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### Statistician Report

#### **Motivation**

Years of sustained, coordinated, and vigilant effort will be required to contain the present opioid epidemic and ameliorate its harmful effects on society. At least 2 million people have an opioid use disorder (OUD) involving prescription opioids. Thus, even if the nation ramps up treatment availability substantially and immediately, death rates will climb and quality of life will be dramatically reduced for many people for years to come. Likewise, the continued progression of still more people from prescription opioid use will demand sustained and coordinated effort to establish and implement the scientifically grounded policies and clinical practices necessary to reshape prescribing practices and reduce the occurrence of new cases of prescription opioid-induced. By the opioid prescriptions not only did the volume of opioids prescribed increase, but well-intentioned healthcare providers began to prescribe opioids to treat pain in ways that we now know are high-risk and have been associated with opioid abuse, addiction, and overdose, such as prescribing at high doses and for longer durations.

In this project we evaluated the effectiveness of public policies in limiting over-prescription for these opioids and reducing the mortality resulting of opioid consumption.

To be more specific, we investigated three public policies, namely, Florida's Operation Pill Nation (February 2010), Texas' enactment of Rule §170.3 (January 2007) and Washington's adoption of new regulations for opioid drug prescription by WSR 11-12-025 enactment (January 2012). We analysed whether there is an observable reduction in mortality associated with opioid consumption following each of these policies. In addition, we also assess the existence of evidence of a reduction of opioid shipments in Florida following Operation Pill Nation.

## **Research Design**

To examine the effectiveness of policy interventions to limit the over-prescription of opioids, we focus on analyzing both the opioid prescriptions and mortality before and after the policy changes. It is possible that the policy will limit opioid addiction for future patients, while the existing addicted patients will turn to alternatives such as heroin and fentanyl which may lead to higher mortality rate. We chose to measure opioid drugs using morphine milligram equivalent (MME) units, as they provide us with a more standardized view of drug quantity than number of pills.

We chose to evaluate the effectiveness of various opioid policies using both pre-post trend graphs and difference-in-difference trend graphs. A simple pre-post analysis will give us a general idea of how effective the policy was, while the pre-post graphs will allow us to partition the potential effect of national changes from state level interventions. Therefore, for the Florida case, we study both the opioid shipments and overdose deaths. However, due to the limitation of available data, we only examine overdose deaths for Texas and Washington cases.

Our analysis is conducted on a county-level of analysis with yearly data, except in the case of Texas, where we also analyse monthly data for more granular results. We address these research questions by combining a pre-post analysis with a difference-in-difference (diff-in-diff) approach. To complete the difference-in-difference analysis, we assume that our policy-change state and non-policy-change state show similar trends before the change being examined, and we will present our results in graphical format.

## **Data**

Three datasets were used in the analysis:

- (1) The first was 2010 county-level population data obtained from the US Census Bureau. Population data was needed in order to calculate per-capita metrics and compare the opioid crisis across regions with varying populations.
- (2) The next dataset was data on opioid shipments collected by the DEA. This shipment data set had information on where drugs were shipped, the quantity of drugs shipped, and various characteristics of the drugs. Shipment data was available from 2006-2012.
- (3) Finally, we also obtained data on causes of death in each county from 2003-2015. This data was used to see if the policy interventions had an impact on deaths related to opioid usage.

One of the main difficulties in our analysis was getting our data into a format that we could use to generate comparison graphs. The first step was removing irrelevant columns from each dataframe; only columns of interest or ones used for merging were kept. Merging the datasets required a common key across all data. We used FIPS codes, a way to uniquely identify

counties, as a way to merge our datasets together. However, some of the datasets did not have FIPS codes- rather, we had to obtain or generate the codes manually. FIPS codes were added to the drug shipment dataset using the add FIPS package. We manually created FIPS codes on the cause of death dataset by concatenating preexisting state and county codes and adding leading zeros. Following the addition of the codes we merged the data on FIPS.

