Evaluation of the Effects of Opioid Regulation Policies in the USA

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Practical Data Science
Ilseop Lee (il72)
Ramil Mammadov (rm564)
Tursunai Turumbekova (tt284)
Yirang Liu (yl1041)

Report Overview

Executive Summary

This report evaluates the effectiveness of state-level opioid regulations in Florida and Washington in reducing opioid consumption and overdose mortality rates. Using pre-post and difference-in-differences analyses, it examines trends in opioid shipments and mortality data from 2006 to 2015. Opioid shipment data from the Washington Post served as a measure of consumption, while U.S. Vital Statistics mortality data tracked overdose deaths, with U.S. Census Bureau population data providing context for rate-based analyses. The study focuses on commonly misused prescription opioids, including hydrocodone, oxycodone, morphine, fentanyl, and methadone. Control states—Georgia, North Carolina, and South Carolina for Florida, and Colorado, Oregon, and Montana for Washington—were selected for their demographic and health care similarities, offering a baseline to distinguish policy impacts from broader trends.

Florida and Washington both initially stabilized opioid shipment growth after implementing their respective policies, though the outcomes varied. In Florida, policies introduced in 2010 curbed the sharp rise in opioid shipments, indicating some success in reducing overprescription. However, similar stabilization trends in Florida's control states suggest broader regional or national factors may have played a role. In Washington, harm reduction policies enacted in 2012 led to a modest initial decline in opioid shipments, but the effect was minimal, with shipment level decreasing only to a limited extent. In contrast, Washington's control states showed more rapid declines, raising questions about the relative effectiveness of Washington's measures. Mortality trends revealed distinct contrasts between the two states. Florida experienced a decrease in opioid-related deaths after its policies, though similar declines in control states point to additional national factors influencing the trend. Washington, on the other hand, saw a slight increase in overdose mortality during the same period. This suggests that while limiting prescription opioids may reduce misuse, it can also push individuals toward riskier alternatives like heroin or fentanyl. These findings highlight the need to balance prescription controls with complementary harm reduction strategies to address substitution risks effectively.

These findings emphasize the need to balance prescription regulations with strategies that mitigate substitution risks. Florida's policies showed greater success in reducing overdose deaths, highlighting the importance of tailored approaches that account for each state's unique challenges. To combat the opioid crisis effectively, flexible, data-driven strategies are essential, combining regulatory measures with public health initiatives like expanded treatment access and harm reduction programs. Insights from Florida and Washington offer valuable guidance for crafting interventions that address both the immediate and long-term complexities of opioid misuse.

Introduction

The opioid crisis remains a critical public health challenge in the United States, characterized by widespread addiction, rising overdose deaths, and an increasing reliance on illicit substances such as heroin and fentanyl. Initially fueled by the overprescription of opioids, the epidemic led millions into dependency. As regulations restricted access to prescription opioids, many individuals turned to unregulated and more risky alternatives, intensifying overdose mortality rates. This dual challenge highlights the complexity of addressing opioid misuse, requiring a balance between curbing prescription availability and mitigating the risks associated with substitution to illicit drugs.

This study examines the impact of state-level opioid regulations in Florida and Washington, specifically assessing their effectiveness in reducing opioid shipments and overdose mortality rates. Florida's measures, including prescription monitoring programs_and pill mill laws, focused on limiting overprescription, while Washington adopted harm reduction policies aimed at minimizing misuse. To distinguish the effects of these interventions from broader trends, control states with comparable demographic, healthcare, and cultural characteristics were selected—Georgia, North Carolina, and South Carolina for Florida, and Colorado, Oregon, and Montana for Washington. Using pre-post and difference-in-differences analyses, this research provides a comprehensive evaluation of these policies, offering actionable insights to inform the development of more effective public health strategies.

Research Question

The project aims to answer the following question:
"What is the effect of opioid prescription regulations implemented in specific states on the volume of opioids prescribed and drug overdose deaths"

Motivation

Initially, the hypothesis for this project suggested that opioid prescription regulations would lead to a reduction in the volume of opioids prescribed. However, these regulations could have unintended consequences on drug overdose mortality rates. Individuals already struggling with opioid addiction might turn to illegal or alternative substances, which are often more dangerous, potentially resulting in an increase in overdose-related deaths. This complex relationship underscores the importance of a nuanced evaluation of both the intended and unintended effects of opioid policy interventions.

Data Sources

This study leverages multiple datasets to analyze the impact of opioid-related policies
including the following: Centers for Disease Control and Prevention (CDC), State health departments, U.S. Vital Statistics Mortality Data

State choices

While not a data source itself, the control group plays a crucial role in establishing a baseline for comparison, enabling researchers to isolate the effects of an intervention or policy. However, due to ethical considerations or other constraints, an ideal control group may not always be available. In our study, for instance, the hypothetical data for Florida and Washington in the absence of their opioid policies do not exist. Instead, control states with similar healthcare systems, cultural contexts, and environmental conditions—but with fewer or no equivalent opioid policies—allow us to account for time trends, isolate the treatment effects, and verify the parallel trends assumption, effectively serving as proxies for Florida and Washington without opioid policies.

To find suitable control states for your evaluation of opioid policies in Florida (FL) and Washington (WA), we need to focus on states with similar healthcare, cultural, and environmental conditions while also ensuring that the states have weak or no state-level opioid regulations, or have not enforced them strongly during our study period. Needless to say that it is important that the control states have weak or no state-level opioid regulations or enforcement during your study period to avoid confounding the results. Similar population size, demographic makeup and healthcare system characteristics ensure that differences in outcomes are more likely attributable to the state-level opioid policies rather than these underlying factors. Similar cultural attitudes toward drug use and the healthcare environment help to isolate the effects of opioid policies on the measures.

