# Opioid Use in the United States

## Open Case Studies Report

**Abstract**

Drug overdose is the leading cause of unintentional injury associated death in the United States [REF]. Recent studies have shown that prescription opioids are involved in a significant proportion of fatal drug overdoses [REF]. Furthermore, recent studies have indicated that users in rural areas are more likely to be introduces to opioids via prescription drugs. However, the extent to which differential opioid prescription rates between urban and rural communities plays a role in this trend is unclear. In this study, we analyze county level rates of opioid shipment to pharmacies across the United States. Classifying counties as urban vs. rural, we find that the rates of opioid to shipment to rural counties are signficantly higher than those to urban counties across the time period considered. This result suggests that higher opioid prescription rates may be one of the underlying reasons why users in rural communities are more vulnerable to opioid abuse. With these results, we hope to motivate further investigation into the causal role that prescription drugs play in the opioid misuse as a foundation for evidence-based interventions to support the communities that are most vulnerable to the effects of the opioid epidemic.

## Introduction

Opioids are a class of pain-relieving drugs that activate the opioid receptors [REF]. In addition to pain-relief, opioids also inhibit sensation, induce euphoria, and reduce respiratory and heart rate [REF]. Starting in the 1990s, the rate of opioid prescription increased dramatically [REF]. This was in part due to a concerted campaign by pharmaceutical companies to reassure the medical community that opioids had limited potential for abuse or dependence [REF]. This resulted in widespread misuse of both prescription and non-prescription opioids.

In the period between 1999 and 2018, 450,000 people had died from an overdose involving opioids [REF]. In 2017, the United States Department of Health and Human Services declared the opioid epidemic a public health emergency [REF]. At this time, drug overdose is the leading cause of unintentional injury-associated death in the United States [REF], with around 130 daily deaths attributed to opioid-related drug overdoses [REF].

Deaths from commonly prescribed opioids have recently plateaued. However, deaths from heroin and other synthetic opioids have been increasing over the past decade [REF]. Opioid users often start by using prescription opioids and after becoming dependent, then switching to heroin or other illicitly manufactured or obtained opioids [REF]. Studies examining rates of opioid use across demographic and geographic groups have shown that opioid use rates are higher in rural communities compared to urban ones [REF].

While the difference in opioid use rates between rural and urban areas has been well documented, the factors underlying this discrepancy remain poorly understood. Given the role that prescription drugs play in initiating substance use and misuse, we wanted to investigate if differential opioid prescription rates could be contributing to this observed trend. We examined the rates of opioid shipment to pharmacies across the United States at a county level using data obtained from the Drug Enforcement Agency. Classifying counties by urbanicity and analyzing data from 2006 to 2014, we compared the rates of opioid shipment to urban counties and rural ones. We found that throughout the period considered, the rate of opioid shipment is significantly higher in small urban or rural counties compared to urban ones, with the difference increasing over time. We hope that these results motivate further investigation into the role that opioid prescription plays in opioid misuse.

**Results**

In this study, we used opioid shipment data collected by the United States Drug Enforcement Agency as part of its Automated Reports and Consolidated Ordering System. The data was obtained and released by the Washington Post. This data also included county level population data. Specifically, we only considered a subset that included oxycodone and hydrocodone, the two most commonly abused opioids.

First, we investigated temporal trends in the average opioid shipment to each county averaged across the United States. We see that, starting in 2006, average opioid shipment numbers increased steadily, peaking in 2011 at about 4.2 million pills (95% CI: 3.8, 4.5 million pills). Since 2011, opioid shipment numbers have been decreasing (Figure 1). A similar trend is seen in number of pill shipment per person, but the peak is seen in 2012 (Figure 2). Comparing number of pills shipped counties in each state, we find that California received the largest number of pills throughout the period considered, peaking in 2012 at over 20 million shipped pills. However, this result does not hold when normalizing by county population.
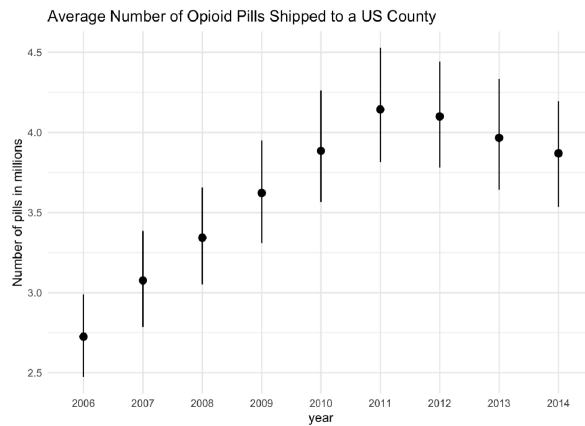