We ultimately ended up with 2 datasets to use for our final analysis:

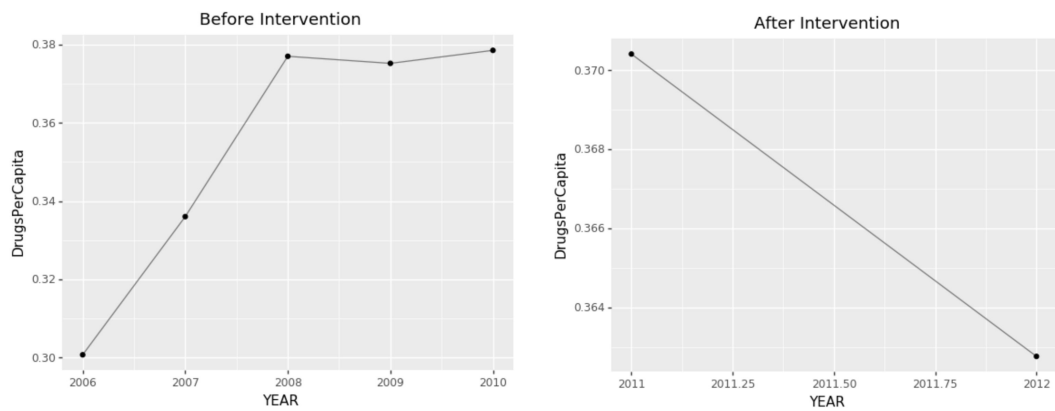
- (1) A combination of population and cause of death data on the county level.
- (2) Drug shipment and population data on the county level.

Following the merge, the data was grouped by county and year to produce aggregate statistics such as total number of opioid deaths in a given county-year. These were then standardized using county population in order to provide measures of the drug crisis that are easier to compare across varying county sizes. Mortality rate was calculated per-hundred-thousand while the amount of drugs was measured in MME units per capita.

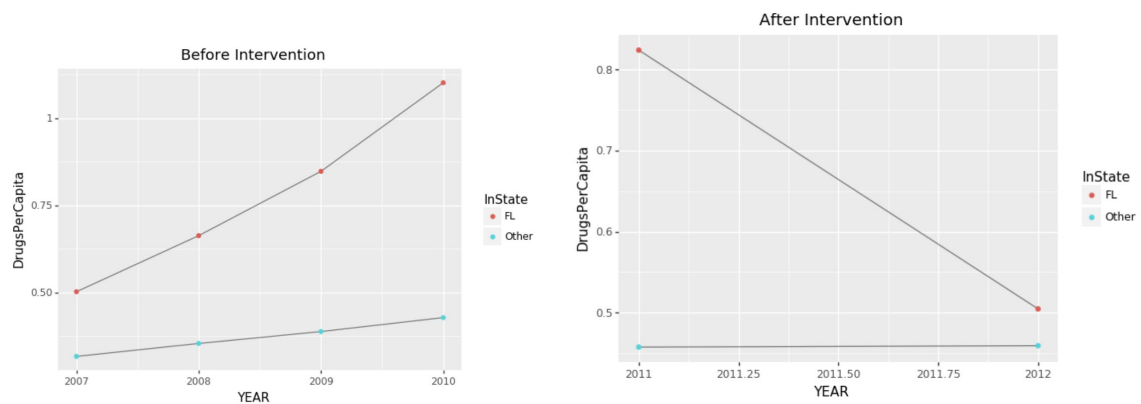
## **Analysis**

Changes in outcomes related to opioid usage pre- and post-intervention were explored using both difference in difference and pre-post graphs. These graphs can be seen below.