For **Florida,** we chose **Georgia, North Carolina**, and **South Carolina**. Georgia has a similar demographic profile to Florida, with a mix of urban and rural populations. It shares some healthcare challenges and has not enacted as strict opioid regulations compared to states like New York or Massachusetts. The climate is similar, and there is a comparable level of opioid use and overdose deaths. North Carolina has a similar demographic profile to Florida, with a mix of urban and rural populations. It shares some healthcare challenges and has not enacted as strict opioid regulations compared to states like New York or Massachusetts. The climate is similar, and there is a comparable level of opioid use and overdose deaths. South Carolina shares many cultural and healthcare characteristics with Florida, including a mix of urban and rural populations, a high percentage of elderly individuals, and similar healthcare access issues. Opioid regulation in South Carolina has been less aggressive, making it a good comparison state for Florida.

For **Washington**, we chose **Oregon, Colorado**, and **Montana**. Oregon is geographically and culturally very similar to Washington, with a temperate climate, progressive policies, and similar healthcare systems. Both states have faced similar challenges regarding opioid misuse, but Oregon's regulations and enforcement have not been as strong as Washington's in recent years, which makes it a good comparison for evaluating Washington's policies. Colorado has similar environmental and cultural characteristics to Washington, with a similar temperate climate. However, Colorado has had less aggressive state-level opioid regulation compared to Washington, making it a useful control state to assess the impact of Washington's opioid policies. Montana shares environmental and cultural similarities with Washington, particularly with respect to its rural areas and mountainous climate. Its healthcare system is more challenged, and opioid regulations are not as strictly enforced as in Washington, making it a reasonable control state for comparative analysis.

Opioid Prescriptions (Shipment)

This dataset, obtained through a Freedom of Information Act (FOIA) request to the U.S. Drug Enforcement Agency (DEA) and released by the Washington Post in 2020 (updated in 2023), provides detailed records of prescription opioid shipments across U.S. counties from 2010 to 2019[1]. It serves as a critical resource for understanding the distribution and availability of prescription opioids, enabling a detailed analysis of prescribing patterns and their potential link to overdose outcomes. According to the Substance Abuse and Mental Health Service Administration (SAMHSA), naloxone and nalmefene are the two FDA-approved opioid overdose reversal medications (OORM) and also under the umbrella of opioids. Drug names used for medical treatment that can readily lead to overdose include hydrocodone, oxycodone, morphine, fentanyl, buprenorphine, codeine, hydromorphone, methadone, meperidine, oxymorphone, tapentadol, powdered opium, levorphanol, and dihydrocodeine, which are the ones used in the research.

Mortality Data

The dataset, spanning from 2003 to 2015, provides granular county-level mortality statistics derived from the U.S. Vital Statistics Mortality Data, a trusted source under the National Center for Health Statistics (NCHS)[2]. To ensure a focused and actionable analysis, the dataset includes only opioid-related overdose deaths, classified according to the Tenth Revision of the International Classification of Diseases (ICD–10).

To enhance the relevance and contextual understanding of the opioid crisis, state-level population data were integrated into the analysis. This allowed the calculation of mortality rates, enabling comparisons across counties and states. As it was mentioned previously, the geographic focus includes eight states—Florida, Washington, Georgia, North Carolina, South Carolina, Colorado, Oregon, and Montana—offering a diverse representation of regional trends. Additionally, some limitations in a form of privacy safeguards take place, including suppression of data with fewer than 10 deaths, maintaining confidentiality while aggregated data minimizes its impact on trend analysis.

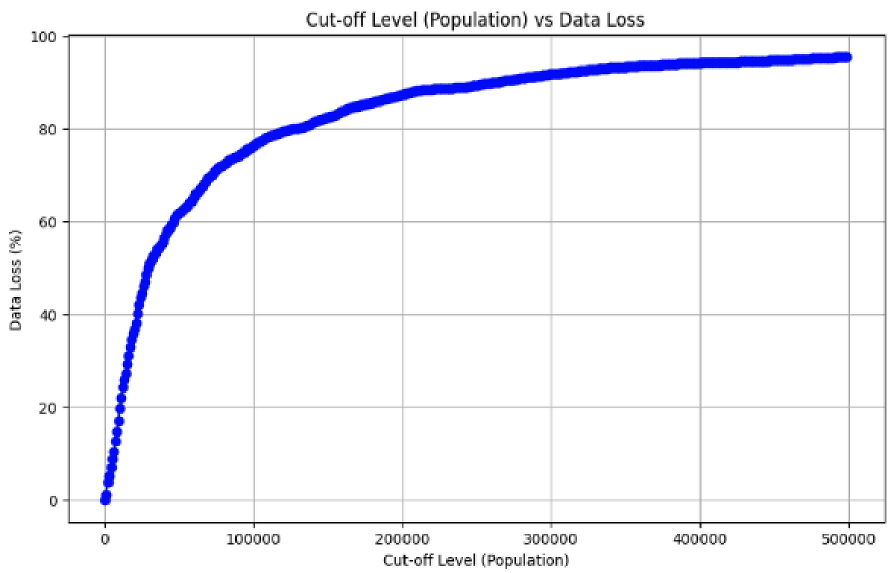
Population

Sourced from the U.S. Census Bureau, the data consists of decennial census statistics, divided into two datasets: 2000-2010 and 2010-2020. To ensure consistency across the data, only the estimated population figures were used, and the analysis focused on county-level data.

