted from the Census estimates was the *yearly population estimates by county*. The two data sets were related along *buyer state* → *state*, *buyer county* → *county*, and *year.* Once combined, the weight imported per capita was calculated for each unique state-year-county combination.

$$Weight_{shipped}perCapita = Weight_{shipped}/Population\_Estimate$$

Two more columns were also added to our dataset, one contained an identifier for states in which policies were implemented and the other to denote whether the data in question was to be analyzed as pre- or post-policy implementation. We also adjusted for the varying strength of different opioids by converting the weight into a milligrams of morphine equivalent (MME).

Preparing the US Census data for merging

To prepare the census data, the initial datasets were reshaped to allow each row to have a singular population value for each state, county, and year combination. When checking the integrity of 2000-2010, and 2010-2019 datasets prior to combining, it was uncovered that Shannon County (SD), Wade Hampton Census Area (AK), and Petersburg Census Area (AK) had undergone name changes that were not synced across both datasets. The new counties names are Oglala Lakota County, Kusilvak Census Area, and Petersburg Borough respectively. Bedford City, VA was also found to have been incorporated into Bedford County, VA which required the Bedford City, VA statistics to be merged with the Bedford County statistics in the 2000-2010 dataset. LaSalle Parish, LA had also been miscoded as La Salle Parish in the 2000-2010 dataset. Once cleaned, the two population datasets were joined.

Preparing the DEA Pain Pills dataset for merging

Data preparation for DEA Pain Pill dataset consisted of two steps. First was data loading and extraction - which was done in chunks due to the size of the dataset. Data corresponding to the three states of interest and the nine control states was extracted in this step. The shipping totals of the extracted data was also converted to a milligrams of morphine equivalent (MME). Second, the DEA Pain Pills dataset and the US Census data were merged on each state-county-year combination. Prior to merging, we resolved county name conflicts and filled missing MME values with 0. Two more columns were also added to our dataset, one contained an identifier for states in which policies were implemented and the other to denote whether the data in question was to be analyzed as pre- or post-policy implementation.

Summary statistics

Figures 1 and 2 below display the number of observations, mean, standard deviation, minimum values, maximum values, and quantiles for the finalized datasets used in the analysis.

	TotalOverdose	TotalDeath	POP	OverdoseProp
count	7851.000000	7851.000000	7.851000e+03	7851.000000
mean	46.803592	2934.133996	3.801631e+05	0.000156
std	70.357543	4250.075723	6.342815e+05	0.000108
min	10.000000	128.000000	1.027000e+04	0.000008
25%	13.000000	920.000000	1.036560e+05	0.000090
50%	22.000000	1596.000000	1.935270e+05	0.000128
75%	47.000000	3300.000000	4.296575e+05	0.000188
max	815.000000	62406.000000	1.008542e+07	0.001269

Figure 1. Summary statistics for the drug overdose data. The data includes observations from all states of interest and control states

	YEAR/MONTH	MME/CAP
count	55314.000000	55314.000000
mean	63232.583903	0.033877
std	77824.718162	0.077334
min	2006.000000	0.000000
25%	20081.000000	0.012500
50%	20105.000000	0.020600
75%	20129.000000	0.031300
max	201212.000000	2.279100

Figure 2. Summary statistics for the opioid shipment dataset. YEAR/MONTH contains the 5-6digit year and month label [YYYYM(M)]. MME/CAP represents the opioid shipment volume in a milligrams of morphine equivalent (MME) per capita.

Analysis

Florida

The chosen control states for Florida are Louisiana, Mississippi, and South Carolina. Like Florida, these states are in the eastern portion of the Sun Belt (Southeastern United States) and share the same political party affiliations to the Republican party. Hence, the three control states fulfill the geographic location and political view similarity criteria mentioned in the *Research Design* section.

Opioid Shipment

The pre-post analysis of Florida opioid shipments, displayed in *Figure 3,* shows that the per capita volume of opioids imported increases annually before the policy change. After policy implementation in 2010, the volume of opioids imported begins decreasing annually. Though it does not necessarily indicate the effectiveness of the new policy, the stark reduction in the volume of opioids shipment does imply that the 2010 policy is correlated with substantial changes in the per capita volume of Florida's prescription opioid shipments.

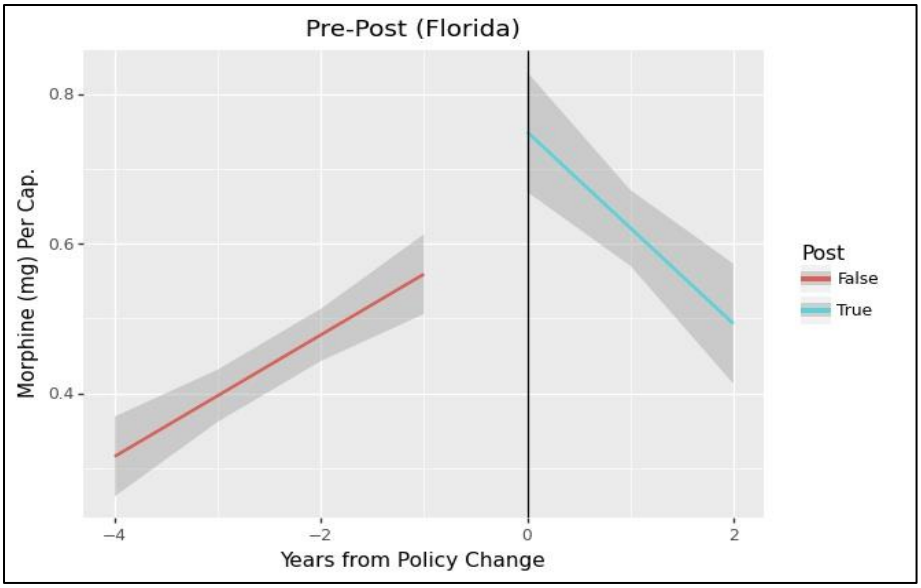

Figure 3. Pre-post graph for opioid shipments in Florida. Policy change (2010) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and decreasing after.

To account for potential national or regional changes in these metrics, the second analysis uses a difference-in-difference methodology to compare the annual per capita volume of opioids imported in Florida before and after policy implementation to that of the control states (Louisiana, South Carolina, and Mississippi). The graph, shown in *Figure 4*, shows that prior to Florida's policy implementation in 2010, Florida and its control states exhibit a similar upward annual trend in the volume of opioids imported. However, only Florida exhibits a decreasing annual trend of the volume of opioids imported after 2010. Thus, we can conclude the enactment of the opioid regulation most likely did play a role in reducing the overall per capita volume of opioids imported in Florida, even when controlling for the political, geographic and demographic factors shared by the control states.

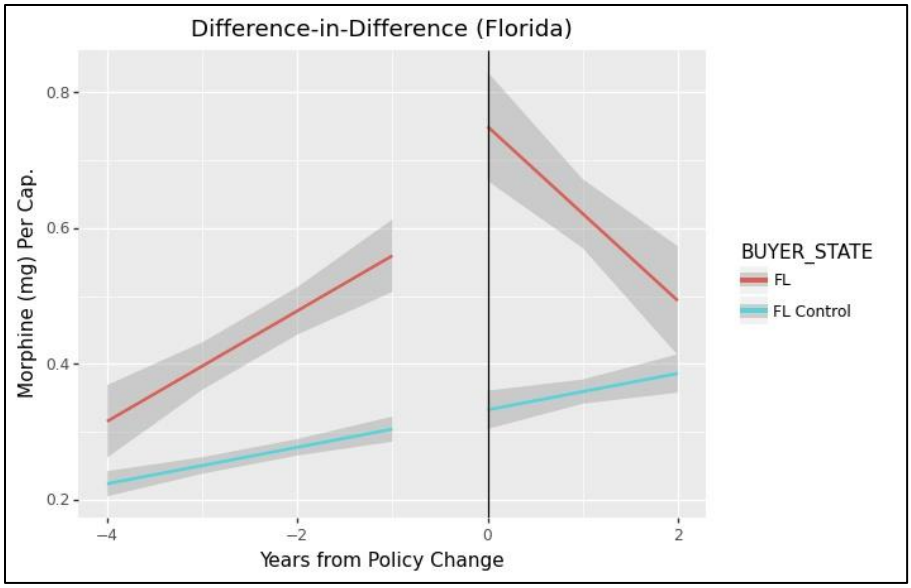

Figure 4. Difference-in-difference graph for opioid shipments in Florida vs control (LA, SC, MS). Policy change (2010) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. After policy implementation, the trend for FL shipment is reversed, while the trend remains the same for control states. Variation in standard errors is due to the difference in the number of state-county-year observations in each group.

Overdose Death

The pre-post analysis of Florida overdose deaths, shown in *Figure 5,* shows that the per capita volume of fatal overdoses was decreasing annually before policy change. After policy change, Florida continues to exhibit a downward trend in total overdose deaths per capita. It should be noted that the volume does appear to be decreasing at a slightly faster rate after policy implementation. Although the result does not necessarily indicate the effectiveness of the new policy due to other factors, like a crackdown on illegal opioids in the region, or the changes in the chemical makeup illegal opioids (i.e. less fentanyl laced heroin), the accelerated decrease in the per capita volume in fatal drug overdoses does imply – albeit mildly – that there is a slight improvement in Florida's per capita volume of fatal overdoses after the enactment of regulatory changes in 2010.