Figure 1: Figure 1: Average number of pills shipped to US counties
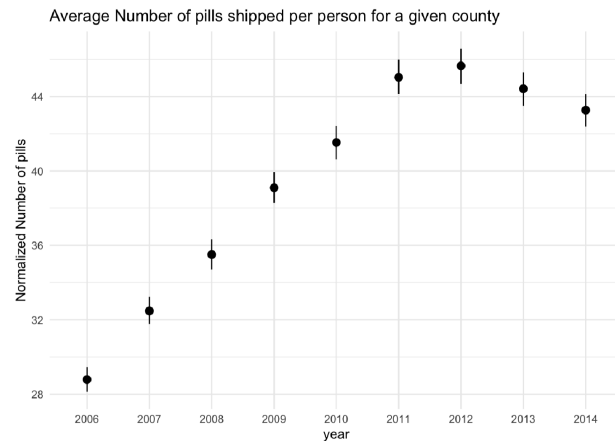


Figure 2: Figure 2: Average number of pills per capita shipped to US counties

Next, to analyze pill shipment trends between urban and rural counties, we classified county urbanicity based on population density. This was was computed using the population data included in the Washington Pos dataest in combination with county level land area data obtained from the United States Census Bureau. First, we considered a binary rural or urban classification based on the United States Department of Agriculture definition: rural counties have a population density of less than 500 people per square mile or have a total population of fewer than 2500 people; urban counties have a population density of greater than 500 people per square mile. Looking at opioid shipment rates per capita given this classification, we find that the rates are

very similar between rural and urban counties throughout the time period considered (Figure 3). However, we see that the variability in rates for urban counties is much greater than the variability for rural counties, as demonstrated by their much wider confidence intervals. This indicates that this definition of urban counties may encompass a wider range of urbanicities.
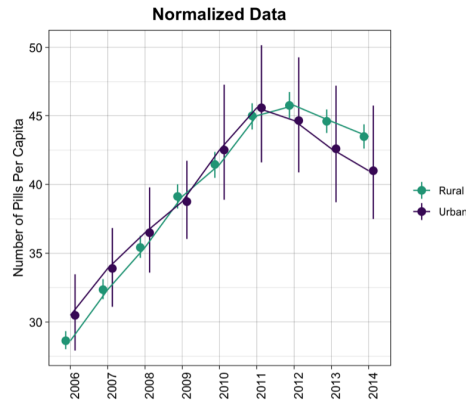


Figure 3: Figure 3: Average number of pills per capita shipped to US counties: rural, urban counties

To better understand the root of this variablity, we applied a more granular definition of urbanicity, as definied by the Organization for Economic Co-operation and Development. Here, we further sub-classified urban counties into large urban (population greater than 200 000) and small urban (population less than 200 000). Looking at opioid shipment rates per capita under this classification, we find that small urban counties have higher shipment rates than both large urban and rural counties across the time period considered (Figure 4). Given this result, we decide to combine small urban counties and rural counties into one group for the subsequent analyses.
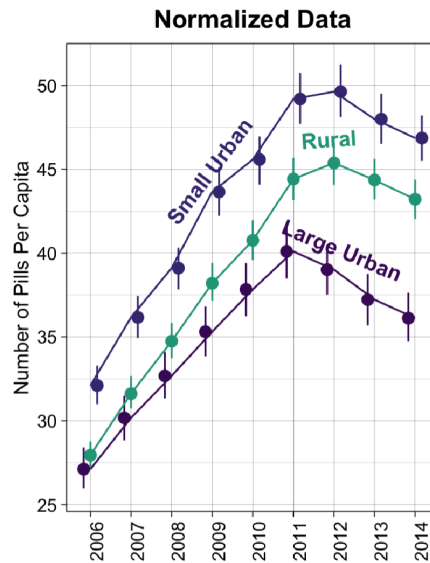


Figure 4: Figure 4: Average number of pills per capita shipped to US counties: rural, small urban, large urban counties