Data Analysis Scope

The mortality dataset under analysis, focused on states and drug overdose incidents, is complete with no missing values. In contrast, the shipping dataset contains missing values, with 23 out of the 567 counties in the analysis exhibiting the value of '0'. Among these, six counties lack data for the entire analysis period (2006–2015), while the remaining counties have missing data for specific years only. This suggests they are actual missing values. However, imputing missing values with arbitrary constants or estimates is not considered. This could distort the dataset, particularly in this time-series analysis focused on examining changes before and after policy implementation. Therefore, excluding data from counties with populations below 20,000 would retain 65% of the dataset for analysis, focusing on counties with substantial population sizes without missing values.

Figure 1: Relationship between Cut-off level (population of counties) and Data loss(%)



Methodology

This research employs two primary methodologies: pre-post analysis and difference-in-difference analysis. These approaches address the core challenge of causal inference by estimating outcomes that might have occurred in the absence of policy changes. Pre-post analysis facilitates a comparison of outcomes in Washington and Florida before and after policy implementation. Meanwhile, the difference-in-difference analysis assesses the policy's impact by examining changes in opioid prescriptions and overdose mortality rates, comparing the treated states to control states with similar pre-policy trends.

The methodology integrates pre-post and difference-in-difference approaches. The pre-post analysis evaluates changes in opioid shipments and mortality within each target state before and after policy implementation, assuming that outcomes in the post-policy period would have remained similar to the pre-policy period in the absence of intervention. The difference-in-difference analysis extends this framework by comparing trends in the target states to control states, accounting for shared external factors such as federal initiatives or national trends in opioid prescribing.

Pre-Post Analysis

The pre-post analysis compares opioid shipments and overdose mortality rates in Florida and Washington before and after the implementation of state-level opioid regulations. This method provides an initial measure of the policies' direct effects within each state.

For Florida, the analysis focuses on policy changes implemented in 2010, which included the establishment of prescription monitoring programs and strict regulations on pain clinics. By comparing trends in opioid shipments and mortality rates from 2006–2009 (pre-policy) to 2010–2013 (post-policy), we assess whether the policies curtailed opioid misuse and related deaths.

In Washington, the focus is on policies enacted in 2012, emphasizing harm reduction strategies such as naloxone distribution and medication-assisted treatment (MAT)[3]. The analysis examines shipment volumes and mortality trends from 2008–2011 (pre-policy) to 2012–2015 (post-policy), evaluating the effectiveness of these measures in reducing opioid misuse and fatalities.

Although the pre-post analysis offers a clear and direct assessment of the policies' effects, it inherently assumes that any observed changes are entirely due to the regulations. To address this limitation and account for potential confounding factors, additional analytical methods are required.

Difference-in-Difference Analysis

To address the limitations of the pre-post analysis, the difference-in-difference (DiD) method compares changes in opioid shipments and mortality rates in Florida and Washington to those in their respective control states. This approach accounts for broader trends and external factors that may influence outcomes in both target and control states. For example, during the study period, federal initiatives such as the 2010 Affordable Care Act may have increased access to healthcare services, including addiction treatment, across the nation.

For the Florida analysis, Georgia, North Carolina, and South Carolina were chosen as control states due to their comparable demographics, healthcare systems, and less stringent opioid regulations during the study period. By examining the differences in trends between Florida and these control states, the DiD analysis aims to distinguish the specific impact of Florida's policies from broader regional or national factors.

Similarly, in Washington, control states—Oregon, Colorado, and Montana—were chosen for their geographic and cultural similarities but less stringent opioid policies. The analysis examines whether Washington experienced significantly different changes in opioid shipments and mortality rates relative to these states following its policy implementation in 2012. For a more detailed discussion of the criteria used to select control states, please refer to Difference-To-Difference in the appendix. The appendix outlines the demographic, healthcare, and cultural similarities between Washington and its control states (Oregon, Colorado, and Montana), which justify their use in the analysis.

The DiD approach employs linear regression to estimate the differential impact of the policies, quantifying the extent to which changes in the target states exceed those observed in the control states. This method strengthens causal inference by leveraging the assumption that, in the absence of policy changes, trends in target and control states would have followed parallel trajectories.

Results

Opioid Mortality Rate

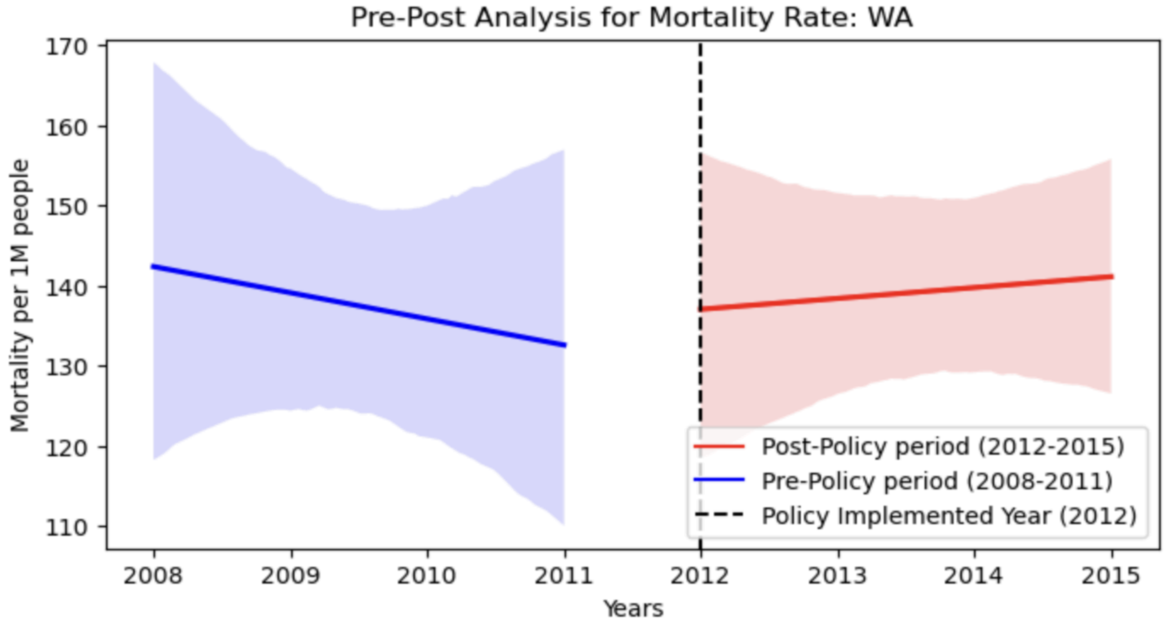
Pre-Post Analysis (Washington)

