

Insights from the Influx of Prescription Painkillers in Northeast Florida: A Retrospective Analysis

Joseph Free
Dr. Michelle DeDeo (Faculty Advisor)
University of North Florida
Dedicated in memory of Kyle Forgy

ABSTRACT

The opioid epidemic has had, and will have, long-lasting ramifications in the United States. To better understand its impact in the Northeast Florida, this research seeks to **identify relationships between hydro- and oxycodone pill concentration at the county and zip code levels and socio-economic factors such as average adjusted gross income and opioid related mortality.**

This project utilizes **time series, regression, and GIS methods** to examine local opioid saturation and has led to the development of an **interactive Tableau dashboard** which allows users to view opioid saturation at various levels of granularity.

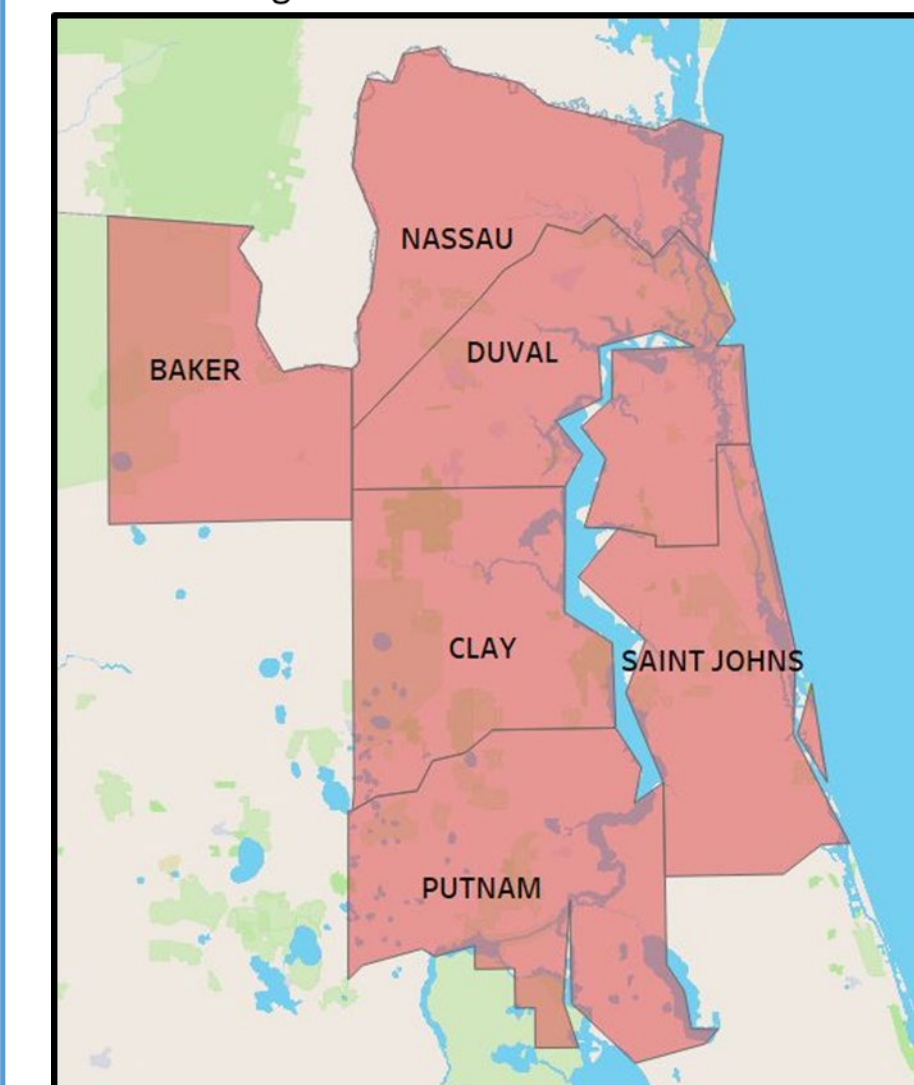
This analysis is made possible by longitudinal data collected and released by the Florida Department of Health, the DEA Automation of Reports and Consolidated Orders System (ARCOS), and other public sources spanning the years 2006-2014.

