ESTIMATING THE EFFECTS OF OPIOD CONTROL POLICIES IN THE UNITED STATES

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Practical Data Science

EXECUTIVE SUMMARY

As the opioid crisis escalated in the United States, several states responded by advocating for policy interventions to limit the widespread prescription of opioid medications to patients. The objective was to decrease access to opioids and mitigate the potential for addiction by only exposing patients to medical opioids when absolutely necessary for their treatment. This study focuses on three states—Texas, Washington, and Florida—that implemented policy measures to curb the excessive prescription of opioids. Our investigation aims to assess the effectiveness of these policy changes in reducing the number of opioid-related deaths in these states. We will specifically analyze the policy modifications implemented in Texas in 2007, Florida in 2010, and Washington in 2012.

The analysis in this report focuses on the following three US states - Texas, Washington, and Florida. It includes an analysis of the mortality rates in each county in these states for deaths that were caused by drugs both before and after the policy came into effect, as well as an analysis of for the prescription opioids present in the state. For this purpose, we used state-wise population data and analyzed data for opioid shipments by their Morphine Milligram Equivalent conversion factor and the calculated base weight in grams.

We conducted a pre-post analysis on the three states to compare the drug related mortality rate of that state before the policy came into effect to its mortality rate after the policy. We also conducted a difference in difference analysis, i.e., a comparison of the mortality rates both before and after the policy in the main state and its control states to study the relative effect of the policy on the main state. This allows us a unique perspective to measure the impact of the policy on a state rather than seeing its post-policy mortality rate in isolation.

We found that after the policy was implemented in Texas, the mortality rate did not reduce but remained consistent. This insinuates a positive impact of the policy in Texas. In Florida, the policy again appeared to have a positive impact as there was a sharp and continuous drop in the opioid induced mortality rate. The mortality rate in Washington initially fell after the policy was implemented and then continued to rise again.

Table of Contents

Introduction

Opioid addiction and overdose have claimed millions of lives around the world. Unfortunately, the United States has had its own fair share of this epidemic and continues to lose lives to it each year. While many cases of opioid addiction stem from illegally obtained opioids, peer pressure in school or desperate attempts at self-medication for mental or physical ailments, a staggering proportion of addiction stems from people becoming hooked to medicines that were prescribed to them by their doctors. While these medications are not intended to be taken for longer than what is required for treating the health problem, they continue to haunt the patients long after they have served the patient's medical requirements.

When the state of the opioid crisis worsened significantly in the United States, there was a call in several US states to enact policy measures to curtail the rampant prescription of opioid medication to patients. This was done in the hopes that the access to opioids and potential subsequent addiction could be reduced if patients were not exposed to medical opioids unless they absolutely needed to be in order to treat their condition.

The aim of this project is to focus on three such states that enacted policy measures to restrict the over-prescription of opioids to patients: Texas, Washington, and Florida. We are investigating the impact of the policy changes made to ascertain whether they successfully brought down the number of opioid related deaths in these states. We will be analyzing the policy changes that were made in Texas in 2007, Florida in 2010 and in Washington in 2012.

Changes in Policy

Texas (2007)

This policy was pushed in 2007 when the Texas Medical Board created regulations for treating pain with controlled substances. The policy mandated a thorough patient evaluation before prescribing opioids for pain management. This would include reviewing patient history which was recorded in the state's prescription drug monitoring program (PDMP) and receiving the patient's consent before they were prescribed opioids. The medical care provider would also have to keep reviewing the patient's treatment and maintain a complete medical record of the treatment.

Florida (2010)

Florida was at the epicenter of the American opioid crisis. When it was discovered that it was home to 98 of the 100 physicians in the US who dispensed the highest quantities of oxycodone directly from their offices, the government decided to act. In order to enact a policy change in furtherance of controlling the crisis, Florida launched Operation Pill Nation which was a collective effort of both administrative and law enforcement agencies. The new requirements included that all pain clinics treating pain with controlled substances had to register with the state by January 4th, 2010. In July, after a declaration of a public health emergency, the government prohibited clinics from prescribing schedule 2 and 3 drugs from their offices. Florida also saw more regulatory mechanisms in regard to wholesale drug distributors.