Figure 2 illustrates that before the 2012 policy implementation, Washington's mortality rates steadily declined, likely reflecting the success of prior health initiatives or public health improvements (blue line). However, following the policy aimed at curbing opioid-related deaths by restricting prescription opioid shipments, mortality rates rose slightly (red line). This suggests unintended consequences: restricted access to prescription opioids may have led individuals to substitute with more dangerous substances like fentanyl and heroin, which carry higher overdose risks. These shifts emphasize the need for strategies such as harm reduction programs, improved addiction treatment, and preventive measures.

Difference-in-Difference Analysis (Washington vs. Control States)

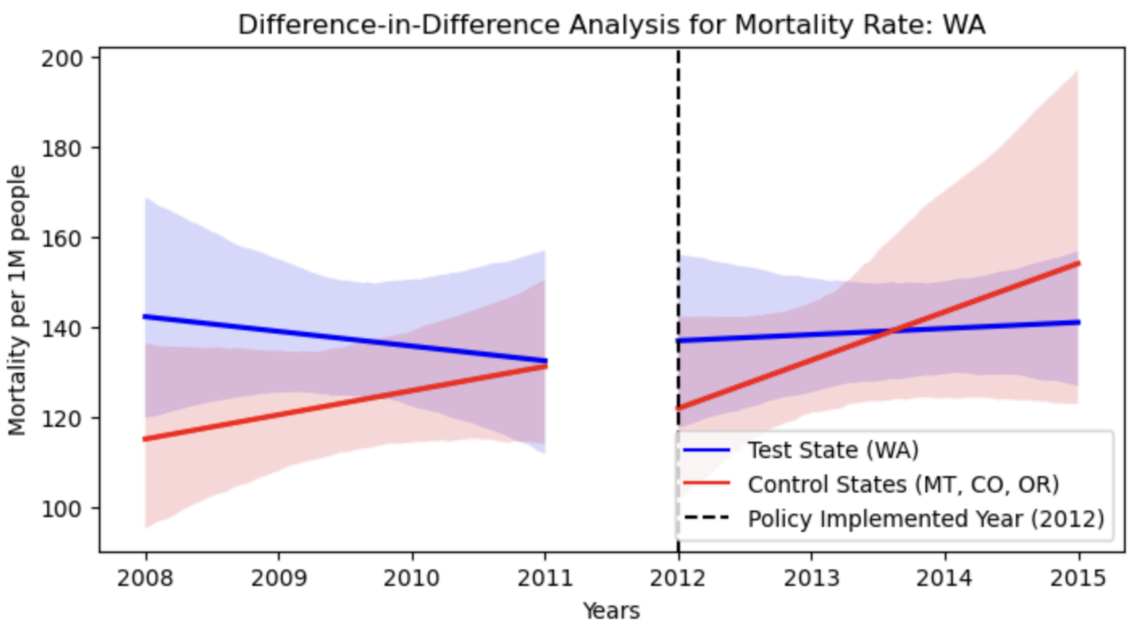
According to Figure 3, Washington's pre-policy decline in mortality rates contrasts with the control states (Colorado, Oregon, and Montana), which exhibited increasing mortality rates even before the policy was implemented. Post-policy, mortality rates rose in both Washington and the control states. However, the increase in Washington was less pronounced, suggesting that the policy had a modest mitigating effect compared to the sharper rise observed in the control states.

Figure 2: Mortality Rate per 1 million Population by Year in Washington



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2012) in Washington. Pre-policy data (2008-2011) and post-policy data (2012-2015) were used.

Figure 3: Mortality Rate per 1 million Population by Year in Washington vs Control States



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2011) in Washington. Pre-policy data (2008-2011) and post-policy data (2012-2015) were used.