Analyzing trends in small urban and rural counties combined and large urban counties, we find that the rates of opioid shipment per capita to small urban or rural counties is consistently higher than that to large urban counties throughout the time period considered (Figure 5). Shipment rates show similar trends between

the two groups, increasing from 2006 to a peak in 2011 or 2012 for large urban and small urban or rural, respectively. The difference in shipment rates per capita between small urban or rural and large urban counties is statistically significant (p=0.006, Wilcox one-sided test).
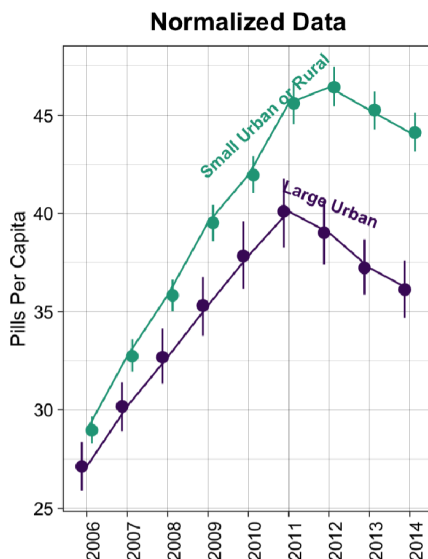


**Normalized Data**

Figure 5: Figure 5: Average number of pills per capita shipped to US counties: rural and small urban, large urban counties

Overall, this analysis supports previous findings that patterns of opioid use differ significantly between rural and urban communities. We show that these differences extend to opioid shipment rates, with rural counties receiving more opioid pills per capita than urban counties. Importantly, our analysis shows that this result is sensitive to the definition of urbanicity.

**Methods**

We obtained land area data from the United States Census Bureau at https://www.census.gov/library/publi cations/2011/compendia/usa-counties-2011.html%23LND. Specifically, we selected the "LND110210" column, which corresponds to 2010 land area in square miles as explained in https://www.census.gov/library/publicati ons/2011/compendia/usa-counties-2011/file-layout.html. Opioid shipment data and county level population data was obtained via the Washington Post ARCOS API at https://arcos-api.ext.nile.works/___swagger___/ using the public key found at https://github.com/wpinvestigative/arcos.

We removed data corresponding to counties that did not have opioid shipment and/or land area data (Puerto Rico, and other US territories). We replaced missing county FIPS code (05097) for the Montgomery county of Arkansas. We removed any counties that were in only one of opioid shipment data or land area data. Next, we calculated county population density for each county by dividing population estimated by land area. Based on population density we classified each county's urbanicity. For later analyses, we used shipment rates per capita, which were computed by dividing the number of pills shipped to each county by the population of that county.

We generated plots using the `ggplot` package. We calculated 95% confidence intervals for all point estimates in our analysis via 1000 bootstrap samples using the `mean_cl_boot` function. A one-sided Mann-Whitney-Wilcoxon test was used to calculate significance. Full code to reproduce this analysis can be found at https://www.opencasestudies.org/ocs-bp-opioid-rural-urban/.

**Conclusions and discussion**

The goal of this study was to compare rates of shipment of opioids between rural and urban counties in the United States. We explored several classifications of urbanicity and found that when combining rural and small urban counties (according to the OECD's definition) and comparing to large urban, we find a statistically significant difference in opioid shipment rates between small urban or rural counties and large urban, with small urban or rural counties having a higher rate of opioids per capita.

This result comes in the context of repeated previous findings in the literature describing the differences in patterns of opioid use between urban and rural communities. This result highlights a potential underlying cause of these observed differences and points towards a possible target for evidence-based systemic interventions to address the opioid use crisis in the most vulnerable communities.

There are several limitations to this analysis that present challenges to the generalizability of the results. First, shipment rates of opioids do not necessarily directly correlate to higher misuse rates or higher rates of drug overdoses. Importantly, prescription opioids only account for a portion of overall drug overdose. To this end, it is important to consider the impact of implementation of haram reduction strategies such as opioid substitution therapy, naloxone distribution, and supervised injection sites on indicators such as rates of drug overdose. Second, we only analyze data on the shipment of oxycodone and hydrocodone. While these are the two most commonly abused opioids, they may not be representative of trends in other commonly used opioids. Further investigation is required to understand trends in other opioids and how they may differ. In this study, we classify urbanicity only based on population density. However, this analysis may benefit from considering other potentially relevant features like average socioeconomic status.

Overall, we hope that these results motivate further investigation into the role that differential prescribing rates play in the observed trends between rural and urban communities.

**Data Analysis**

Read the case study - https://www.opencasestudies.org/ocs-bp-opioid-rural-urban/