Washington (2012)

In 2012, Washington decided to bring into effect new policy measures to curb the crisis. The new guidelines were as follows:

- Mandatory consultation threshold for adults is 120 mg MED/day (oral). In the event a physician prescribes a dosage that meets or exceeds the consultation threshold, a consultation with a pain management specialist is required.
- The physician shall document each mandatory consultation.
- Recommended that a practitioner not prescribe more than an average
- MED of 120 mg without either the patient demonstrating improvement
- in function or without first obtaining a consultation from a pain management expert.

Methodology

To understand the impact of policy change in the overall opioid consumption trends, we are going use two approaches to assess it: a pre-post analysis and a difference in difference analysis. In them, we are using two main variables to measure the effect of the policy change in each state: 1) drug related mortality rates and 2) opioid consumption measured by a proxy of prescription drugs shipments.

Pre-post analysis

A pre-post analysis of policy implementation in our selected states can give us an overall picture of the impact of the policy change on opioid-related deaths. This would give us a clearer picture of how the policy impacted a particular state and what the state of mortality due to opioids was like before the policy came into effect as compared to after the policy came into effect. However, a simple pre-post comparison might lead to inaccurate causal inferences, as external factors, such as changes in national policies, could confound the results.

Difference in differences

A difference in differences (DiD) analysis will also be used as it is more robust than a pre-post analysis for causal effects. In it, we are comparing the policy change effects in the selected states with other control states. This way we can analyze the trends in control states and treatment states before and after the policy change to understand if the trends are indeed a product of the policy change. The policy change's effects will be measured in the change in drug-related deaths and opioid consumption. Furthermore, the statistical estimation of DiD using linear regression models provides a rigorous quantitative assessment.

Control states selection

To conduct the DiD analysis, we will use control states to compare with each of the three treatment states: Texas, Florida, and Washington. These control states were chosen separately for each state based on their geographical and demographic similarity and proximity to the state they were being compared with. (For specifics of each state, go to Section II of the Appendix.) Since the control states are chosen for their similarity with the treatment states, they are expected to behave how the treatment states would have behaved if the treatment states had not implemented the policies.

Data sources

To conduct these analyses, we will use data from different sources. To account for opioid consumption, we will use the proxy of data prescriptions coming from a dataset of all prescription drug shipments in the United States at county level between 2006 and 2019, released by the Washington Post in 2020. To account for drug-related deaths we will use mortality related information at the county level published by the US Vital Statistics Records, consisting of data from 2003 to 2015. Finally, to rate deaths by population at a county level, we will use a population dataset from the Center for Disease and Control prevention (link). The population data is used here in conjunction with mortality data and with opioids shipment data to calculate mortality rates and opioid rates per capita at both county and state levels. Furthermore, to standardize different opioids on the same basis, the morphine milligram equivalency (MME) is used.