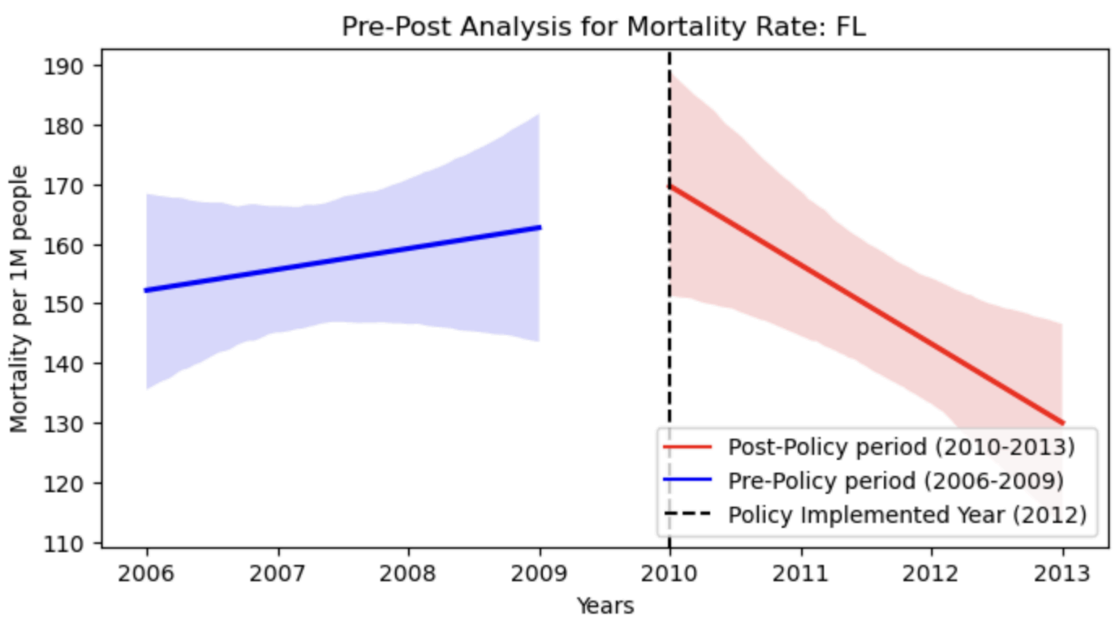
Pre-Post Analysis (Florida)

Before the policy implementation, Florida's mortality rate showed a gradual upward trend (fig. 4). However, after 2010, the mortality rate began to decline sharply, indicating a significant reduction in deaths per 1 million people. This suggests that the policy effectively addressed key factors contributing to mortality. The success of Florida’s approach highlights the importance of targeted public health interventions. Comparing these outcomes with states like Washington may provide valuable insights into effective strategies for broader adoption.

Difference-in-Difference Analysis (Florida vs. Control States)

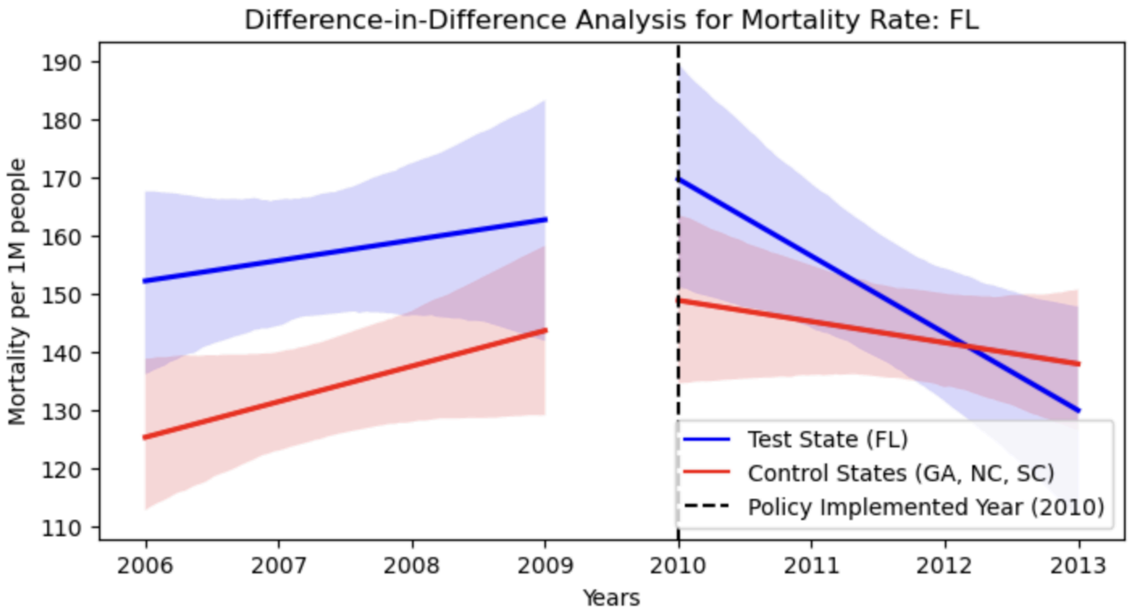
Figure 5 shows that both Florida and the control states (Georgia, North Carolina, and South Carolina) experienced reductions in mortality rates following policy changes, despite having upward trends between 2006 and 2009. However, the similarity in trends across all states suggests that the observed decline in Florida may not be solely attributable to state-specific policies. Broader federal or nationwide initiatives likely contributed to the decrease, making it difficult to isolate the effects of Florida’s policies alone (a phenomenon often referred to as a "placebo effect" in scientific studies).

Figure 4: Mortality Rate per 1 million Population by Year in Florida



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2010) in Florida. Pre-policy data (2006-2009) and post-policy data (2010-2013) were used.

Figure 5: Mortality Rate per 1 million Population by Year in Florida vs Control States



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2010) in Washington. Pre-policy data (2006-2009) and post-policy data (2010-2013) were used.