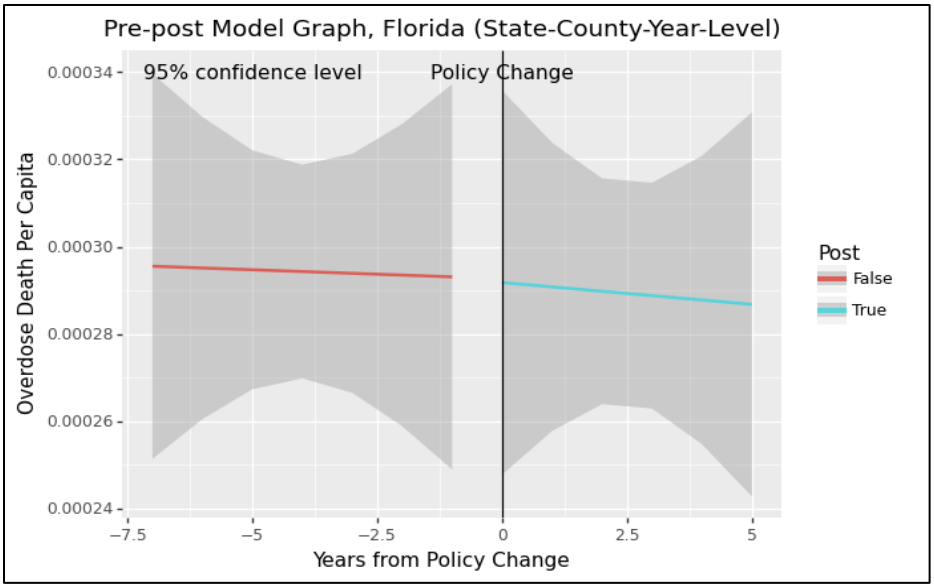

Figure 5. Pre-post graph for overdose death in Florida. Policy change (2010) is denoted by the vertical line. The plot shows overdose death decreasing before the policy change and continuing to decrease at a slightly increased rate after.

To account for potential national or regional trends that may have impacted overdose deaths in Florida, the second analysis uses a difference-in-difference methodology to compare the annual overdose deaths per capita in Florida before and after policy implementation to that of the control states, Louisiana, South Carolina, and Mississippi. The graph in *Figure 6* shows that prior to Florida's policy implementation in 2010, the per capita volume of fatal drug overdoses was trending downward in Florida (albeit very slightly) and trending upward in the control states. While the trend for control states stays the same after 2010, Florida's per capita volume of fatal drug overdoses decreases at a faster pace after policy changed. Even though the causal relationship between policy change and overdose deaths is not prominent in FL (exhibits downward trend both before and after policy change), the accelerated decrease in the per capita volume in fatal drug overdoses does indicate that the enactment of regulatory changes in 2010 may have a positive impact on reducing overdose deaths after controlling for the political, geographic and demographic factors shared by the control states.

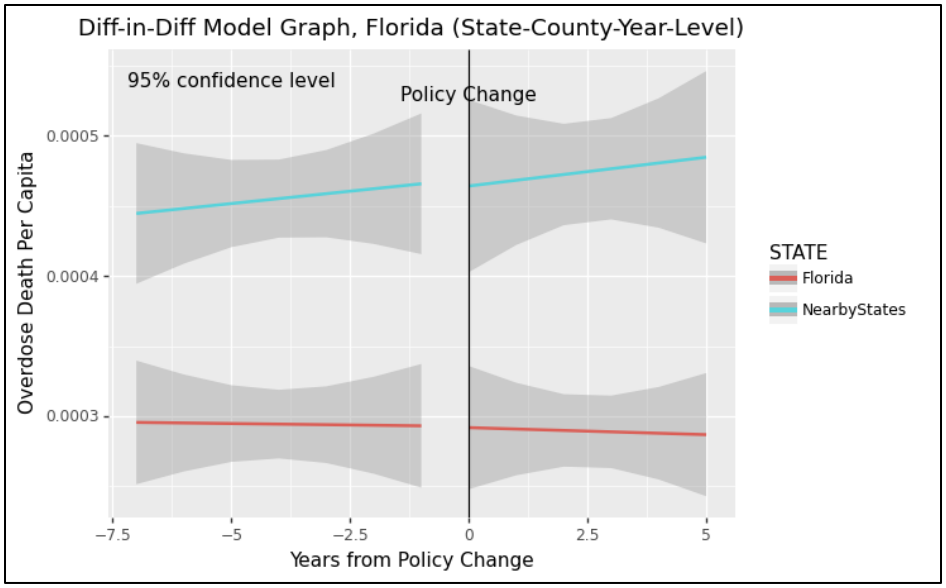

Figure 6. Difference-in-difference graph for overdose death in Florida vs control (LA, SC, MS). Policy change (2010) is denoted by the vertical line. Prior to Florida's policy implementation in 2010, per capita volume of fatal drug overdoses trends down in Florida (albeit very slightly) and trends up in the control states. After 2010 the control continues to increase unchanged while Florida's negative trend become slightly more significant.

Texas

The chosen control states for Texas are Arkansas, New Mexico, and Kansas. New Mexico, while different in political views, is very similar to Texas in terms of geography and demographic composition as both states are in central southern United States and located at the US-Mexico border. Arkansas and Kansas both share the strong conservative political views Texas has. Like Texas, the population of both states also is of majority evangelical, Caucasians. Hence, the three control states fulfill the geographic location and political view similarity criteria mentioned in the *Research Design* section.

Opioid Shipment

The pre-post analysis of Texas opioid shipments in *Figure 7* shows that the per capita volume of opioids imported increased every month prior to the policy change. After the policy implementation in 2007, the per capita volume of opioids imported continues to increase at a similar rate. Moreover, a spike in the volume of opioids imported can be observed in the first month of 2007. Though these phenomena do not necessarily indicate the policy itself is ineffective in reducing Texas' per capita opioid shipment volume, the consistent upward trends before and after the policy change does imply that the policy change does not help reducing the per capita volume of opioids imported and that it potentially lead to a short-term spike in opioid imports.

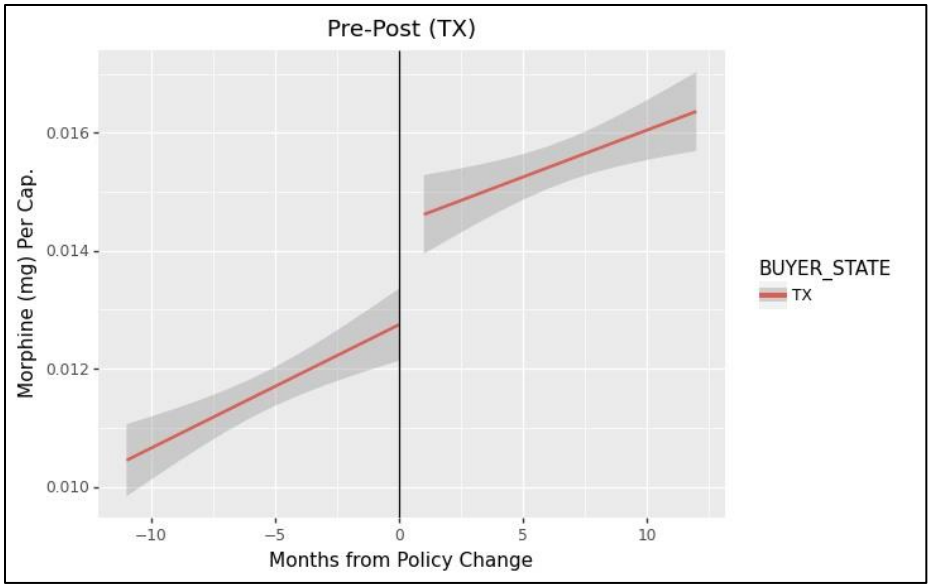

Figure 7. Pre-post graph for opioid shipments in Texas. Policy change (2007) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and continuing to increase after.

To account for potential national or regional changes in these metrics, the second analysis uses difference-in-difference methodology to compare the annual per capita volume of opioids imported in Texas before and after policy implementation to that of the control states (New Mexico, Kansas, and Arkansas). The graph, shown in *Figure 8*, shows that prior to Texas' policy implementation in 2007, both Texas and its control states show annual increase in per capita volumes of opioids imported. While there does appear to be the slightest rate decrease in Texas after the 2007 policy change, after controlling for the political, geographic, and demographic factors the two contexts follow nearly identical trends which does not imply an effective policy.

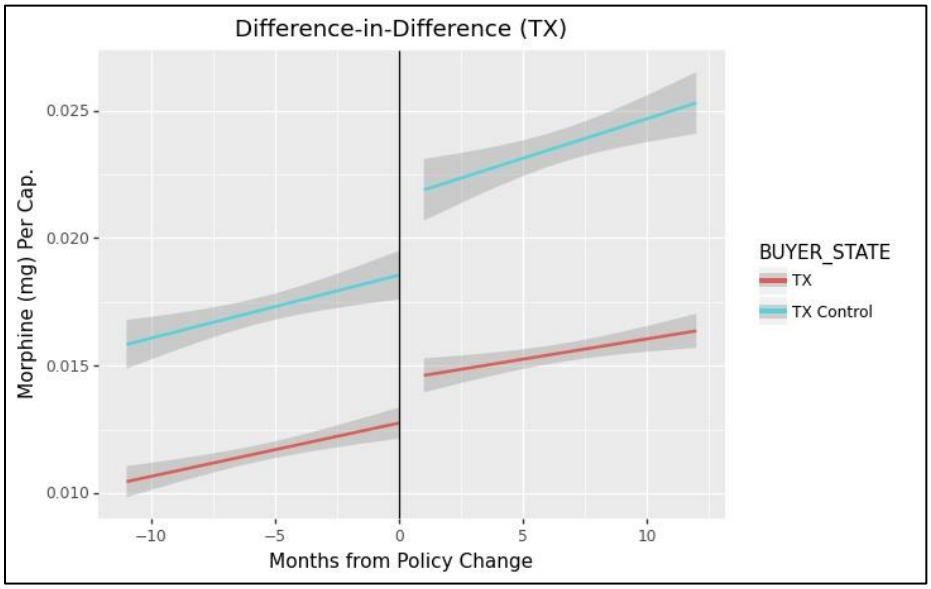

Figure 8. Difference-in-difference graph for opioid shipments in Texas vs control (NM, AR, KS). Policy change (2007) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. After policy FL shipment

sees the trend reverse while in the control states the opioid volume continues to increase.