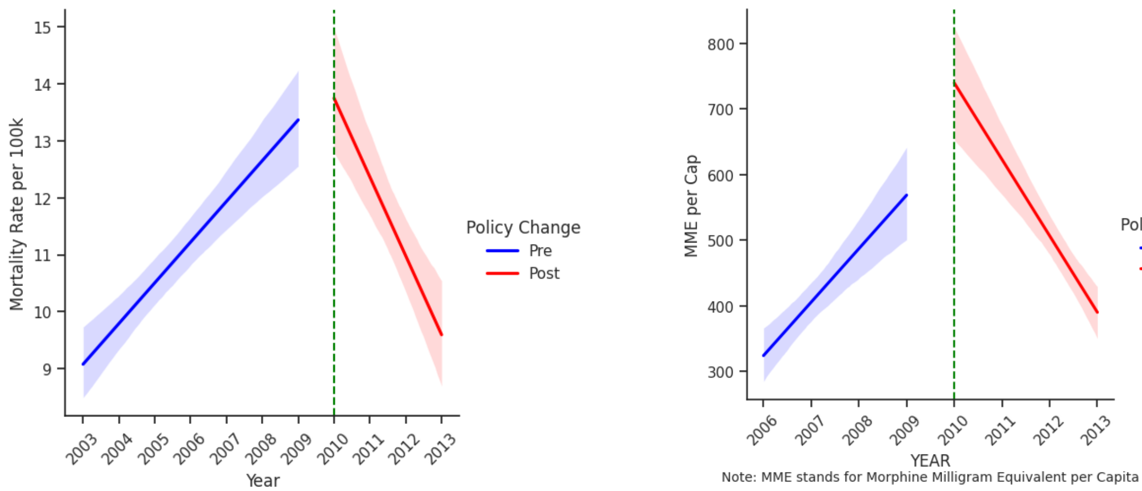
Pre-Post Results

Florida

In 2010, Florida faced a significant public health crisis fueled by the rampant diversion of narcotic medications, particularly opioids, orchestrated by groups like the Stouffer drug trafficking organization. Operation Pill Nation, launched by the DEA in 2011, aimed to address the epidemic of opioid abuse by targeting illegal prescription practices. The Stouffer organization had recruited doctors to prescribe unnecessary narcotics to individuals, contributing to addiction and the illicit distribution of drugs (Reuter,D. L., n.d.). The subsequent mass closure of pain clinics, like Stouffer, led to a substantial policy change, and this analysis explores how Florida's mortality rate changed in the years following this intervention.

Fig 1. Pre-Post Analysis for Florida

Drug related mortality rate per 100k population in Florida	Morphine Milligrams Equivalent shipments per capita in Florida



Mortality Rate: Pre-policy change shows an upward trend in Mortality Rate per 100k, while the post-policy change regression line depicts a notable decline, implying a potential impact of the policy.
MME per Cap: The plot shows an increase in MME per Cap pre-policy change and a subsequent decrease post-policy change. This suggests a potential impact of the policy shift on the consumption of Morphine Milligram Equivalent per capita in Florida.

Seven years before the policy change, Florida experienced a concerning increase in opioid-related mortality, with the mortality rate per 100k rising from approximately 9 to *13.* However, the implementation of Operation Pill Nation and the subsequent closure of problematic pain clinics showed a positive impact. By 2013, the mortality rate in Florida began to decline, approaching the pre-crisis level of around 9 deaths per 100k, indicating the effectiveness of the policy in curbing opioid-related deaths. In the Opioid shipments per capita graph, Florida exhibited a significant decrease post-policy change, plummeting from 800 to 400 shipments, contrasting with the previous rise from 300 to 600 shipments between 2006 and 2010.

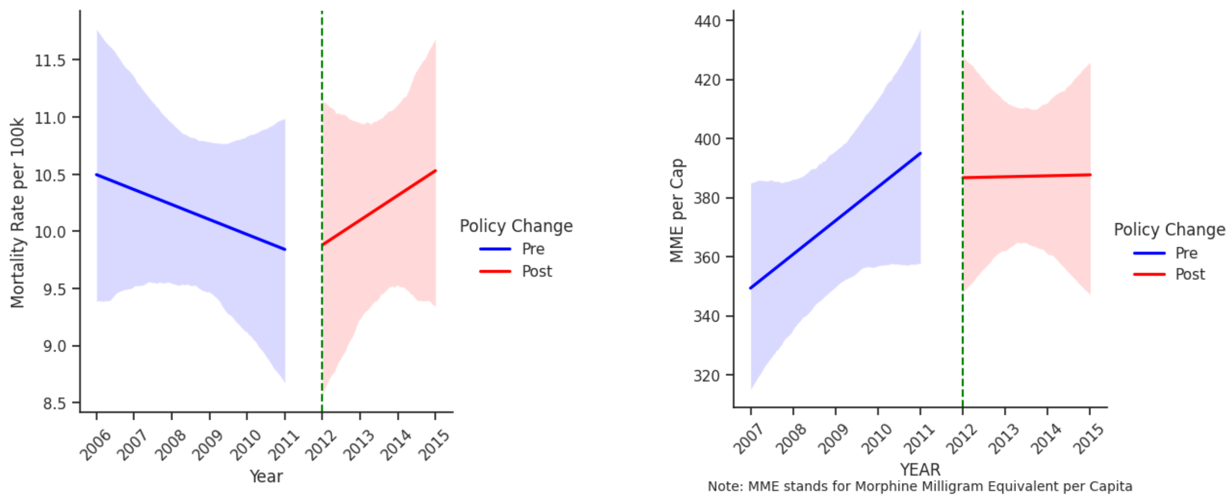
Washington

Washington implemented pain management rules in 2011, driven by legislative directives in ESHB 2876. The aim was to replace existing rules and emphasize dosing criteria, specialty consultations, and tracking clinical progress to ensure appropriate pain relief while minimizing the risks of inappropriate prescribing and drug diversion (Washington State Code Reviser's Office, 2011).