Opioid Shipments

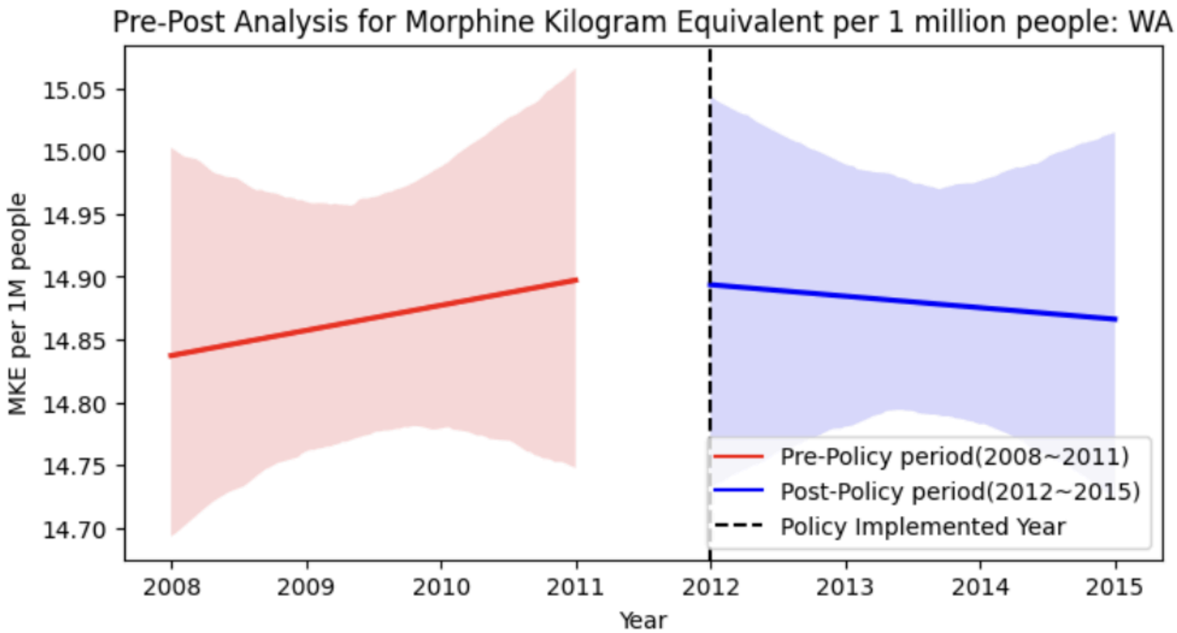
Pre-post analysis (Washington)

Figure 6 below illustrates the trend in Morphine Kilogram Equivalent (MKE), a standardized measure of opioid potency and consumption, shipped per one million population in Washington. The data is divided into pre-policy and post-policy periods around the implementation of harm reduction-focused opioid policies in 2012. During the pre-policy period, MKE shipments showed a steady upward trend. Post-policy, MKE shipments stabilized with minimal decline, suggesting the policy had a limited impact.

Difference-In-Difference Analysis (Washington vs. Control States)

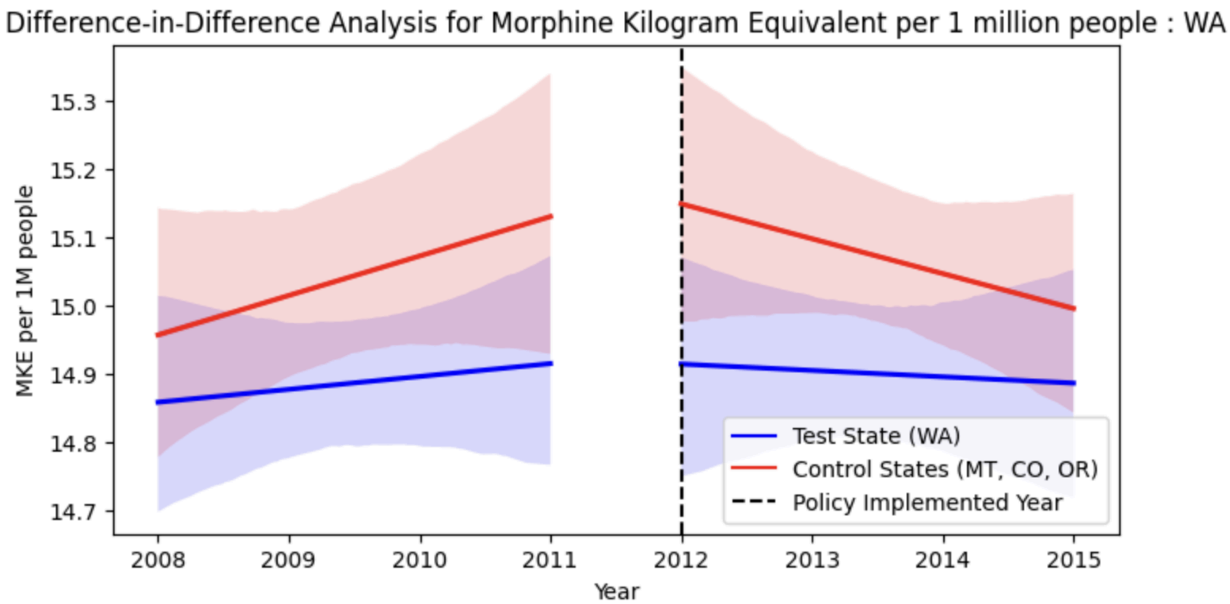
Figure 7 below presents a Difference-in-Differences analysis of MKE shipped per one million population in Washington and its control states—Montana, Colorado, and Oregon—before and after Washington's harm reduction-focused opioid policies in 2012. During the pre-policy period, Washington's MKE shipments showed a steady increase, while control states experienced a gradual rise. Post-policy, control states showed a substantial and sustained decrease in MKE shipments, whereas Washington's shipments showed minimal decline. This contrast suggests that broader regional or national factors, rather than Washington's specific policies, may have played a more significant role in reducing opioid shipments.

Figure 6: Morphine Kilogram Equivalent Shipped per 1 million people by Year in Washington



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2012) in Washington. Pre-policy data (2008-2011) and post-policy data (2012-2015) were used.

Figure 7: Morphine Kilogram Equivalent shipped per 1 million people in Washington vs. Control States



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2012) in Washington. Pre-policy data (2008-2011) and post-policy data (2012-2015) were used.