Overdose Death

The pre-post analysis of Texas overdose deaths, shown in *Figure 9,* shows the per capita volume of fatal overdoses decreasing slowly in the years leading up to the policy change. After policy change, the trend stays the same with overdose deaths per capita continuing to decrease annually. The rate of decrease does appear to have increased. Although the result does not necessarily indicate the effectiveness of the new policy due to other factors like a crackdown on illegal opioids in the region, or the change in chemical makeup of illegal opioids (i.e. less fentanyl laced heroin), the accelerated decrease in overdose deaths does imply there is a slight improvement in Texas' per capita volume of fatal overdoses after the enactment of regulatory changes in 2007.

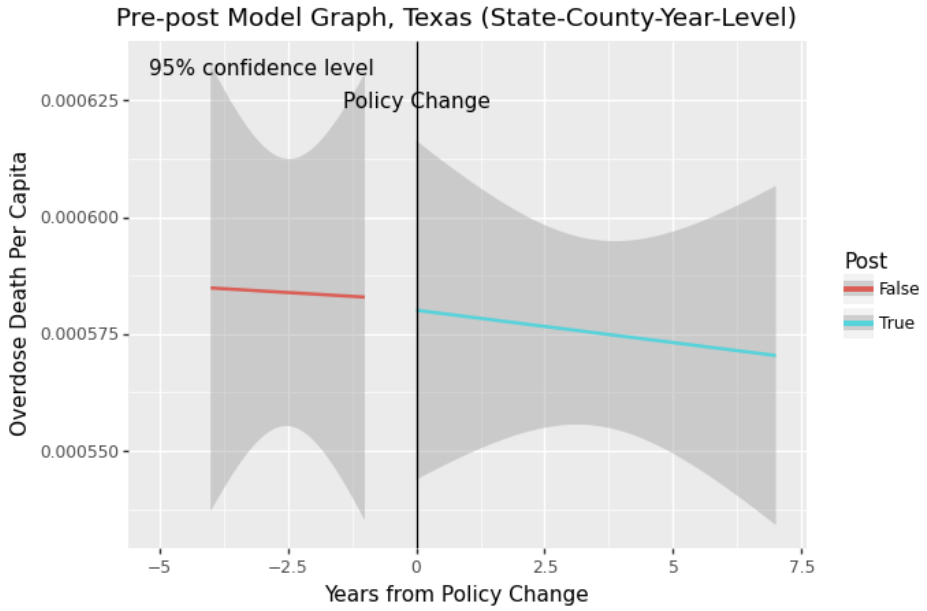

Figure 9 Pre-post graph for overdose death in Florida. Policy change (2007) is denoted by the vertical line. The plot shows overdose death decreasing before and after the policy change.

To account for potential in national or regional changes in overdose deaths, the second analysis uses a difference-in-difference methodology to compare annual overdose deaths per capita in Texas before and after policy implementation to that of its control states (Arkansas, Kansas, and New Mexico). The graph in *Figure 10* shows that prior to Texas' policy implementation in 2007, Texas and other control states display opposite trends in overdose death per capita (downward trend for Texas and upward trend for control states). Such difference in trend remains unchanged after the policy change. Thus, we can conclude that the enactment of regulatory changes in 2007 makes little impact on overdose deaths after controlling for the political, geographic, and demographic factors shared by the control states.

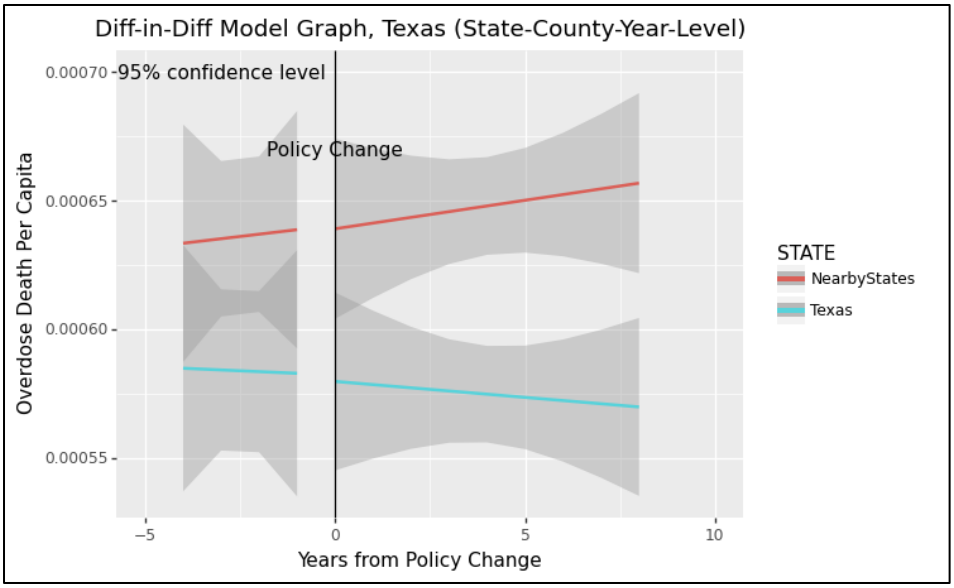

Figure 9. Difference-in-difference graph for overdose death in Texas vs control (NM, AR, KS). Policy change (2007) is denoted by the vertical line. Overdose death decreases in Texas and increases in control states before the policy change. After the policy, the trend remains and the gap grows larger.

Washington

The chosen control states for Washington are Colorado, Oregon, and California. These three states shared the same progressive political views and attitudes towards drugs and drug regulation (among the first states to legalize recreational marijuana). In addition, like Washington, these three states are geographically located in the Western region of USA. Thus, the three control states fulfill the geographic location and political view similarity criteria mentioned in the *Research Design* section.

Opioid Shipment

The pre-post analysis of Washington opioid shipments in *Figure 11* shows that the per capita volume of opioids imported increases every month leading up to the policy change. After the policy implementation in 2012, the per capita volume of opioids imported continues to increase, just at a slightly lower rate. There also appears to have been a steep drop in volume imported in the first month of 2012. Note that while the upward trend does not necessarily indicate that the policy itself is ineffective in reducing Washington's per capita opioid shipment volume, nor the initial drop-off indicate short term effectiveness, the trends to imply that the enactment of regulatory changes in 2012 may have a small impact on reducing total opioids shipment and should be further explored.

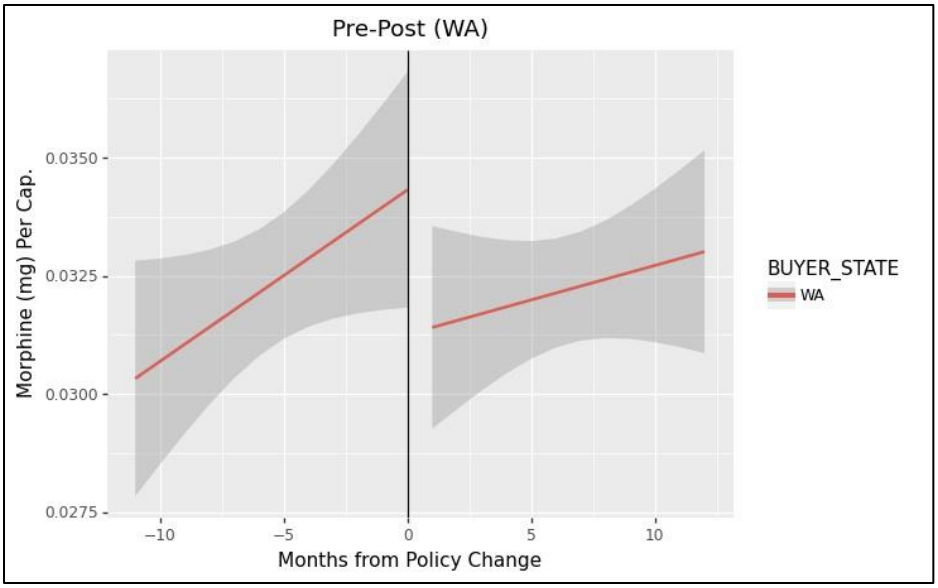

Figure 10. Pre-post graph for opioid shipments in Washington. Policy change (2012) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and continuing to increase after - at a lower rate. There does appear to be a decrease in shipment volume that occurred in the year of the policy implementation.

To account for potential national or regional changes in these metrics, the second analysis uses a difference-in-difference methodology to compare the annual per capita volume of opioids imported in Washington before and after policy implementation to that of the control states, California, Oregon, and Colorado. The graph displayed in *Figure 12* shows that prior to Washington's policy implementation in 2012, Washington and its control states exhibit a similar upward monthly trend in the volume of opioids shipment. Likewise, after 2012 the volume of opioids shipment continues to steadily increase in both Washington and its control states. For both Washington and control states, the monthly rate of increase does appear to decrease after the January 2012. Since Washington and the control states exhibit a similar trend post policy change, there might be potential national or regional factors (e.g. If US Customs blocked opioid importation) contributing to the decelerate increase. It should also be noted that there is a sharp decrease in per capita opioid volume shipped for Washington in January 2012, while the control states experienced a spike in per capita opioid volume shipped in January 12. Therefore, we can conclude that when comparing Washington to control states, the 2012 opioid regulation appears to result in a short-term decrease in the per capita opioid volume imported while the overall trend remains relatively unchanged.