Fig 2. Pre-Post Analysis for Washington

Drug related mortality rate per 100k population

Morphine Milligrams Equivalent shipments per capita



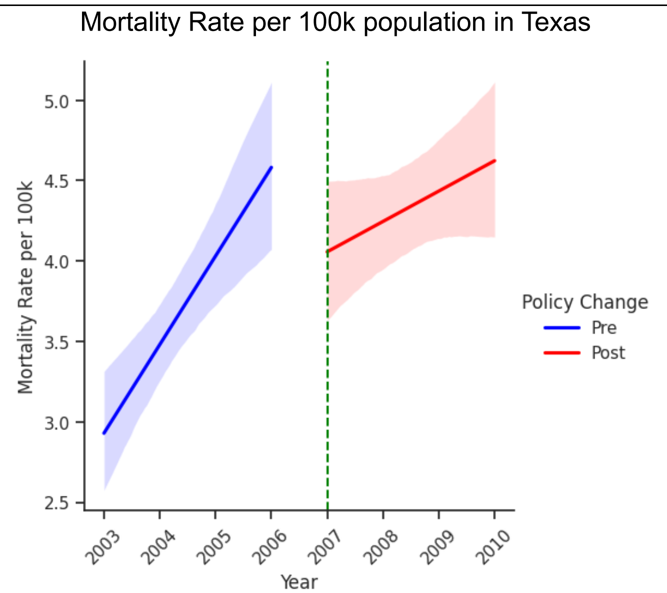
Mortality Rate: Pre-policy change shows a downward trend in Mortality Rate per 100k, while the post-policy change regression line depicts a notable increase, implying no impact of the policy in the state.
MME per Cap: The plot shows an increase in MME per Cap pre-policy change and a subsequent steadiness post-policy change. This suggests a no significant impact of the policy shift on the consumption of Morphine Milligram Equivalent per capita in Florida.

Washington's opioid-related mortality rate exhibited an interesting trend. From 2006 to 2011, there was a slight decline from 10.5 to 9.8 deaths per 100k. However, post-policy change in 2012, there was a notable increase, reaching 10.5 deaths per 100k within three years. This unexpected outcome led to further investigation. The Addictions, Drug, and Alcohol Institute at The University of Washington revealed a 257% increase in drug treatment admissions for opioids in 2013-2015 and drug caused deaths involving opioids increased 10% over 2018(ADAI, 2023). In the Opioid Shipments Graph, showed an initial decrease and then no distinct difference in opioid shipments post-policy change. Washington's graph shows a stabilization with a constant slope from 2012, indicating that the policy was initially very helpful and gradually lost effectiveness in reducing opioid-related harm over time.

Texas

In 2007, Texas responded to the escalating opioid epidemic by implementing stringent regulations under Rule 170.3. Motivated by a growing awareness of the risks associated with opioid prescriptions, the Texas Medical Board aimed to establish a comprehensive framework for physicians treating chronic pain. This policy, marked by measures such as thorough patient evaluations and written treatment plans, reflected Texas's commitment to responsible pain management practices in the face of a nationwide crisis (TexReg, 2007)

Fig 3. Pre-post analysis for Texas



Mortality Rate: Pre-policy change shows a sharp rising trend in Mortality Rate per 100k, while the post-policy change regression line also depicts a notable increase, implying no impact of the policy in the state.