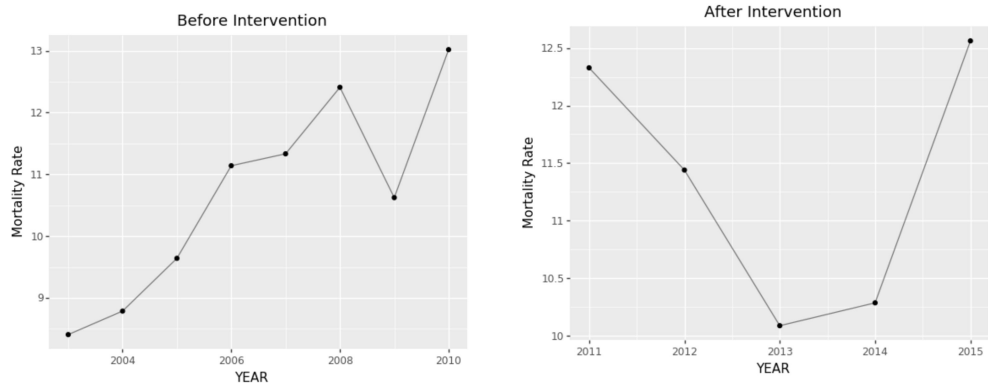
## Florida Drug Quantities Pre-Post



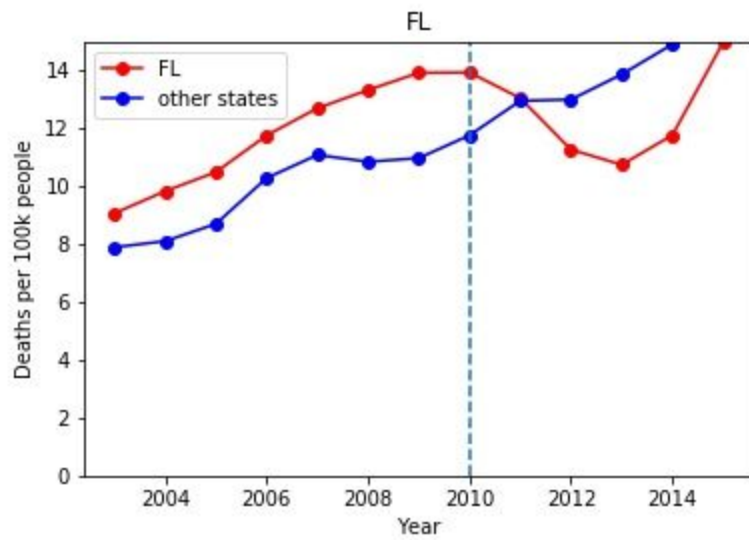
## Florida Drug Quantities Difference-in-Difference



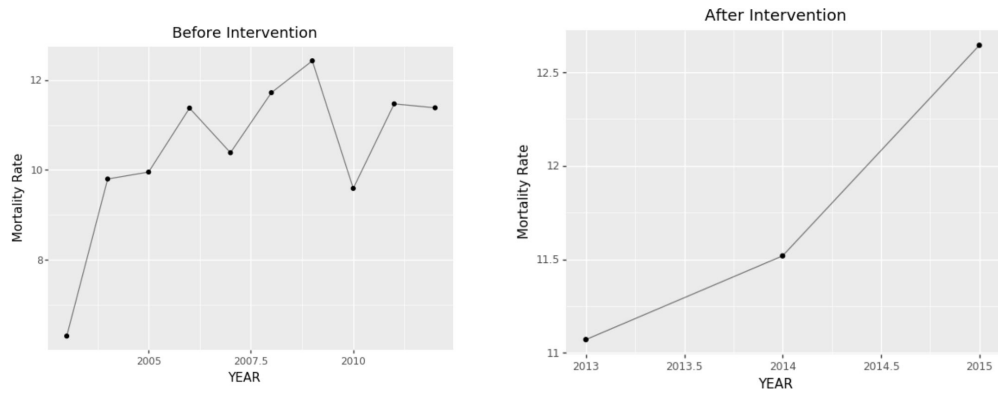
## Florida Mortality Rate Pre-Post



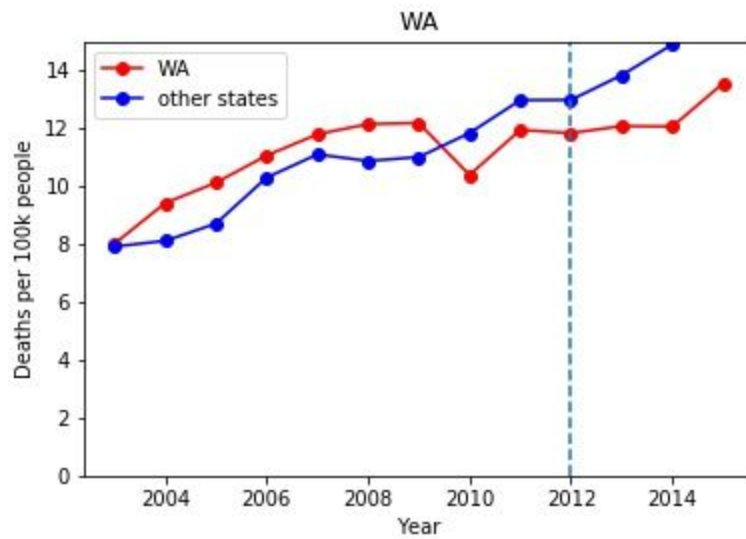
## Florida Mortality Rate Difference-in-Difference