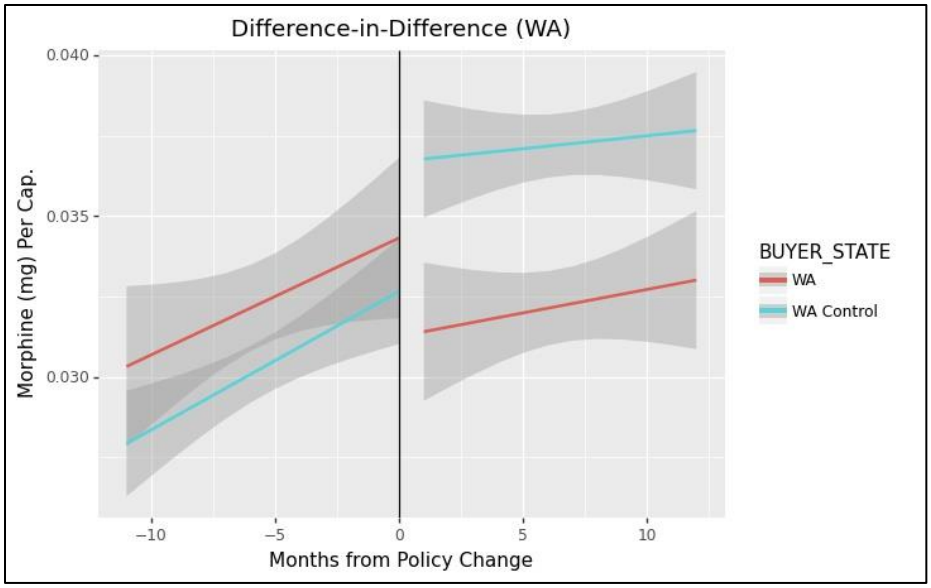

Figure 11. Difference-in-difference graph for opioid shipments in Washington vs control (CA, OR, CO). Policy change (2012) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. The rate of increase decreases after 2012 in both groups. Imported volume in 2012 shows a sharp drop-off for WA and a spike in the control states.

Overdose Death

The pre-post analysis of Washington's overdose deaths, shown in *Figure 13,* shows that the per capita volume of fatal overdoses follows a slightly downward trend leading up to the policy change. After the policy change, we see the per capita volume of fatal overdoses plateau. These results alone do not necessarily indicate the ineffectiveness of the new policy since other factors like policing differences, or changes in the chemical makeup said illegal opioids (i.e. fentanyl laced heroin) could have affected the analysis. However, Washington's opioid regulation does not appear to be correlated with any significant change in per capita opioid overdose deaths. The 95% confidence interval for the pre-post plot is wide, indicating the statistical results generated from these graphs may not be significant. One potential factor contributing to the large standard error might be resulting from the possible non-linear relationship between overdose death and year. The width of the confidence intervals also casts doubt on the idea that the Washington policy resulted in an increase in fatal overdoses because the error is quite significant compared to the slope.

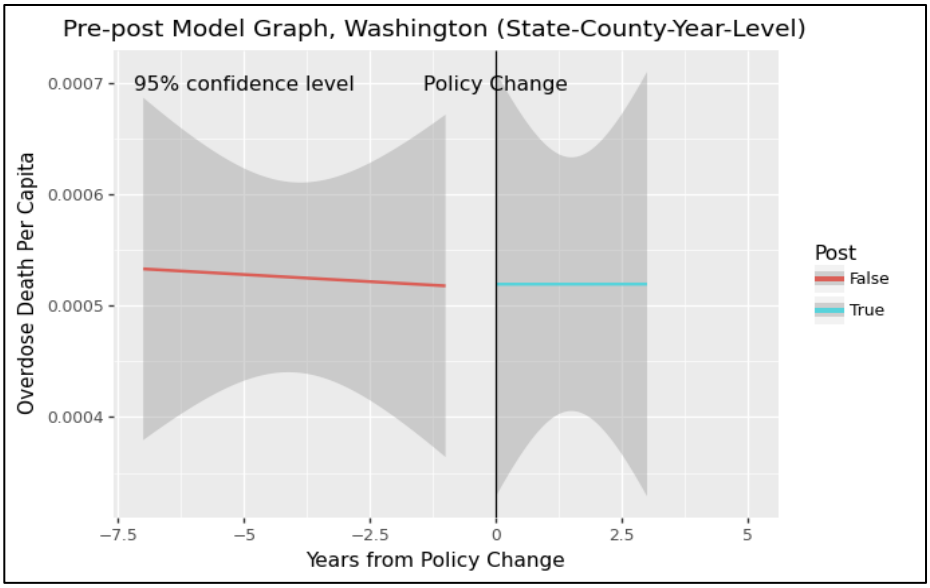

Figure 12. Pre-post graph for overdose death in Washington. Policy change (2012) is denoted by the vertical line. The plot shows overdose death decreasing before the policy change. After the policy change the per capita volume of opioid deaths appears to plateau.

To account for potential national or regional trends in overdose deaths unrelated to the 2012 policy, the second analysis uses difference-in-difference methodology to compare the annual overdose deaths per capita in Washington before and after policy implementation to that of the control states, California, Colorado, and Oregon. The graph in *Figure 14* shows that prior to Washington's policy implementation in 2012, the per capita volume of fatal drug overdoses was trending downward in Washington and trending upwards in other control states. However, while the trend for control states remains upward after 2012, Washington's per capita volume of fatal drug overdoses starts to flatten after policy changed. Again, we are unable to make any definitive conclusion on whether the policy change had any sort of significant effect on the per capita volume of fatal drug overdoses given the large standard error (likely due to the limited sample size post policy change).

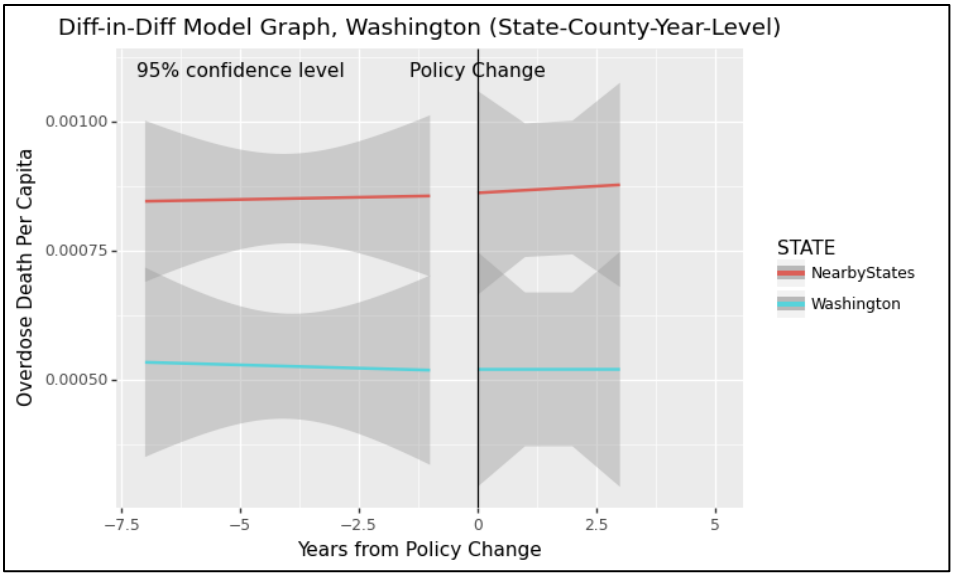

Figure 13. Difference-in-difference graph for overdose death in Washington vs control (CA, OR, CO). Policy change (2012) is denoted by the vertical line. Per capita volume of fata overdoses was trending up in the control states and down in Washington in the years leading up to the policy change. After the policy, the trend in Washington appears to plateau while in the control states it appears to continue increasing at a slightly accelerated rate.

Interpretation

In Florida, the 2010 policy effectively decreases the per capita volume of prescription opioids imported in Florida. *Figure 3* displays how the growth in opioids imported continues to increase in the control states while completely reversing in Florida. Overdose deaths, however, sees no change in its annual trends after the policy implementation. In summary, the 2010 policy in Florida does have a significant impact on opioid shipments but has very little effect on overdose deaths.

In Texas, the 2007 policy seems to have little impact on reducing opioid shipments. However, it does not necessarily indicative of the policy being ineffective since there are only 24 months of data being reviewed for this analysis. Overdose deaths in Texas were decreasing before policy implementation and continue decreasing after. In the control states, per capita overdose fatalities were seen to increase over the same timeframe. In summary, the 2007 policy in Texas is not proven to be clearly effective in reducing the per capita volume of opioids imported or the per capita volume of fata overdoses in the state.

In Washington, the 2012 policy does have a significant impact on the per capita volume of opioids imported. Imported volume in Washington begins to decrease after policy implementation while increasing in the control states over the same time range. However, due to only being able to look at monthly shipment data over 2 years we lack sufficient data to make judgement on the regulations overall effect. In addition, overdose death seems to be unaffected by the policy as it the pre-regulation downward trend continues after policy implementation. Improve confidence in our findings it would we would need to explore data beyond the three years available at the time of this analysis

We presume that due to the notoriety surrounding the incredibly large volumes of opioid prescribed in Florida, the state's 2010 policy contains a series of mandatory regulations and physician requirements not seen in the other state's regulations. There is even a special task force established to deal with the Prescription Abuse. In contrast, the policies in Texas and Washington are one-time and there are no follow-up polices or institutions to oversee the implementation. Some of these guidelines are also merely recommendations that do not mandate physicians and medical institutions to comply. Thus, the differences in the results the policies yielded across the states are understandable and foreseeable.