In this presentation, preliminary results and analyses from the previous semester are reviewed and summarized.

OBJECTIVES

The primary aim of this project is to explore and assess the effects of prescription opioids in Northeast Florida at the macro level. For the purposes of this research, Northeast Florida has broadly been

Working Definition of Northeast Florida



defined as consisting of **Baker, Clay, Duval, Nassau, Putnam, and Saint Johns** counties and the zip codes contained therein.

To assess potential effects, focus was placed on:

1. Identifying the amount of prescription oxy- and hydrocodone pills present in NE Florida
2. Determining specific regions of NE Florida with the highest concentration of prescription opioids

3. Creating an interactive summary dashboard to view descriptive statistics within NE Florida and aid in identifying spatial effects for future research.

4. Determining whether a presumptive causal link exists between the amount of prescription opioids in a given region and opioid related fatalities within that region.

DATA

Most data used in this project originated from publicly available sources. The principal data used in the preliminary analysis include:

- The DEA ARCOS database records from 2006-2014 filtered by NE Florida counties. ARCOS tracks drug sales to retailers such as pharmacies, grocery stores, hospitals, and doctor's offices. Released via Washington Post lawsuit July 16, 2019 (available through the Washington Post).
- Interval Revenue Service Statistics of Income (SOI) data. Contains summary individual tax return information at zip code level. Available via <http://www.irs.gov>
- Florida Department of Health opioid related mortality data. Released via FLDOH IRB approval and data sharing agreement.
- Bureau of Labor Statistics Unemployment Statistics for NE Florida. Available via <http://www.bls.gov>

Data manipulation was conducted using a combination of Python, R, SQL, and SAS.

METHODS

- Daily reports from the DEA's ARCOS database between 2006-2014 were aggregated to create monthly summary totals. These summary totals were then plotted in Figure 1 to chart the evolution of prescription oxy- and hydrocodone pills in NE Florida. Additionally, time series methods were then used to fit a seasonal autoregressive moving average model using R (SARIMA(0,1,1)x(01,2)₁₂) after assessing PACF/ACF plots and model diagnostics. The model was then used to estimate monthly pill totals for 2015 to 2018. These estimates were also plotted in Fig. 1 with their margin of errors.
- Since the range of available data overlaps with the housing crisis, the NE Florida unemployment rate was compared to the influx of pills at the yearly level in Fig. 2.
- Tableau was utilized to address foci #2 and #3 simultaneously. ArcGIS geocoding was used along with the ARCOS records to extract relevant spatial information and local pill concentrations at the zip code level. Based on the number of ARCOS transactions, zip codes were ranked between 1 and 60 to denote relative levels of opioid saturation with 1 indicating most saturated and 60 denoting least saturated. Fig. 3 gives a summary view of the generated map. The resulting dashboard allows for users to drill into individual zip codes and retailers (the red dots in Fig. 3) to view opioid purchases over time.
- Lastly, modeling was used to measure the effect of opioid saturation on opioid-related fatalities. Initial analysis consisted of a general linear mixed effect regression whereby opioid deaths were modelled as a response with predictors: year, zip, and number of pills sold. A propensity score matching was also employed in SAS to control for economic variation (using average adjusted gross income) between zip codes. The top 20 ranked zip codes were designated as saturated, and coded with value 1; the remaining zip codes were coded 0. After securing a satisfactory match, a paired difference test was conducted to assess the significance of deaths in highly saturated zip codes vs. low saturated zip codes. The results of the test were then verified with a randomization test using systematic permutation.