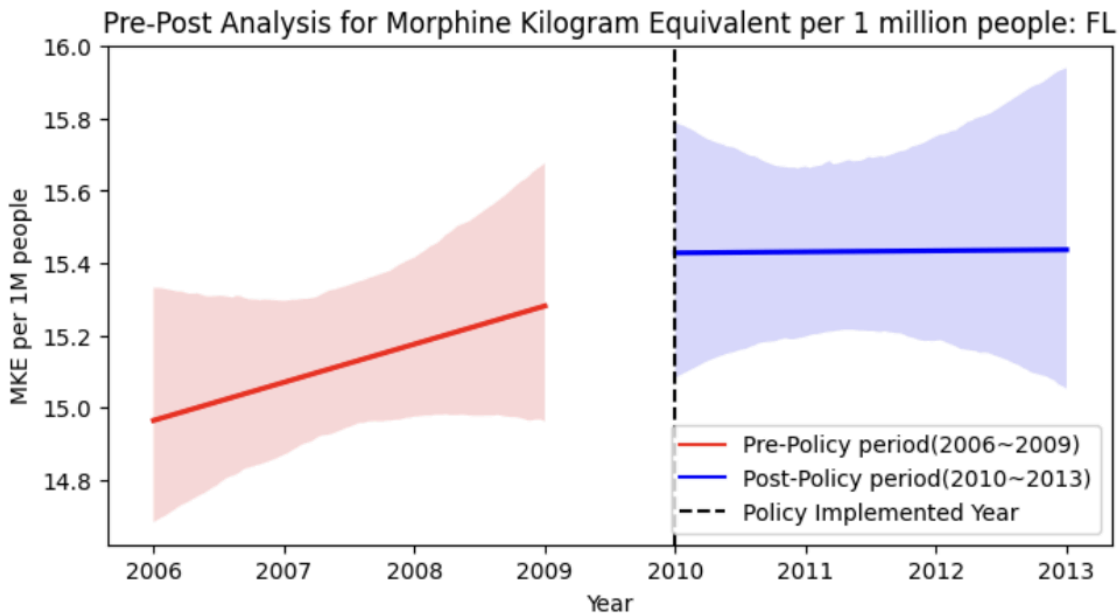
Pre-post analysis: Florida

In Florida, the opioid prescription rate per population increased sharply during the three years prior to the policy implementation (2006–2009). However, following the introduction of opioid regulations in 2010, this growth trend stagnated. Figure 8 below illustrates these trends in MKE shipments before and after the policy implementation. During the pre-policy period, represented by the red line, MKE shipments per capita showed a steady upward trend, reflecting increasing opioid distribution. In the post-policy period (2010–2013), represented by the blue line, this growth stabilized, suggesting that Florida's policies curbed the rapid rise in opioid shipments and had an immediate impact on overprescription.

Difference-in-Difference analysis: Florida vs. control states

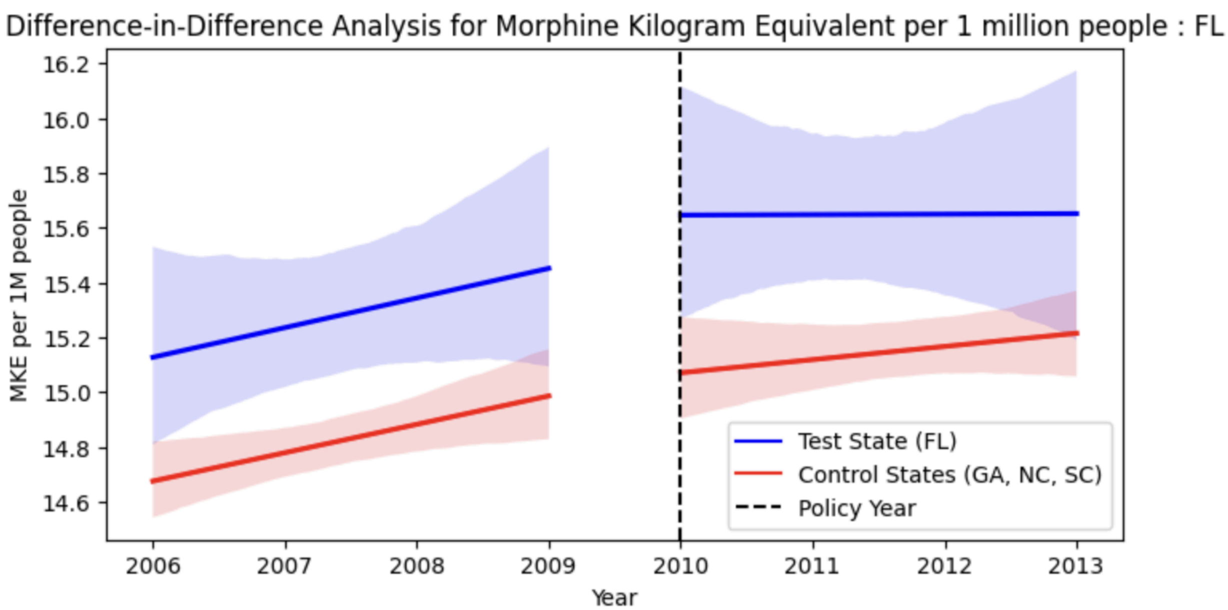
The figure 8 below compares opioid shipments in Florida and its control states—Georgia, North Carolina, and South Carolina—before and after Florida implemented opioid prescription regulations in 2010. Before the policy (2007–2010), shown on the left side of the graph, Florida exhibited a steady upward trend in MKE shipments per one million population, while the control states showed a similar parallel increase. After the policy (2010–2013), Florida’s MKE shipments stabilized, whereas the control states continued a slight increase. This divergence suggests that Florida’s policies effectively curbed the growth of opioid shipments, unlike the control states without similar regulations. However, broader national trends or external factors may also have played a role in these outcomes.