In general, this analysis that the policies reviewed appears to be more effective in decreasing the volume of opioids imported, and less effective in reducing the volume of fatal overdoses. While there are likely many reasons as to why this is, some potential confounders include like mental well-being of drug addicts and the fact that restricting access to a drug doesn't the address the underlying addiction that influences both demand for opioids and overdose rates. Also important is that these policies only aimed to restricting the flow of prescription opioids. As a result, addicts might purchase and overdose on illegal opioids like heroin or fentanyl. This even has the potential to exacerbate the overdose problem as the unstandardized strength of illegal opioids is one of the causes for accidental overdoses.

Policymaker report

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Motivation for the project

Over the past two decades, prescription opioid addiction and overdose deaths, resulting from the increased prescription and abuse of opioids, has wreaked havoc on communities across the Unites States. These problems have become one of the most pressing health concerns in the country. To decrease the severity of the problem at hand, many states have begun implementing policies with the goal of restricting the flow of prescription opioids. The goal of this analysis is to estimate the effectiveness of three such policy interventions implemented in Florida, Texas, and Washington state.

Research Design

In 2010, Florida enacted policy that required registration of plain clinics that treat pain with controlled substances – like opioids. In addition, during the second half of the year, the state legislature prohibited physicians from dispensing schedule II or III drugs from their offices and activated regional strike forces to address the emergency. To measure the impact of this policy we will analyze annual trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Florida before and after 2010.

In 2007, the Texas Medical Board adopted regulations on treating pain with controlled substances that required thorough reviews of any applications for opioid prescriptions and required physicians to conduct periodic reviews of ongoing opioid treatments. To measure the impact of this policy we will analyze trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Texas before and after 2010. Since opioid shipment data only runs from 2006 to 2012, we will analyze Texas opioid shipment data by month.

In 2012, the Washington Department of Health adopted rules regulating the prescription of opioids for pain treatment, with the goal of reducing patient consumption of opioids. To measure the impact of policy intervention, we will analyze trends in the per capita volume of prescription opioids imported and the per capita volume of fatal drug overdoses in Washington before and after 2012. Since opioid shipment data only runs from 2006 through 2012, we will analyze Washington's opioid shipment data by month.

To account for potential national or regional trends on our observations, we will compare trends in the quantity of opioids imported and overdose deaths of our states of interest to a set of control states. The criteria for selecting the control states for comparison are similarities in geographic location, political affiliation, and/or demographic composition. For Florida, we will look at Louisiana, Mississippi, and South Carolina; for Texas, we will look at Arkansas, New Mexico, and Kansas; for Washington, we will look at Colorado, Oregon, and California.

Data

Datasets used

Datasets used in the analysis are the opioid shipment data from the DEA Pain Pill Database, mortality data from the US Vital Statistics record, and the 2000-2010 and 2010-2019 population estimates from the US Census Bureau. Actual census population, not an estimate, was used for 2010.

Overdose deaths

To account for the varying population sizes between states and counties leading to variation in the number of overdose deaths, the metric used for analysis is the total number of overdose deaths per capita for each county. In this original dataset overdose deaths are classified into four categories: Unintentional (X40-X44), Undetermined (Y10-Y14), Suicide (X60-X64), and Homicide (X85) related drug deaths. These categories are combined in this analysis.

Opioid shipment

To account for varying population sizes between states and counties leading to variation in the volume of opioids shipped, the indicator we use for analysis is the weight of opioids per capita imported into each county. In addition, to account for the variation in strengths of different opioid compounds, we converted all shipment weights to milligrams of morphine equivalent for easier comparison. As such, the unit of observation in the analysis of opioid shipments is in milligrams of morphine per capita for each county.

Analysis

Florida

The states like Florida, that meet the geographic, political, and/or demographic control selection criteria laid out in the research design are Louisiana, Mississippi, and South Carolina.

Opioid Shipment

Our first analysis of Florida opioid shipments shows that the per capita volume of opioids shipped increases every year up until the policy change. After the policy implementation in 2010, the volume of opioids shipped begins decreasing annually compared to the previous year. Though these phenomena do not necessarily indicate the effectiveness of the new policy, it does imply that the 2010 policy is correlated with the substantial changes in the per capita volume of Florida's prescription opioid shipments.

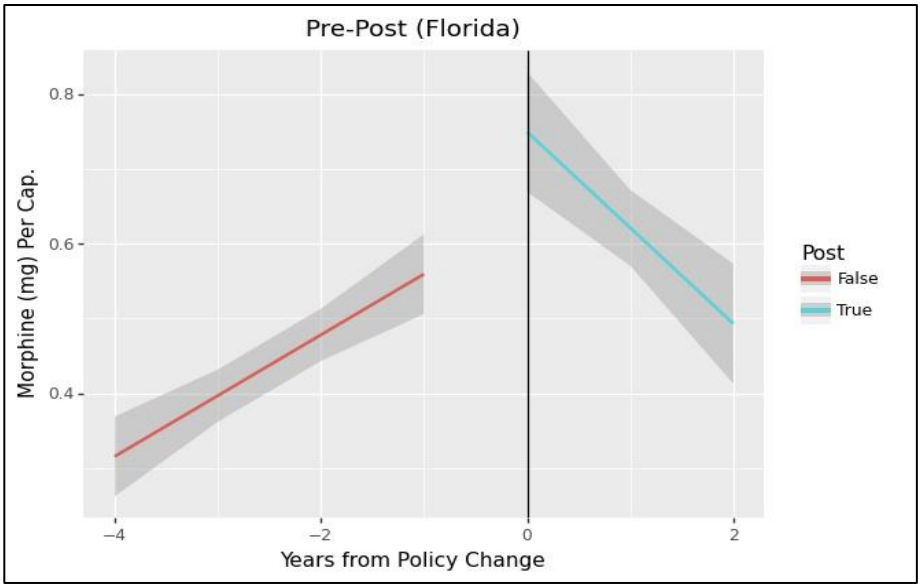

Figure 1. Pre-post graph for opioid shipments in Florida. Policy change (2010) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and decreasing after.

To account for potential national or regional trends, the second analysis compares the annual per capita volume of opioids shipped in Florida before and after policy implementation to set of control states – states like Florida but did not see policy changes implemented in the timeframe of analysis. The analysis shows that prior to Florida's policy implementation in 2010, Florida and its control states exhibit a similar upward annual trend in the volume of opioids shipped. However, only Florida exhibits a decreasing trend of the volume of opioids shipped after 2010. Therefore, we can conclude the enactment of the opioid regulation did indeed play a role in reducing the overall per capita volume of opioids shipped in Florida.

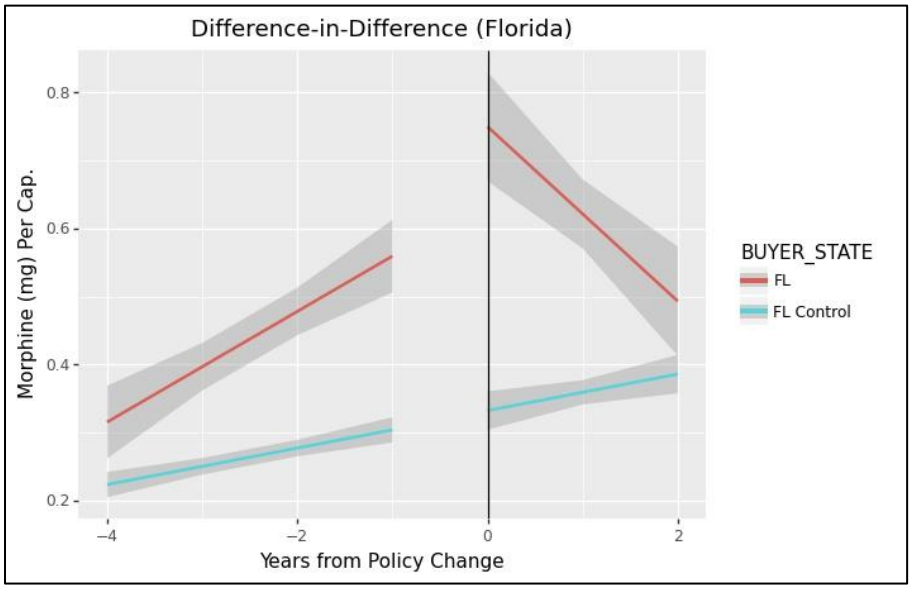

Figure 2. Difference-in-difference graph for opioid shipments in Florida vs control (LA, SC, MS). Policy change (2010) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. After policy FL shipment

sees the trend reverse while in the control states the opioid volume continues to increase.

Overdose Death

Our first analysis of Florida overdose deaths shows that drug overdose deaths decreases annually in the years leading up to the policy change. After the policy change, we see the trend generally remain the same, with the per capita volume of fatal overdoses continuing to decrease annually at a slightly increased rate. Although the result does not necessarily indicate the effectiveness of the new policy due to other factors like a crackdown on illegal opioids in the region, or the chemical makeup said illegal substances (i.e., less fentanyl laced heroin), the slightly accelerated decrease in overdose deaths does imply that there may be a slight improvement in Florida's per capita volume of fatal overdoses after the enactment of regulatory changes in 2010.