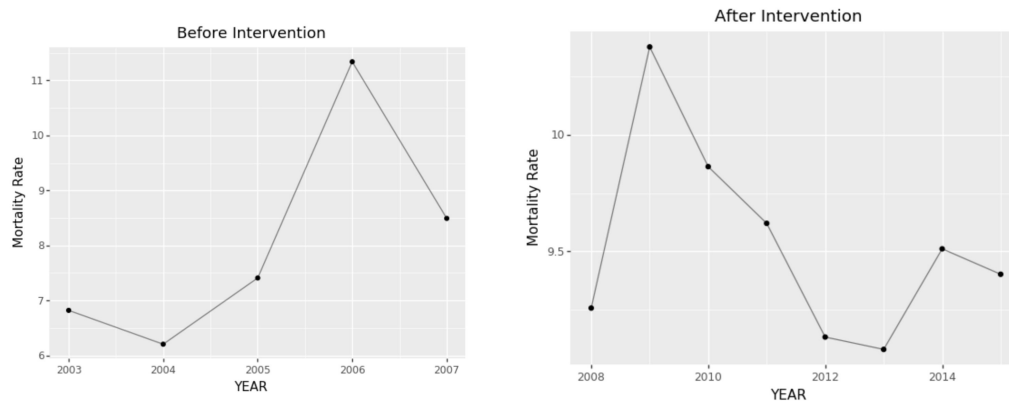
## Washington Mortality Rate Pre-Post



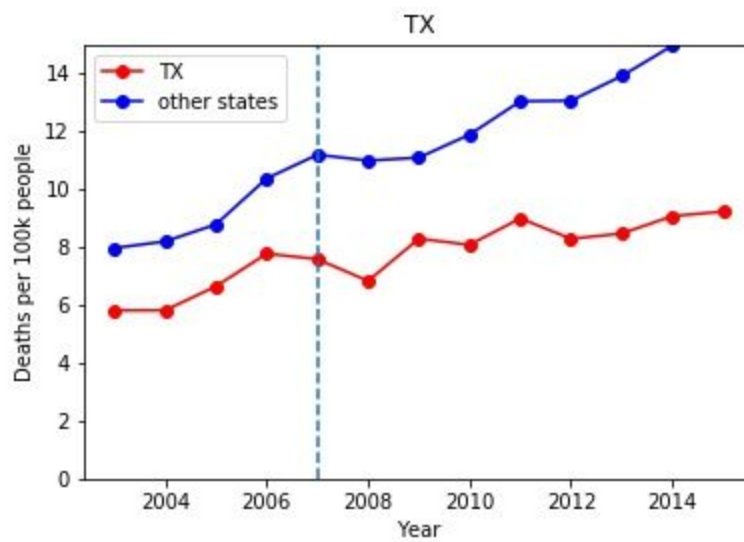
## Washington Mortality Rate Difference-in-Difference



## Texas Mortality Rate Pre-Post



## Texas Mortality Rate Difference-in-Difference





## **Interpretation and Conclusions**

### **1. Florida**

It appears that the policy changes in Florida have been effective in reducing the quantity of opioid drugs overall. The amount of drugs in the rest of the United States has increased slightly, while the quantity in Florida has reduced sharply. The effect on mortality rate, however, is less clear. The mortality rate trends in Florida appear to be moving with the rest of the United States, but the magnitude of the increase in drug rates is less. Given that a policy limiting access to opioids could lead to more overdoses (as people move to harder drugs) the trends in Florida may indicate that government interventions have been effective.

### **2. Washington**

Washington's drug mortality rate has remained about the same since 2010; this stands in contrast to the larger increase in the overall rate in the United States in the same time period. It may be that the new regulations on how opioid medications are prescribed have helped cushion the effect of national trends.

### **3. Texas**

The difference and difference analysis suggests that the policy in Texas does not seem to have reduced the number of deaths due to overdose overall. However, it does seem to have softened the previous increasing trend. The mortality rate in Texas is not increasing nearly as fast as the mortality rate for the rest of the United States.

## Policy Maker Report

### **Motivation**

Years of sustained, coordinated, and vigilant effort will be required to contain the present opioid epidemic and ameliorate its harmful effects on society. At least 2 million people have an opioid use disorder (OUD) involving prescription opioids. Thus, even if the nation ramps up treatment availability substantially and immediately, death rates will climb and quality of life will be dramatically reduced for many people for years to come. Likewise, the continued progression of still more people from prescription opioid use will demand sustained and coordinated effort to establish and implement the scientifically grounded policies and clinical practices necessary to reshape prescribing practices and reduce the occurrence of new cases of prescription opioid-induced. By the opioid prescriptions not only did the volume of opioids prescribed increase, but well-intentioned healthcare providers began to prescribe opioids to treat pain in ways that we now know are high-risk and have been associated with opioid abuse, addiction, and overdose, such as prescribing at high doses and for longer durations. So what should be done in reshaping the prescribing practices and reduce the occurrences of addiction and associated overdose, death, and other harms?