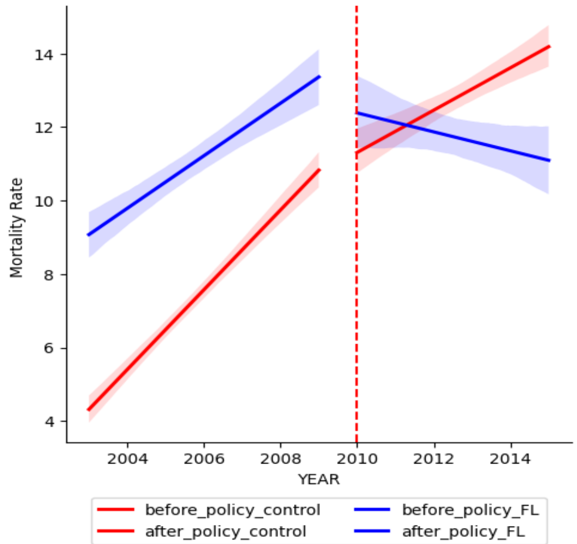
The mortality rate in Texas experienced a steep incline from 2007 to 4.6 deaths per 100k, indicating the severity of the opioid crisis pre-policy change. However, following the implementation of the 2007 regulations, there was a noticeable decline in the mortality rate, albeit at a less steep slope. This suggests a gradual improvement in the situation, indicating the policy's effectiveness in reducing deaths related to opioid abuse.

Difference in Differences Results

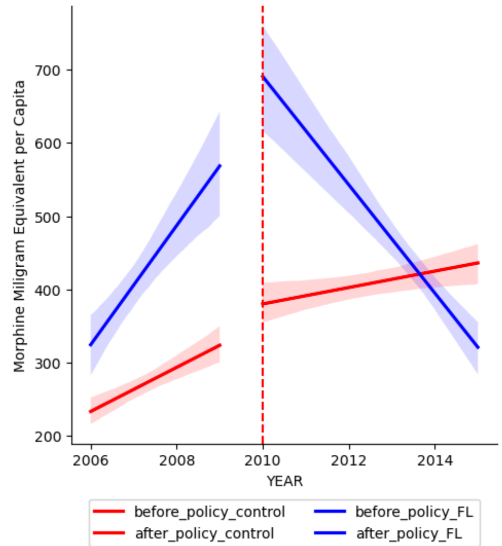
Florida

Fig 4. Florida difference in differences analysis

Florida and control states DiD analysis for drug-related Mortality Rate



Florida and control states DiD analysis for MME per Capita shipments



Mortality Rate: Pre-policy both control states and Florida exhibited an increase in mortality rate. Post-Policy, the control states continued to show a steady rise in mortality rate with a very slight initial slowdown in pace. Florida showed a sharp and continuous decline in mortality.
MME per Cap: Pre-policy, Florida's opioid shipments showed a steep increase in shipments compared to control states. Post-policy, Florida saw an initial increase and then a continuous decrease in opioid shipments while control states exhibited an increase in shipments.

The Difference-in-Differences (DiD) analysis of Florida's opioid policy reveals an effectiveness in reducing opioid-induced mortality rates. Comparing post-policy mortality rates with those of control states provides insight into the potential trajectory in Florida had the policy not been implemented. The observed reduction in mortality is supported by a comprehensive study analyzing the impact of Florida's opioid prescription policy in 2011, affirming the policy's strength in not only lowering mortality rates but potentially preventing non-prescription opioid deaths, such as those caused by heroin (Kennedy-Hendricks A et al., 2016).