RESULTS

- Over the period 2006 to 2014, there were a total of approximately **645 million** oxy- and hydrocodone pills that entered NE Florida. This is enough to provide **approximately 453 pills for each resident in the entire NE Florida region** over the same period.
- The predictions for pill sales over the 2015 to 2018 period (Fig. 1) suggest that anywhere **between 244 million to 381 million pills entered NE Florida in four years**. Note: Predictions had to be used for the period 2015-2018 because the DEA does not publish nor readily permit access to the full ARCOS database. Thus there is no easy way to verify actual NE Florida pill sales over this period.
- **Unemployment and pill sales appeared to be highly correlated** over the period 2006 to 2010, coinciding with the economic crisis. Post-2010, the relationship between pill sales and unemployment becomes more opaque.
- Analysis of the geospatial data and opioid saturation ranks in Tableau **appear to suggest that opioid deaths are related to the proximity of highly saturated zip codes**. For example, from 2006 to 2018 there were 140 deaths in 32210 (Fig. 3, Rank 1). One immediate neighbor to 32210 is 32244 (Fig. 3, Rank 16), which has 109 deaths over the same period. Additionally, the data suggest that population density and distribution of income could potentially be confounding factors.
- The mixed effect model was specified to estimate fixed yearly effects and allow for the effect of opioid concentration (measured by amount of pills) to vary by zip code. Effect estimates for years 2006 to 2010 were found to be insignificant, while those for 2011 to 2014 were significant with $p < 0.005$ for each year. Twenty-six (26) zip codes showed significant effects of pill concentration on death as assessed by whether zero fell within the estimates' margins of error—**many of these zip codes neighbored one another** (Fig. 6).
- The PSM conducted in SAS is summarized in Fig. 4. Zip codes were matched by controlling for average adjusted incomes over 2006 to 2014. Fig. 4 shows adequate balance in the covariates, and negligible differences between the treated and control groups. Of the 20 saturated zip codes, matches were found for 14 of them. A paired differences test was then conducted ($t = 2.11, df = 13, p = 0.055$). It was found that after controlling for the average AGI, **zip codes with higher opioid saturation had a larger number of opioid related fatalities than their lower ranked comparisons** at the $\alpha = .10$ level of significance.
- To verify the results of the PSM, a systematic randomization test of the paired differences was employed (Fig. 5). **The test indicated that for the 14 matched zip codes, fatalities were in fact larger in the opioid saturated zip codes**. Only 90 of 16,384 of the data permutations had equivalent statistics that exceeded the observed value from the paired difference test. ($p = 0.005$).