In this project we evaluated the effectiveness of public policies in limiting over-prescription for these opioids and reducing the mortality resulting of opioid consumption. To be more specific, we investigated three public policies, namely, Florida's Operation Pill Nation (February 2010), Texas' enactment of Rule §170.3 (January 2007) and Washington's adoption of new regulations for opioid drug prescription by WSR 11-12-025 enactment (January 2012). The main question we try to answer is whether sustained and coordinated effort to

establish and implement the scientifically grounded policies is effected not in these states. To quantify the solution for this problem we analysed whether there is an observable reduction in mortality associated with opioid consumption following each of these policies. In addition, we also assess the existence of evidence of a reduction of opioid shipments in Florida following Operation Pill Nation.

## **Data**

To examine the effectiveness of policy interventions to limit the over-prescription of opioids, we focus on analyzing both the opioid prescriptions and mortality before and after the policies changes. It is possible that the policy will limit the opioids addiction for future patients, while the existing addicted patients will turn to the alternatives such as heroin and fentanyl which may lead to higher mortality rate.

To evaluate the policy changes in Florida, Texas and Washington, we obtained county-level data on opioid shipments collected by the DEA from 2006 to 2012, and causes of death from 2003 to 2015. Moreover, we also obtain the county-level population data in 2010 to calculate standardized metrics for comparison. We measured the amount of opioids shipped to a county in morphine milligram units (MME) per-capita. This metric allows you to convert pills of various strengths into one single measure. Deaths due to opioids were measured per-hundred-thousand people. The previously mentioned sets of data were merged together so we could use them to conduct our analysis. For the Florida case, we studied both the opioid shipments and overdose deaths. However, we only examined overdose deaths for the Texas and Washington cases.

## **Analysis**

Our goal was to produce graphs of drug-related outcomes (opioid deaths per-hundred-thousand and morphine milligram units per-capita) to see if various government policies were effective. We start with a pre-post analysis, which is where we just look at the data from before and after the policy to see if there is a change. We also do a difference-in-difference analysis. A difference-in-difference means that we look at how a state with a policy changes compared to the country as a whole. Comparing these trends allows us to better understand if it is the policy leading to the difference or if changes are due to other factors. For length purposes we have elected to not include the graphs again here. If we were constructing a separate report for a policy maker we would include them.

## **Interpretation and Conclusions**

### **1. Florida**

Florida's policy changes have successfully reduced the consumption of opioid drugs. Indeed, consumption of such drugs has decreased in Florida since the enactment of the policy change, while remaining on the rise for the country as a whole.

Despite being successful in reducing the consumption of opioid drugs, there is less clear evidence that this policy was also successful in reducing the mortality rate associated to drug overdose. Though the number of deaths due to drug overdose did reduce right after the policy change, it has returned to increase recently. One possible explanation for this behavior is that limiting access to opioid drugs drive addicted consumers to heavier and more lethal drugs. Therefore, though the policy seems to have been efficient in reducing the death rates immediately, its long term effectiveness remains unclear.

## 2. Washington

There is no clear evidence that the policy enacted by Washington state to limit the consumption of opioid drugs was effective.

Washington drug mortality has remained fairly stable since 2010. Hence, drug mortality had already been stabilized two years before the enactment of the policy, which suggests that the policy in itself was not effective. It may be, however, that the policy did help to “cushion” Washington from the effects which led the rest of the country to experience an increase in drug mortality during the same period.

## 3. Texas

The policy enacted in Texas to limit access to opioid drugs seems to have been partially successful. Though it does not seem to have reduced the number of deaths due to drug overdose, it does seem to have made these deaths level off. This is a positive result, especially considering that the number of deaths due to drug overdose in Texas had been growing at much higher rates than in the rest of the country. Though it is true that, even before the enactment of the policy, Texas had already experienced a year of significant reduction in the number of deaths due to drug overdose, it is also true that this number has not experienced any significant increase since the enactment of the policy at hand.