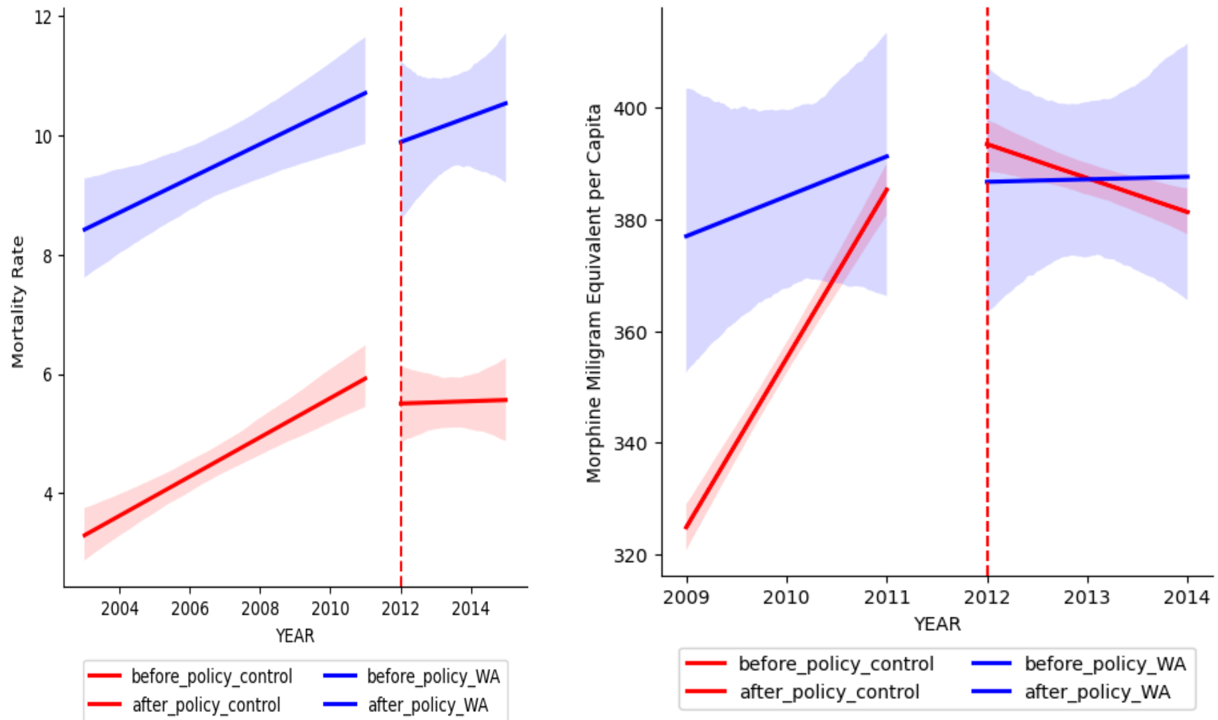
Additionally, the analysis of (MME) per capita shipments shows intriguing dynamics in both Florida and its control states. Pre-policy, both experienced a steep rise in shipments, but post-policy, Florida witnessed a brief surge before a sustained decline, while control states displayed a less steep increase in shipments. The nuanced changes in shipment rates post-policy in both Florida and control states merit closer examination, presenting policymakers with valuable insights into the multifaceted impacts of policy interventions on opioid consumption trends.

Washington

Fig 5. Washington Difference in Differences analysis

Washington and control states DiD analysis for drug-related Mortality Rate

Washington and control states DiD analysis for MME per Capita shipments



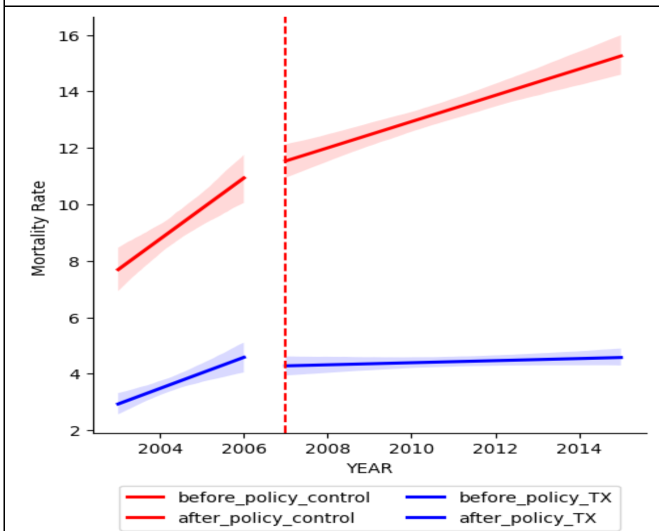
Mortality Rate: Pre-policy both control states and Washington exhibited an increase in mortality rate. Post-policy the control states had an initial decrease and then constant slope compared to Washington that had an initial decrease then increase in mortality rate.

MME per Cap: Pre-policy, Washington's opioid shipments showed a steep increase in shipments compared to control states. Post-policy, Washington has a decreased and then stable slope of shipments compared to control states that exhibited a steep decrease in shipments.