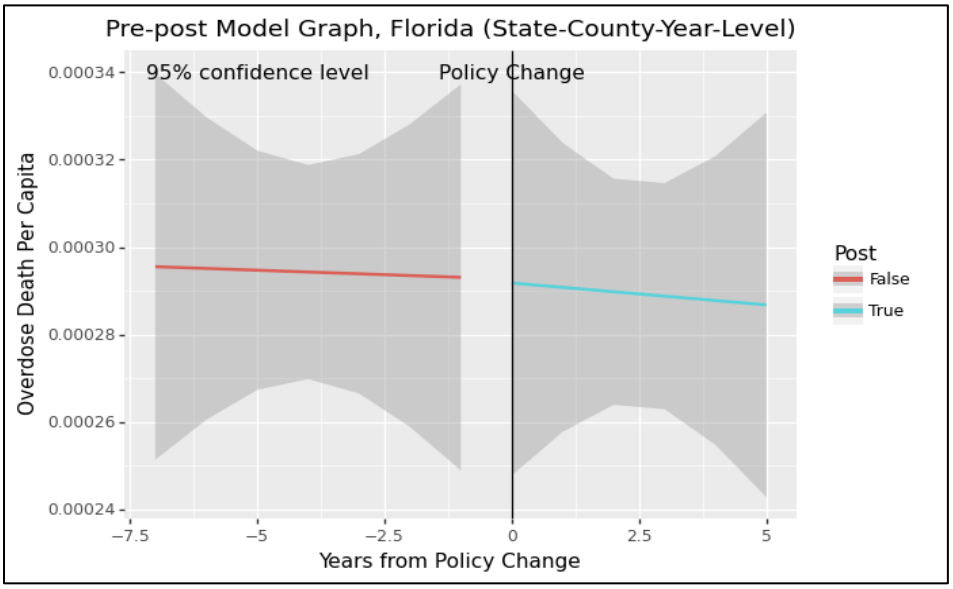

Figure 3. Pre-post graph for overdose death in Florida. Policy change (2010) is denoted by the vertical line. The plot shows overdose death increasing before the policy change and decreasing after.

To account for potential national or regional trends that may have impacted overdose deaths in Florida, the second analysis compare the annual overdose deaths per capita in Florida to the control states. The graph shows that prior to Florida's policy implementation in 2010, Florida and its control states trend in opposite directions in per capita volume of fatal overdoses – with the overdose deaths per capita increasing annually for the control states. Following implementation of the policy, this difference of trend remains, and the gap between Florida and its control states in terms of total overdose deaths continues to widen. Since the trends stay the same after 2010, we can conclude that the enactment of policy did not play a significant role in reducing the total drug overdose deaths in Florida.

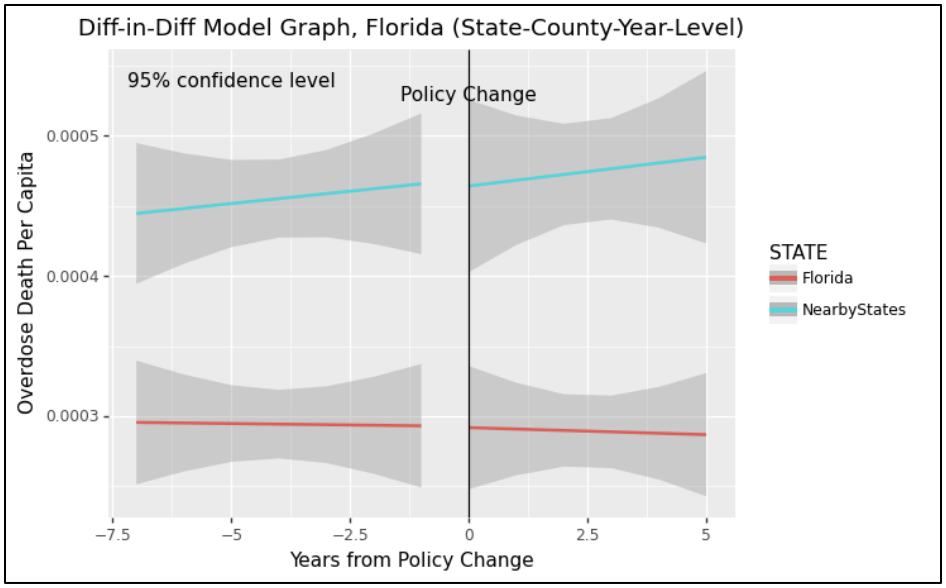

Figure 4. Difference-in-difference graph for overdose death in Florida vs control (LA, SC, MS). Policy change (2010) is denoted by the vertical line. Overdose death increases in both groups before the policy change. After the policy, such trend reversed in Florida while remained the same in the control states.

Texas

The states like Texas, that meet the geographic, political, and/or demographic control selection criteria laid out in the research design are Arkansas, New Mexico, and Kansas.

Opioid Shipment

Our first analysis of Texas opioid shipments shows that the per capita volume of opioids shipped increases every month prior to the policy change. After the policy implementation in 2007, the per capita volume of opioids shipped continues to increase at the similar rate. Moreover, a spike in the volume of opioids imported can be observed in the first month of 2007. Though these phenomena do not necessarily indicate the policy itself is ineffective in reducing Texas' per capita opioid shipment volume, the trend of the graph does imply that the enactment of policy did not reduce the per capita volume of opioids imported and potentially lead to a short-term spike in opioid shipments.

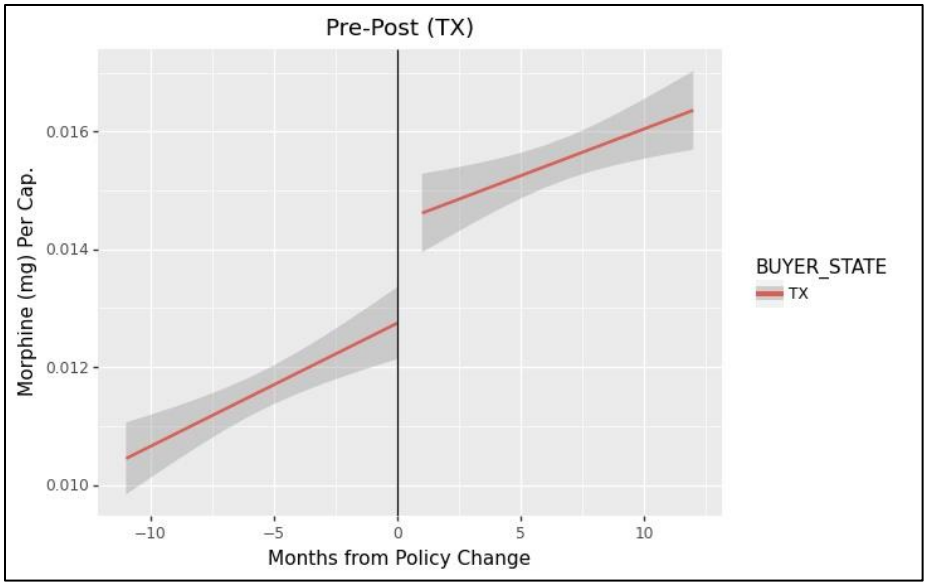

Figure 5. Pre-post graph for opioid shipments in Texas. Policy change (2007) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and continuing to increase after.

To account for potential national or regional trends, the second analysis compares the annual per capita volume of opioids shipped in Texas, before and after policy implementation, to the control states – states similar to Texas but did not see policy changes implemented in the timeframe of analysis. The graph shows that prior to Florida's policy implementation in 2007, Texas and its control states exhibit a similar upward monthly trend in the volume of opioids shipped. Likewise, after 2007 the volume continues to steadily increase in both Texas and its control states. It should be noted that Texas appears to show a slight decrease in the rate of increase per capita opioid volume shipped, while the control states show a slight increase in that shipment weight. As such, while we cannot conclude that the Texas policy served to reduce the volume of opioids shipped, there is evidence to conclude that the 2007 policy implementation may have served to slow Texas' increase in per capita volume of opioids shipped when compared to similar states.

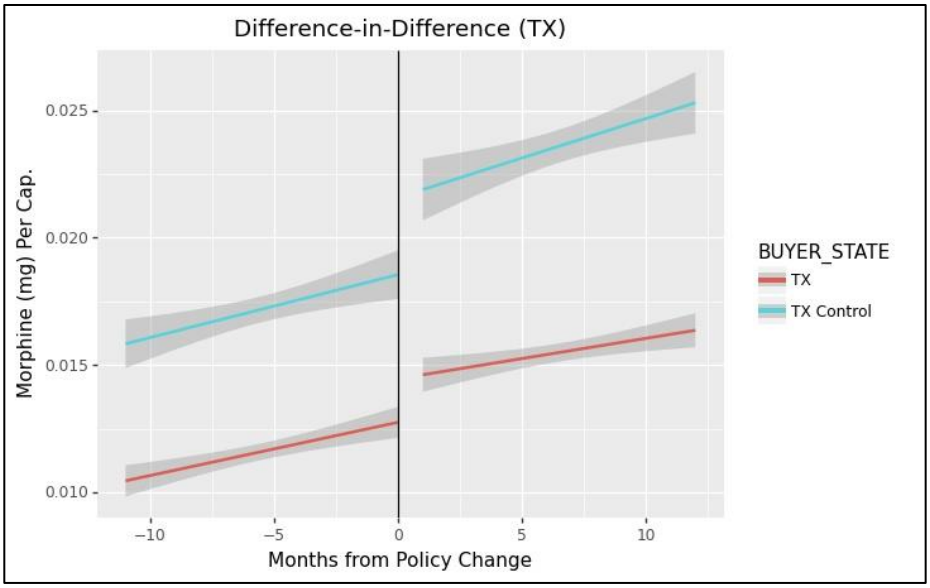

Figure 6. Difference-in-difference graph for opioid shipments in Texas vs control (NM, AR, KS). Policy change (2010) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. After policy FL shipment sees the trend reverse while in the control states the opioid volume continues to increase.