Figure 8: Morphine Kilogram Equivalent shipped per 1 million people by year in Florida



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2010) in Florida. Pre-policy data (2006-2009) and post-policy data (2010-2013) were used.

Figure 9: Morphine Kilogram Equivalent Shipped per 1 million people in Florida vs. Control States



Note: The shaded regions represent 95% confidence intervals. The analysis compares mortality rates before and after the policy implementation year (2010) in Florida. Pre-policy data (2006-2009) and post-policy data (2010-2013) were used.

Conclusion

Our analysis revealed significant differences in the effectiveness of state-level opioid policies in Florida and Washington. The study focused on misused prescription opioids, including hydrocodone, oxycodone, morphine, fentanyl, and methadone. In Florida, opioid prescription policies slowed the rapid increase in opioid shipments and significantly reduced overdose mortality rates. By contrast, Washington’s harm reduction-focused policies led to an initial modest decline in opioid shipments, but this effect was limited, with only a modest reduction in overdose mortality rates observed.These findings underscore the highly context-dependent nature of policy outcomes, shaped by each state’s unique characteristics and challenges. Florida’s approach illustrates the potential of regulations to effectively lower overprescription and save lives, although the trend was present for control states as well, suggesting that another nation-wide factor was affecting the decline. The outcomes in Washington highlight unintended consequences, such as individuals seeming to turn to riskier alternatives like heroin or fentanyl when access to prescription opioids is restricted. This underscores the need for policymakers to balance regulatory controls with harm reduction strategies to minimize these risks. Our findings suggest that a one-size-fits-all approach is unlikely to succeed; instead, opioid policies must be tailored to address the distinct needs and demographics of individual states.

We also identified key areas where further research is essential. Evaluating local-level interventions, such as community-based treatment programs and public education initiatives, could shed light on their role in supporting state-level policies. Long-term studies are needed to understand the sustained impacts of opioid regulations and how they adapt to shifting drug use patterns. Additionally, exploring the effects of these policies across diverse population subgroups—such as age, race, and socioeconomic status—can help address disparities in outcomes and promote equity in combating the opioid crisis.

Our analysis faced certain limitations that should guide future research. Privacy-related data suppression and incomplete records for smaller counties constrained the scope of our findings. Additionally, unmeasured factors, such as variations in enforcement or regional dynamics, may have influenced the results. Future studies should prioritize using more granular data and refining analytical methods to provide a clearer understanding of policy impacts. Not only that, setting the cutoff level focusing on counties with populations over 20,000 may have influenced the study results. Thus, future research could explore alternative cutoff levels or imputation techniques to evaluate the robustness of the findings and avoid potential biases.

In conclusion, the study highlights both the opportunities and challenges associated with state-level opioid regulations. By learning from the outcomes observed in Florida and Washington, policymakers can develop more balanced, adaptable, and equitable strategies to effectively address the opioid epidemic.

Appendices

Mortality Data Cleaning

The mortality dataset, which is central to this analysis, has undergone a detailed cleaning process to ensure its accuracy and usability. The dataset originally contained information on all drug-related deaths in the United States from 2003 to 2015, categorized by county and year. To focus the analysis on opioid overdose deaths specifically, we filtered the data to include only deaths classified under the following ICD–10 codes: unintentional overdoses (X40–X44), Drug poisoning suicides (X60–X64), Drug poisoning homicides (X85), and cases of undetermined intent (Y10–Y14). This targeted approach ensures that the analysis remains focused on opioid-related fatalities.

During the cleaning process, we addressed several challenges to make the data consistent and reliable for analysis. For instance, privacy rules in the dataset meant that information was suppressed when fewer than 10 deaths were recorded in a given county, year, or cause-of-death category. To manage this, the data was aggregated across years or counties when necessary, reducing the likelihood of missing or incomplete records while maintaining the validity of the trends.

The dataset also required reorganization to improve readability and facilitate analysis. Irrelevant columns, such as notes and unused cause-of-death codes, were removed to streamline the dataset. Additionally, any non-numeric values in the "Deaths" column, such as missing or invalid entries, were converted to a consistent format or excluded from the analysis.

To enable a fair comparison across regions and time periods, the dataset was merged with population data, allowing us to calculate per capita mortality rates. This adjustment is essential for accurately identifying patterns and disparities in opioid overdose deaths across different counties and states.

Overall, these cleaning efforts have transformed a raw, complex dataset into a structured, focused resource. This ensures that the data is not only reliable but also meaningful, enabling an accurate and insightful analysis of opioid overdose mortality trends. By addressing inconsistencies and aligning the dataset with the study's goals, we’ve laid a solid foundation for understanding the impact of opioid policies and interventions.

Difference-In-Difference Analysis

In selecting control states, we considered factors such as similar healthcare infrastructure, population demographics, and opioid use trends. Oregon, for instance, shares geographic and cultural similarities with Washington but implemented fewer harm reduction policies during the study period. Similarly, Colorado and Montana provide valuable comparisons due to their temperate climates and rural healthcare challenges, ensuring a robust basis for evaluating Washington's policy effects."=

Data Columns

Opioid Prescription	Mortality	Population
Year Buyer State Buyer County MME (Morphine Milligram equivalent)	Year State County County Code Deaths (drug related only)	Year State County County Code Estimated Population + FIPS code integrated

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