In the context of the difference-in-differences analysis, the Mortality Rate graph for Washington displays outcomes akin to both pre- and post-policy analysis. Following the implementation of the policy, Washington exhibited an initial decline followed by an increase in deaths attributed to opioid abuse. This initial decrease is supported by a study that documented the opioid epidemic in Washington and noted a 27% decline in prescription opioid overdose death rates from 2008 to 2012 (Franklin et al., 2015). In contrast to control states, which maintained a consistent slope in deaths per 100,000 people. The divergent trajectory in Washington suggests that the state did better with the policy change. Examining the DiD analysis for (MME) per Capita Shipments reveals a significant reduction in shipments for control states, while Washington demonstrated an initial reduction and then sustained level of shipments from 2012 to 2014. Washington initially reduced its opioid shipments less than the control states because of strong motivation to implement policy change however, the inability to maintain a constant decline in shipments explains the initial decrease in the mortality rate and why mortality rate didn't continually decrease over time.

Texas

Fig 6. Texas Difference in differences analysis



Mortality Rate: Pre-policy, both control states and Texas exhibited an increase in mortality rate. Post-policy, Texas started with a slight decrease and then maintained a constant slope: comparatively, control states continued a growing slope of mortality.

A Difference-in-Differences (DiD) analysis for opioid shipments in Texas was not feasible due to the policy change occurring in 2007, and the available information on opioid shipments starting from 2006. This limitation resulted in an insufficient number of observations to conduct a comprehensive analysis. Nonetheless, we successfully employed DiD to examine drug-related mortality rates, revealing insightful outcomes. Following the policy implementation, Texas demonstrated a sustained level of drug-related deaths, in contrast to the control states where drug-related mortality rates continued to rise. Although Texas did not witness a decrease in drug-related deaths, the ability to maintain a consistent rate amid a growing trend in other comparable states indicates the effectiveness of the policy change. This suggests that the implemented policy in Texas had a discernible impact on controlling drug-related fatalities.

Conclusion

Our examination of opioid policy changes in Texas, Florida, and Washington demonstrates nuanced outcomes in the battle against opioid-related deaths. Florida's Operation Pill Nation, implemented in 2010, stands out as a success story, leading to a substantial reduction in mortality rates and opioid shipments. However, the Washington state policy of 2012, while initially effective, faced challenges in sustaining its impact over time, resulting in a subsequent rise in opioid-related deaths. Texas, with its 2007 regulations, maintained a consistent level of drug-related fatalities amidst a rising trend in control states, indicating a tangible and enduring impact of the policy.

The divergent trajectories across these states underscore the need for ongoing evaluation and adaptation of policy measures in the complex landscape of opioid addiction. Policymakers can draw valuable lessons from both successful and less-sustainable interventions, emphasizing the importance of a dynamic and region-specific approach to effectively curb the opioid epidemic and save lives.

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Appendix

Section I: Data cleaning

To build the mortality rate dataset, we used US Vital Statistics (Link) to get mortality information for each state and county from 2003 to 2015. The link contains 13 text files for each year. We concatenated all the text files and created one single CSV for all the years. The data cleaning involved removing the notes at the end of every text file and having a proper delimiter to create columns for the csv. The dataset then had missing values for Alaska and Virginia which were directly dropped. We filtered out for only required categories of Drug Induced Cause which are Drug poisonings (overdose) Unintentional (X40-X44) , Drug poisonings (overdose) Suicide (X60-X64), Drug poisonings (overdose) Undetermined (Y10-Y14), All other drug-induced causes. We further did analysis and decided to keep only “Drug poisonings (overdose) Unintentional (X40-X44)” as this is the most frequently occurring across all states and can help in capturing the trend.

Then we worked on imputing missing values. It begins by reading and preparing two datasets: one containing population estimates and another recording deaths.

For population data we read a text file containing information about population data from the CDC. Then removes a specific section delimited by triple double quotes to sanitize the data. Essentially, we are preparing the population data file by removing certain sections and cleaning the text, making it more suitable for further processing or analysis.

For Deaths data we consolidate all the ".txt" files present in the specified folder into a single file named "output.txt". Then, we read this merged file and transform its content into a CSV format named "output.csv" using regular expressions to parse and structure the data accurately. Subsequently, the code imports this CSV file into a Pandas DataFrame, ensuring proper indexing and column naming conventions. Further data cleaning involves removing unnecessary rows, handling missing values labeled as "Missing," and correcting instances where death values are marked as "999." Finally, we save the cleaned dataset into a new CSV file titled "US_Vital_Stats_Deaths.csv." This entire process streamlines the aggregation of various death records from 2003 to 2015, present across multiple text files, into a consolidated and formatted CSV file ready for further analysis or modeling.