Overdose Death

Our first analysis of Texas overdose deaths shows that the per capita volume of fatal overdoses increases annually in the years leading up to the policy change. After the policy change, we see the trend reverse, with the total drug overdose deaths decreasing annually. Although the result does not necessarily indicate the effectiveness of the new policy due to other factors like a crackdown on illegal opioids in the region, or the chemical makeup said illegal substances (i.e., less fentanyl laced heroin), the decrease in total drug overdose deaths does imply that there is significant decrease in the total drug overdose deaths in Texas after the enactment of regulatory changes in 2007.

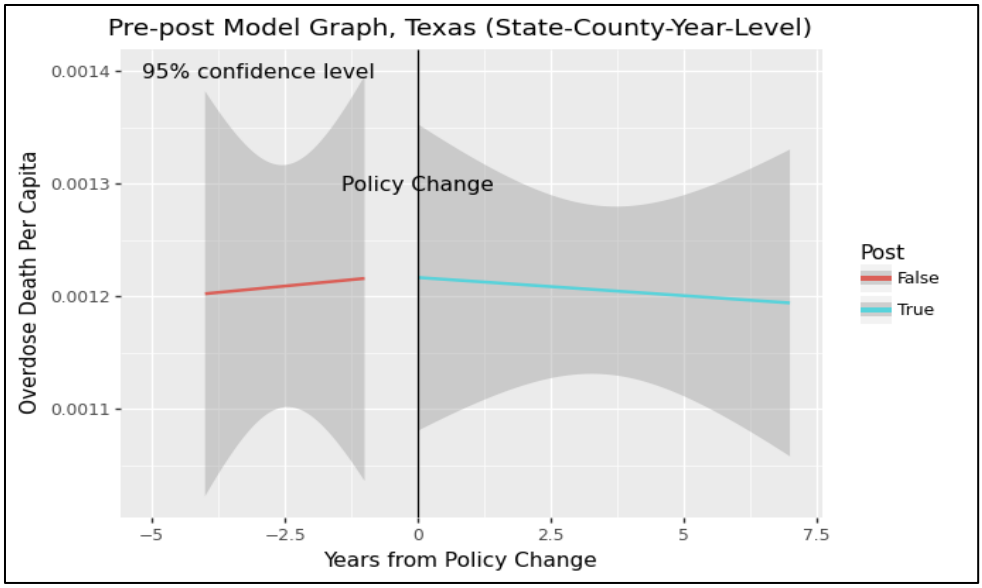

Figure 7. Pre-post graph for overdose death in Florida. Policy change (2007) is denoted by the vertical line. The plot shows overdose death increasing before the policy change and decreasing after.

To account for potential national or regional trends that may have impacted overdose deaths in Texas, the second analysis compares the annual overdose deaths per capita in Texas to the control states. The graph shows that prior to Texas' policy implementation in 2007, the per capita volume of fatal drug overdoses was trending upward in both Texas and its control states. However, while the trend in the control states remains the same after 2010, Texas' per capita volume of fatal drug overdoses decreases gradually after the policy change. Thus, we can conclude that the enactment of regulatory changes in 2010 may result in the decrease of overdose deaths after controlling for the political, geographic, and demographic factors shared by the control states.

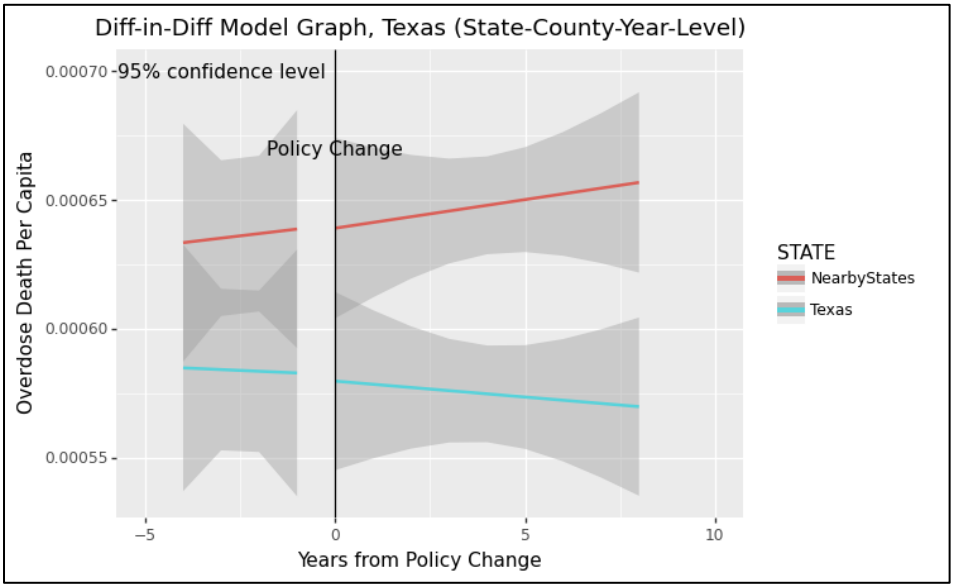

Figure 8. Difference-in-difference graph for overdose death in Texas vs control (NM, AR, KS). Policy change (2007) is denoted by the vertical line. Overdose death decreases in

Texas but increases in control states before the policy change. After the policy, such trend remains, and the gap grows larger.

Washington

The states like Washington, that meet the geographic, political, and/or demographic control selection criteria laid out in the research design are Colorado, Oregon, and California.

Opioid Shipment

Our first analysis of Washington opioid shipments shows that the per capita volume of opioids shipped increases every month leading up to the policy change. After the policy implementation in 2012, the per capita volume of opioids shipped begins continues to increase, albeit at a slower rate. It should be noted that there also appears to have been a steep drop off in the volume of opioids shipped in January of 2012. While this analysis does not necessarily indicate the that the policy itself is ineffective in causing a long-term reduction in Washington' per capita opioid shipment volume, or that it caused the initial drop off in volume, it does imply that the Washington policy may be correlated with a decrease in the growth rate of per capita opioid volume and an a short term reduction in volume imported.

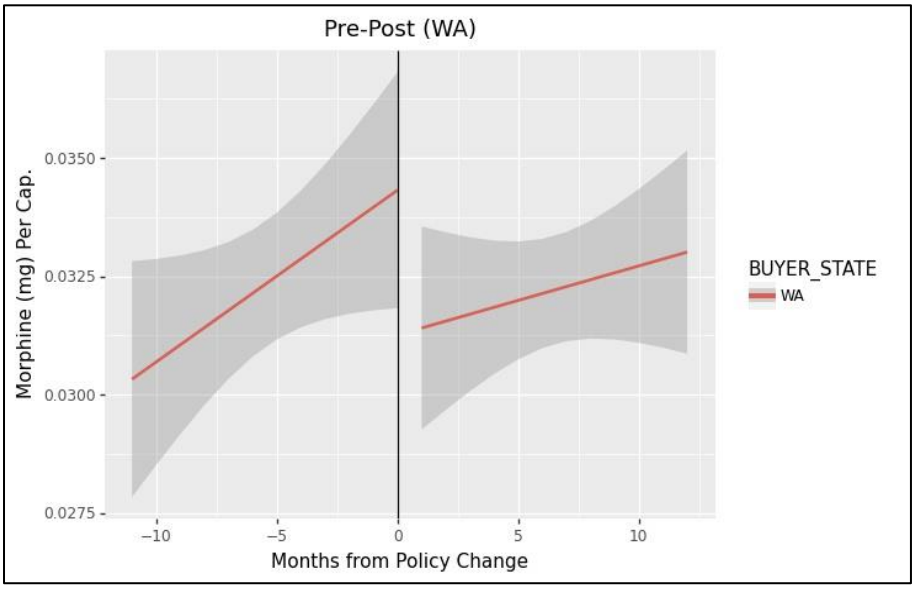

Figure 9. Pre-post graph for opioid shipments in Washington. Policy change (2012) is denoted by the vertical line. The plot shows opioid shipment weight per capita increasing before the policy change and continuing to increase after - at a lower rate. There does appear to be a decrease in shipment volume that occurred in the year of the policy implementation.

To account for potential national or regional trends, the second analysis compares the monthly per capita volume of opioids shipped in Washington before and after policy implementation to a set of control states – states like Washington but did not see policy changes implemented in the timeframe of analysis. The analysis shows that prior to Washington's policy implementation in 2012, Washington and its control states exhibit a similar upward monthly trend in the volume of opioids shipped. Likewise, after 2012 the volume continues to steadily increase in both Washington and its control. In both contexts the monthly rate of increase does appear to decrease after the

January 2012. It should be noted that while Washington saw a sharp drop off in per capita opioid volume shipped in January 2012, the control states saw a spike. From this analysis we can conclude that Washington's 2012 opioid regulations only led to short term decrease in the per capita opioid volume shipped while the overall trend remained relatively unchanged.