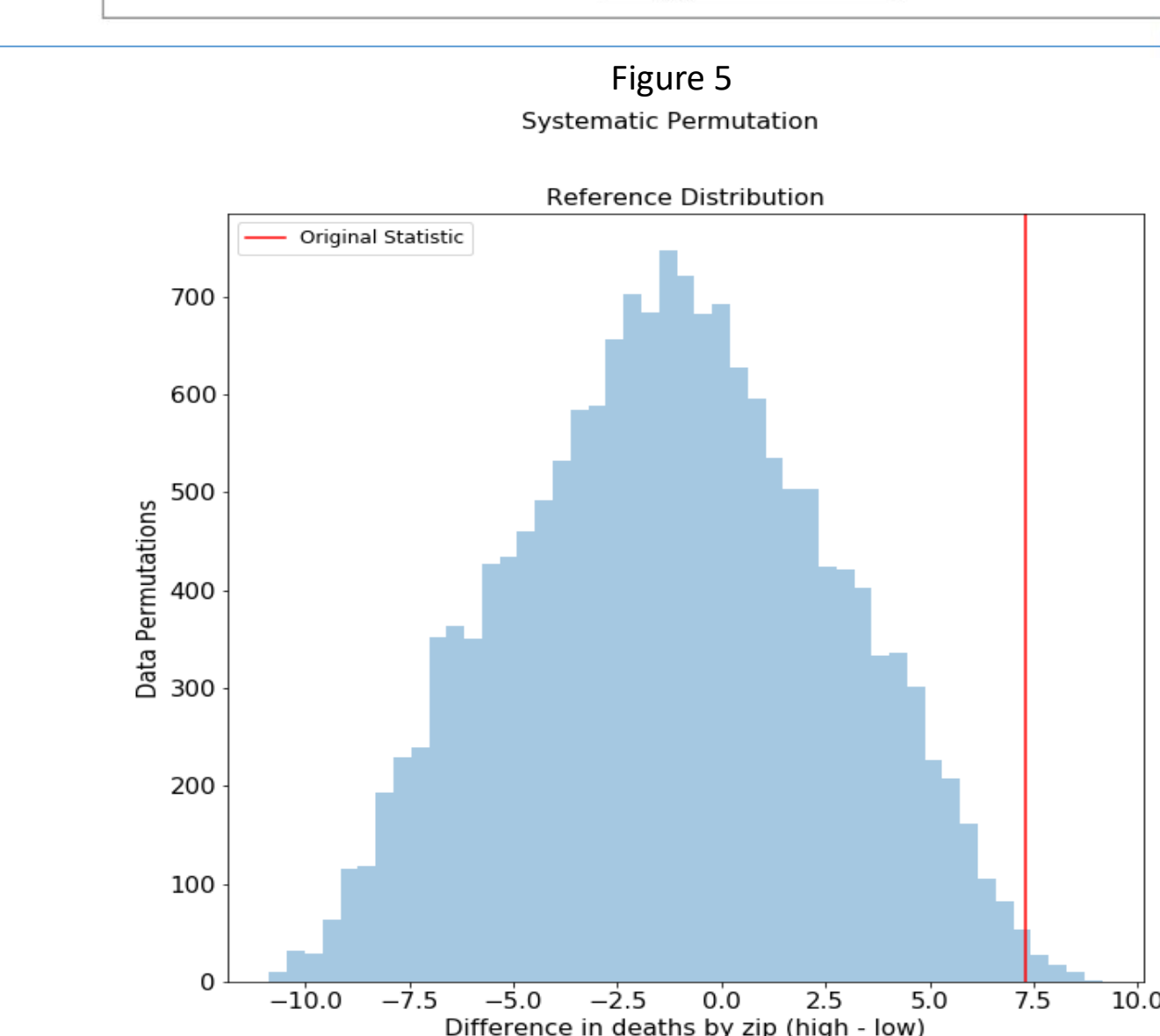
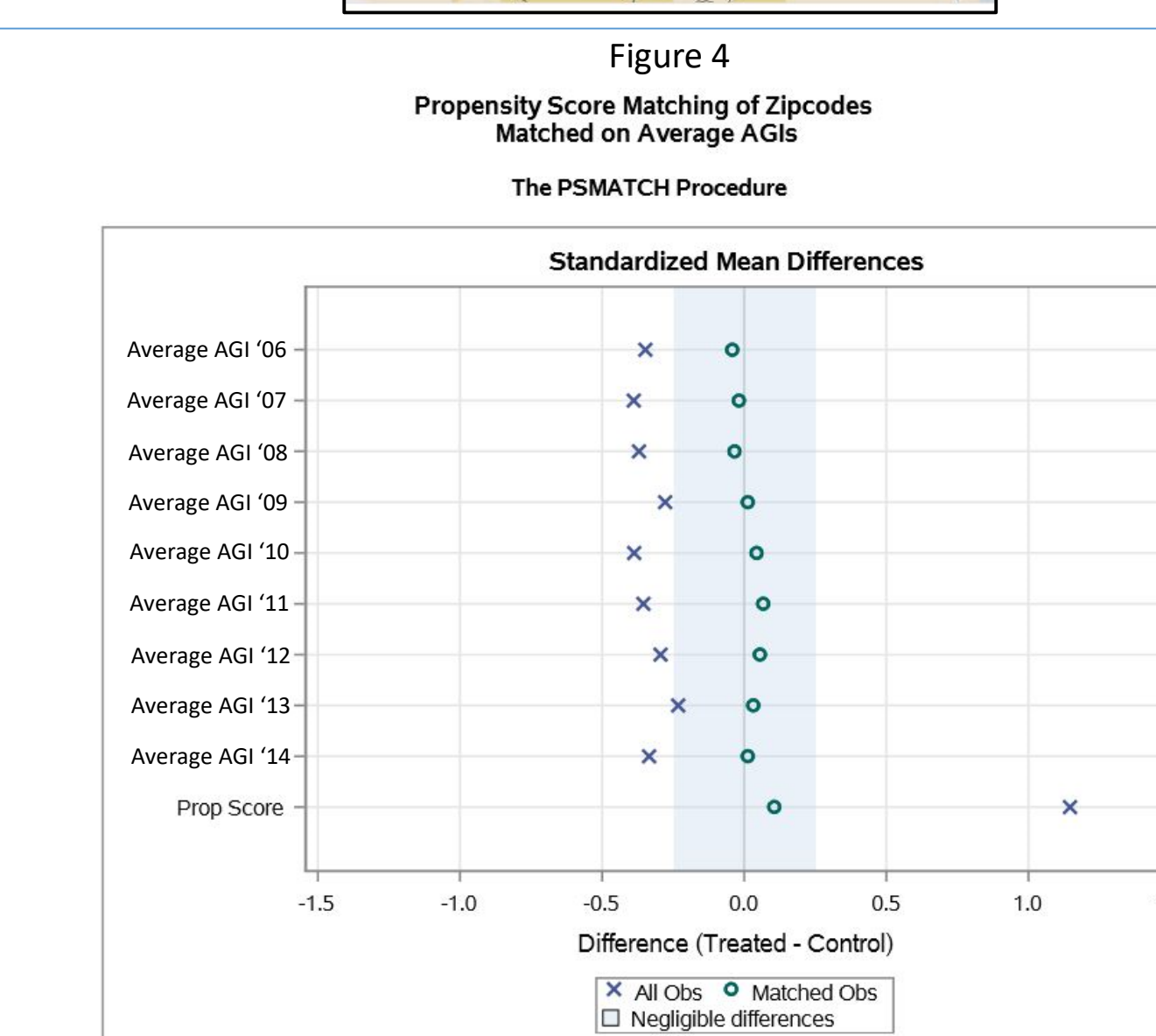
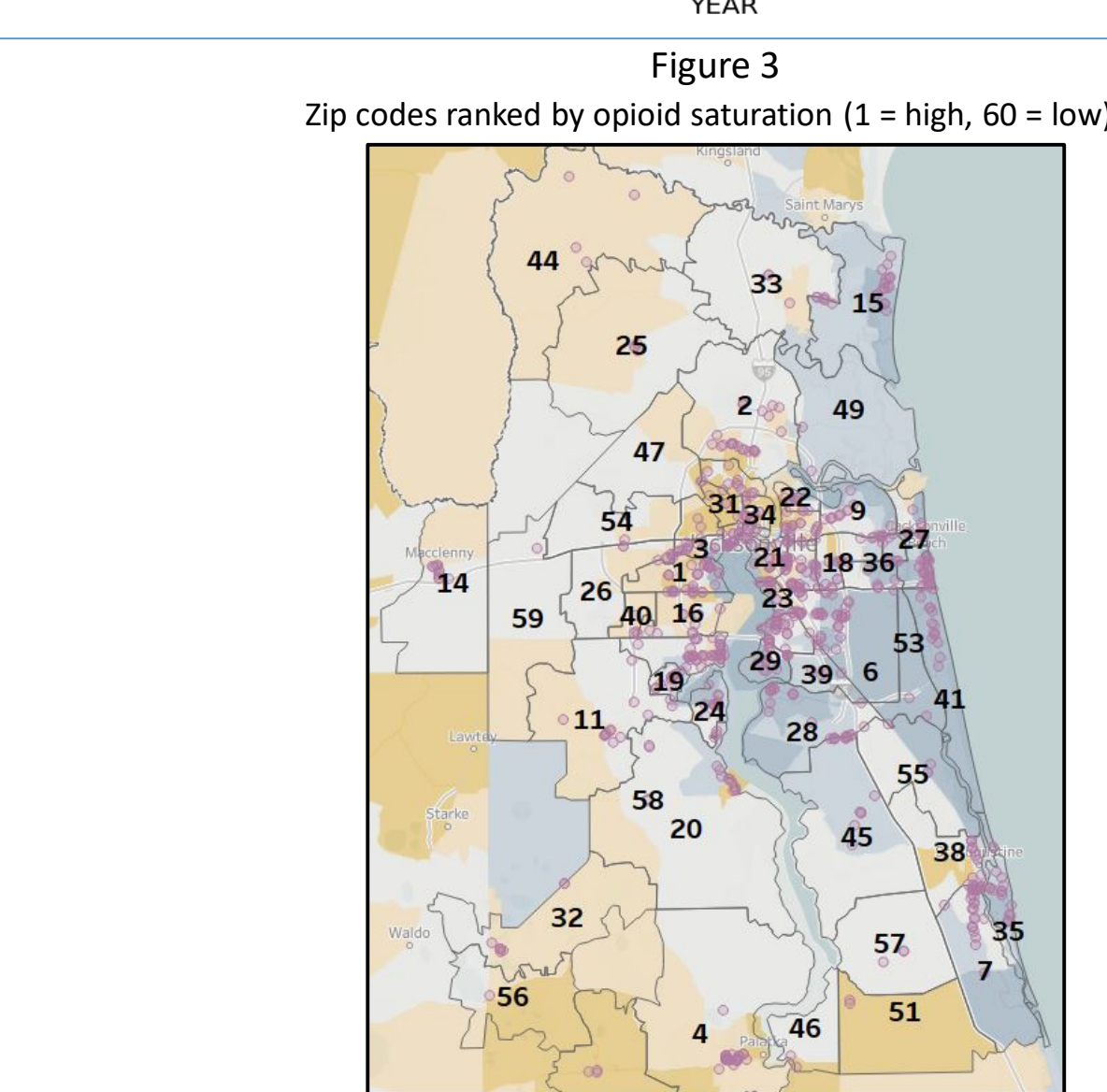
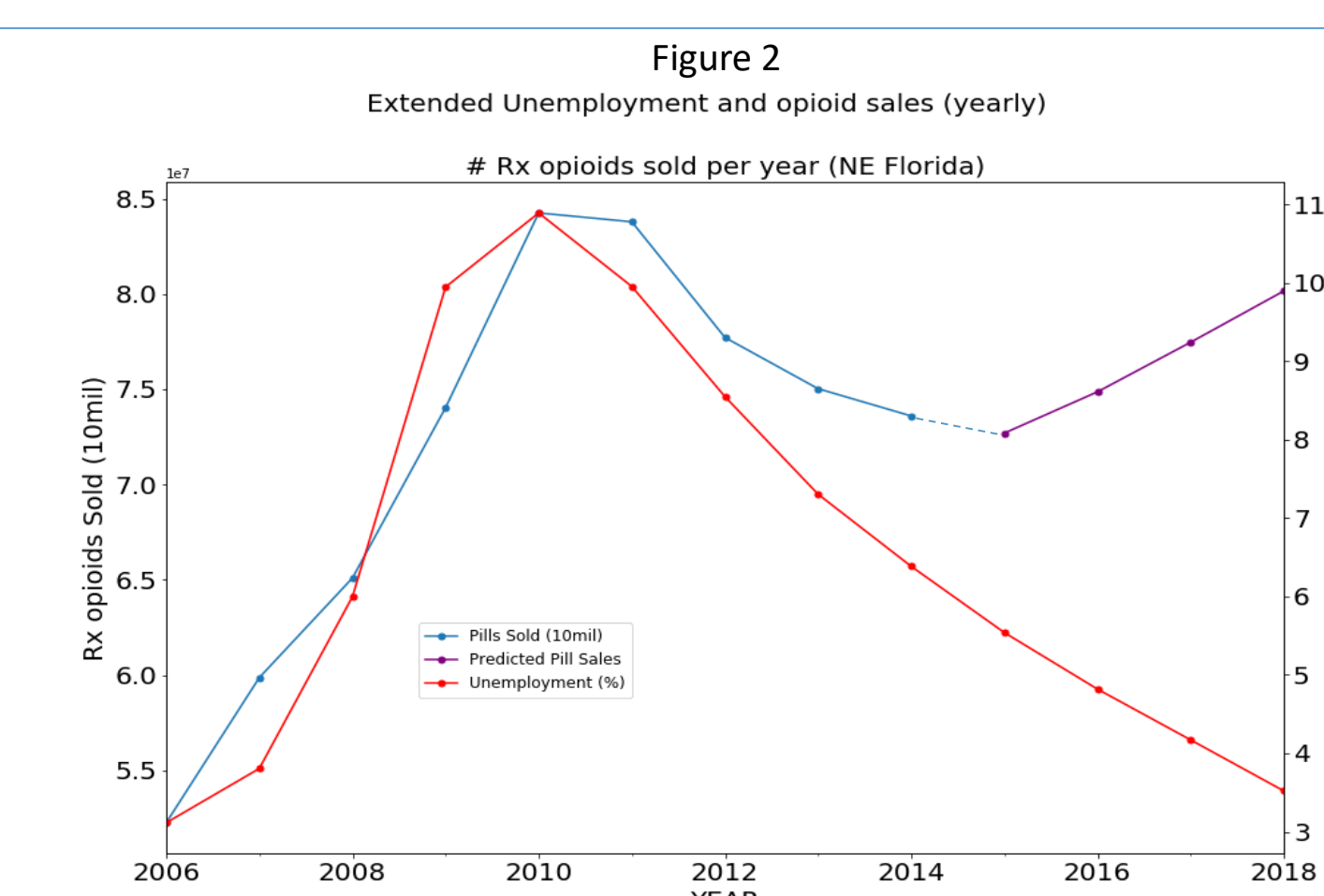
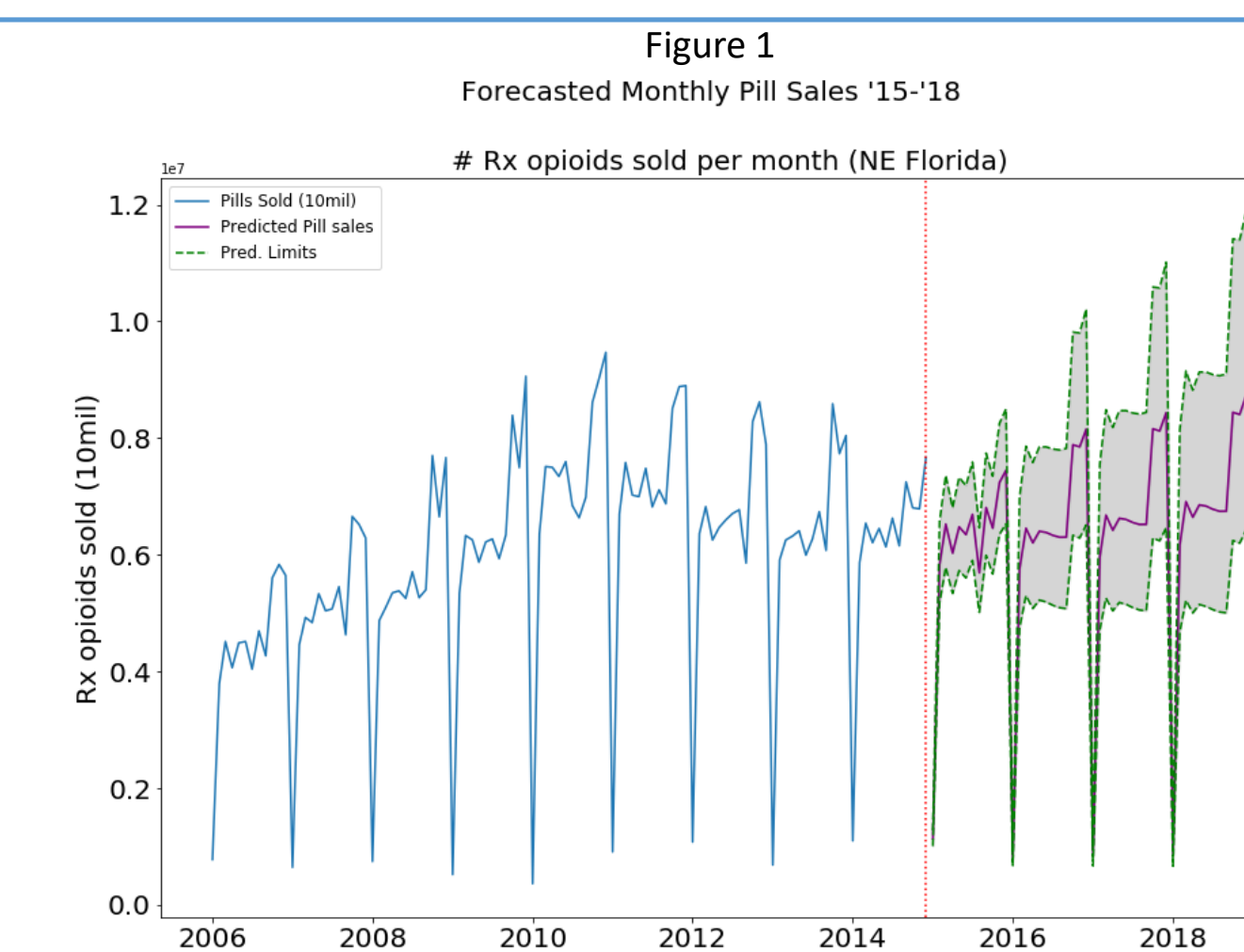
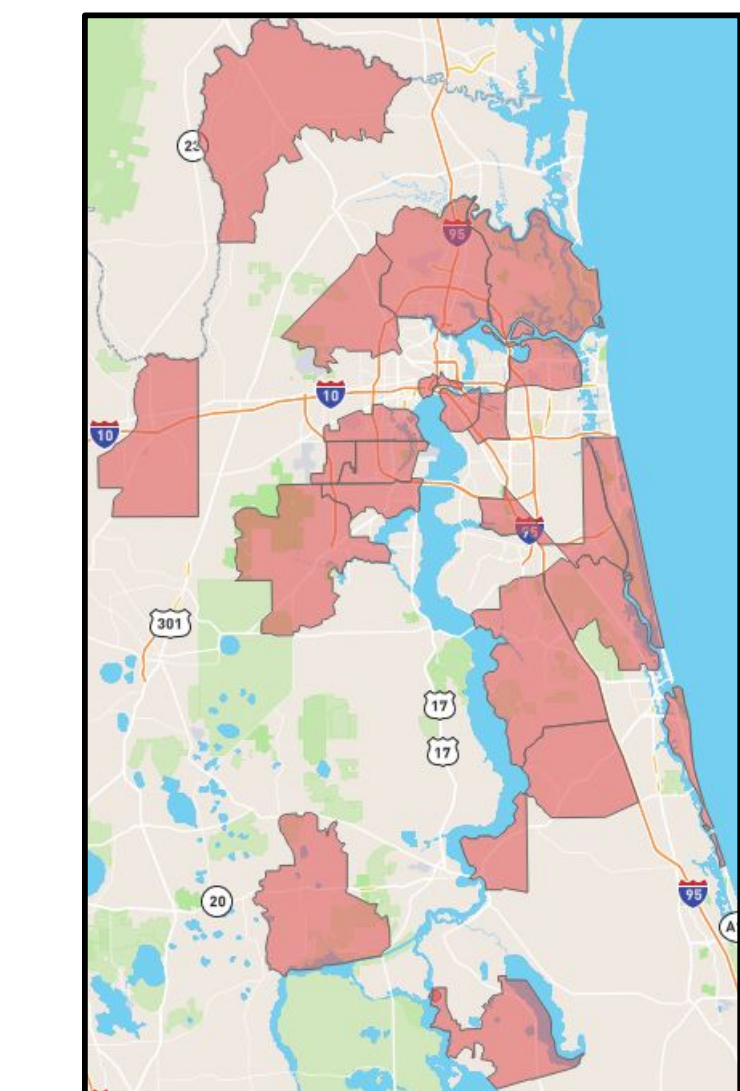


Figure 7
Significant Zips Identified by Regression



CONCLUSION

Based on the preliminary findings of this research, it would appear that a **presumptive causal link exists between the amount of prescription opioids within a zip code and the number of opioid related fatalities**. This much is supported via the results of the paired difference and randomization tests which followed the PSM. The mixed effects model additionally **suggests a link between opioid related fatalities and pill concentrations at the zip code level**. However, these results are less sound than the PSM due to the number of potential unobserved confounding factors including, but not limited to, complex geospatial relationships, changes in reporting cause-of-death to FL DOH over the period 2006 to 2014 (which may explain the insignificance of years 2006-2010), and other socio-economic factors that could not readily be incorporated due to collinearity concerns.

These results seem to indicate that additional research into the nature of opioid concentration and opioid related fatalities as they relate to geographic and socio-economic features could prove fruitful.

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