The process involves data cleaning steps like removing specific states from the death records. Sub setting focuses on drug/alcohol-induced death causes and merges relevant columns for consistency. Through merging these datasets based on state, county, and year, the code creates a unified dataset. Mortality rates at both county and state levels are computed by dividing deaths by the population, addressing drug-induced deaths specifically for unintentional drug poisonings. Missing death records are handled using a function called 'calculate_deaths,' which utilizes the state mortality rate and county population. This function fills in missing values by estimating deaths; however, it caps the imputed deaths at 9 to maintain realistic figures. Finally, the code aggregates data at the county level and computes final mortality rates per 100,000 population, providing a comprehensive analysis of mortality rates considering population size and cause-specific death rates.

The County Population data from 2003 to 2015 was sourced from this link. We then merged the mortality data with this county's population. The mortality rate was then calculated and further used for analysis and graph plotting.

To build the prescription drug dataset, we used the dataset of all prescription opioid drug shipments in the United States from 2006 to 2019 published by the Washington Post. For this purpose, we summarized the dataset to make it more manageable since it had observations for each purchase of each county during the year from 2006 to 2019. This summation of the data involved grouping by year, state, and county, and summing specific variables that would be used for our analysis: Active weight of the drug in the transaction in grams, Morphine Milligram Equivalent, and MME. The final data set consisted of observations at state-county-year level that accounted for purchased opioids in that year. To obtain a rate per capita, the County Population data from this link was merged into the dataset to have population information to calculate the MME per Capita.

Missing Data Imputation

Overall, a one-unit observation in our data consists of a State-County-Year combination with information on drug prescriptions and drug-related deaths per 100,000 inhabitants. As the data was riddled with missing values for mortalities for each county, we computed the state-level mortality rates from grouped data. Here grouped data refers to the aggregated information on deaths and population at the state level. This data is obtained by grouping the county-level mortality and population data by 'State', 'Year', and 'Drug/Alcohol Induced Cause', summing up deaths, and summing population values. The resulting dataset represents the mortality rates calculated at the state level for specific causes and years. After merging this data with county-level information, missing death values are filled using the state-level mortality rate and county population. The logic utilizes a lambda function to estimate these missing values while capping them at a maximum of 9, considering population size and the state's mortality rate as proxies.

Section II. Control states selection criteria

Texas

For Texas, the control states that we chose were Alabama, Louisiana and New Mexico. The rationale behind choosing the states was that they are all southern, coastal states lying on the same border of the US. Any illegal opioid supplies that make their way into the US from this coastal area from the countries of Mexico or the Dominican Republic are bound to make their way to all four of these states. The internal land routes,i.e, national highways also make it easier for these drugs to reach the other three states once they have entered at least one of these four states from the coast. As a result, they are all likely to behave similarly to each other in the absence and presence of an opioid control policy as compared to any other states in the US.

Florida

For Florida, the control states that we chose were Alabama, Arizona and Mississippi. Much like Texas and its control states, the reason for choosing these control states for Florida was that they are all coastal states lying on the southern border of the US. Illegal opioid supplies that make their way into the US from this coastal area will eventually make their way to all four of these states. They are also connected by internal land routes,i.e., national highways making it easier for these drugs to disperse to the other three states once they have entered one of them. An interesting point to note here is that while Alabama and Mississippi are geographically close to Florida, i.e., south- eastern states, Arizona is to the Southwest of the US map. The reason it has been chosen as a control state here is because both Florida and Arizona are connected by interstate 10 which has been used to carry opioids from Phoenix, Arizona to Jacksonville, Florida. Further, they lie along the same US border and are exposed to a similar risk of illegal drug imports.

Washington

For Washington the control states we chose were Oregan, Idaho and Montana. These states neighbor Washington and as a result, will be closely connected via land routes providing a convenient environment for the easy transportation of drugs from one state to the other. Any opioid that enters one of these states is likely to make its way to the other states. Each of these states is likelier than others (at least as far as the impact of geographical positioning is concerned) to behave similarly to Washington in both the presence or absence of a drug related policy.