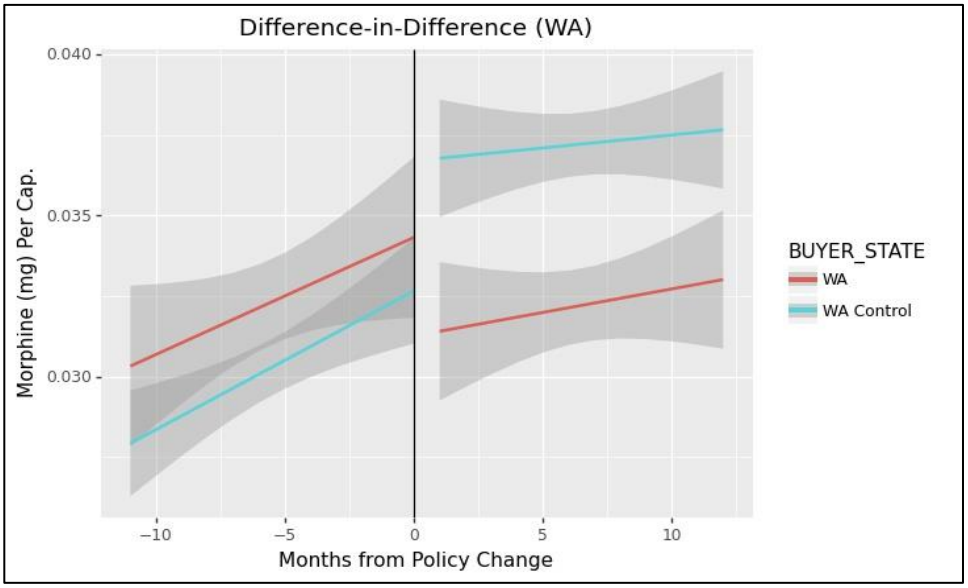

Figure 10. Difference-in-difference graph for opioid shipments in Washington vs control (CA, OR, CP). Policy change (2012) is denoted by the vertical line. Opioid shipment weight per capita increases before the policy change in both groups. The rate of increase decreases after 2012 in both groups. Shipped volume in 2012 shows a sharp drop-off for WA and a spike in the control states.

Overdose Death

Our first analysis of Washington's overdose deaths shows that the per capita volume of fatal overdoses decreases before the policy implementation but remains constant after as shown in *Figure 11.* While it does appear that the rate of change varies, a closer observation of the figure shows that any variation is nearly negligible. These results alone do not necessarily indicate a lack of effectiveness of the new policy since other factors like policing differences, or changes in the chemical makeup said illegal substances (i.e., fentanyl laced heroin) could have affected the analysis. However, Washington's opioid regulation does not appear to be correlated with any significant change in per capita opioid overdose deaths.

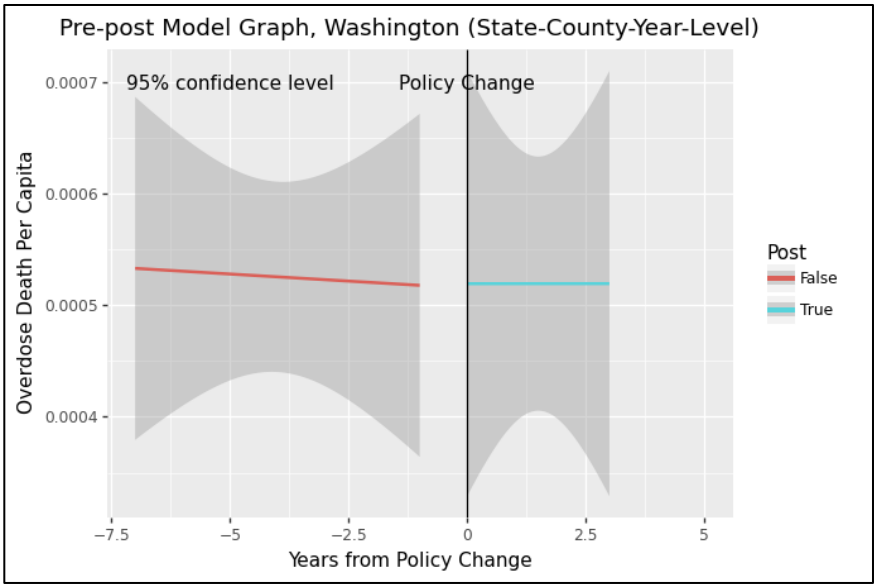

Figure 11. Pre-post graph for overdose death in Washington. Policy change (2012) is denoted by the vertical line. The plot shows overdose death decreasing before the policy change and increasing after. However, the standard error is large and indicates insignificance of the plotted trend.

To control for other potential factors that may have resulted in the observed changes per capita volume of fatal overdoses, the second analysis of overdose death proportion looks at Washington in comparison to a set of control states. The analysis shows that the per capita overdose rates prior to the policy implementation in 2012 differ, in both Washington and the control, the annual trend remains consistent. Therefore, we can conclude the enactment of Washington's 2012 policy did not play a role in reducing – or changing in any way – the total drug overdose deaths.

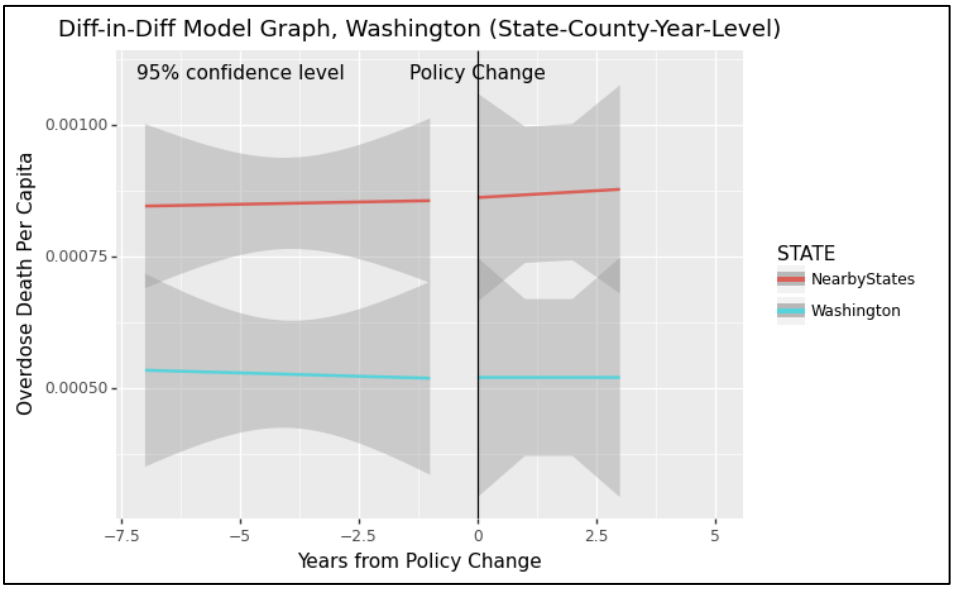

Figure 12. Difference-in-difference graph for overdose death in Washington vs control (CA, OR, CO). Policy change (2012) is denoted by the vertical line. Overdose death increases in both groups before the policy change. After the policy, the rate of increase

decreases in Washington while remains the same in the control states. There are drop in overdose death cases in both Washington and its control states.

Interpretation

Given that the three states each and their corresponding nearby states display similar trend in opioid shipment and overdose death before the policy change, the following interpretations are made based on what happens after the policy change.

In Florida, the 2010 policy effectively decreases the per capita volume of prescription opioids imported in Florida. Figure 3 displays how the growth in opioids imported continues to increase in the control states while completely reversing in Florida. Overdose deaths, however, sees no change in its annual trends after the policy implementation. In summary, the 2010 policy in Florida does have a significant impact on opioid shipments but has very little effect on overdose deaths.

In Texas, the 2007 policy seems to have little impact on reducing opioid shipments. However, it does not necessarily indicative of the policy being ineffective since there are only 24 months of data being reviewed for this analysis. Overdose deaths in Texas were decreasing before policy implementation and continue decreasing after. In the control states, per capita overdose fatalities were seen to increase over the same timeframe. In summary, the 2007 policy in Texas is not proven to be clearly effective in reducing the per capita volume of opioids imported or the per capita volume of fata overdoses in the state.

In Washington, the 2012 policy does have a significant impact on the per capita volume of opioids imported. Imported volume in Washington begins to decrease after policy implementation while increasing in the control states over the same time range. However, due to only being able to look at monthly shipment data over 2 years we lack sufficient data to make judgement on the regulations overall effect. In addition, overdose death seems to be unaffected by the policy as it the pre-regulation downward trend continues after policy implementation. Improve confidence in our findings it would we would need to explore data beyond the three years available at the time of this analysis

We presume that due to the notoriety surrounding the incredibly large volumes of opioid prescribed in Florida, the state's 2010 policy contains a series of mandatory regulations and physician requirements not seen in the other state's regulations. There is even a special task force established to deal with the Prescription Abuse. In contrast, the policies in Texas and Washington are one-time and there are no follow-up polices or institutions to oversee the implementation. Some of these guidelines are also merely recommendations that do not mandate physicians and medical institutions to comply. Thus, the differences in the results the policies yielded across the states are understandable and foreseeable.

In general, this analysis that the policies reviewed appears to be more effective in decreasing the volume of opioids imported, and less effective in reducing the volume of fatal overdoses. While there are likely many reasons as to why this is, some potential confounders include like mental well-being of drug addicts and the fact that restricting access to a drug doesn't the address the underlying addiction that influences both demand for opioids and overdose rates. Also important is that these policies only aimed to restricting the flow of prescription opioids. As a result, addicts might purchase and overdose on illegal opioids like heroin or fentanyl. This even has the potential

to exacerbate the overdose problem as the unstandardized strength of illegal opioids is one of the causes for accidental overdoses.