

**An Observation of Access to Substance Abuse Treatment Facilities and the Effect
on Opioid Overdose Deaths**

by

Amber Lancaster

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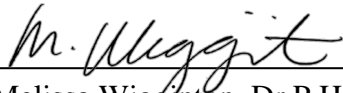
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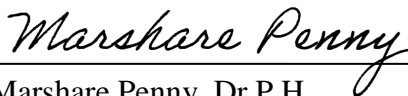
The College of Health Science
California Baptist University
Riverside, California

This is to certify that the Master's Thesis of
Amber Lancaster

has met the thesis requirements
for the degree of
Master of Public Health
Approved by:



Melissa Wigginton, Dr.P.H., CHES
Committee Chair



Marshare Penny, Dr.P.H.
Committee Member



Lindsay Fahnestock, Dr.P.H.
Committee Member

Abstract

This study examines the accessibility of opioid use disorder (OUD) facilities in Riverside and San Bernardino Counties zip codes that experience high rates of fatal opioid overdose. This study also aimed to investigate the types of communities (rural or urban) that experience the highest rates of fatal opioid overdose in the two counties. This descriptive study used geographic information system (GIS) software and crosstabulation analyses to compare the rates of opioid overdoses that occur in each zip code of these counties and substance abuse treatment facilities available in these same zip codes in their respective counties. Results showed that rural communities within these counties experienced some of the highest rates of fatal opioid overdose deaths while simultaneously lacking access to treatment facilities that were abundant in urban areas of these same counties. The findings of this research suggest that there are inadequate resources available for those suffering from OUD that live in the rural communities of Riverside and San Bernardino Counties. Policy reforms are recommended at the county government levels in order to increase access to treatment for residents of these areas, including access to medication assisted treatment (MAT).

Keywords: opioids, opioid use disorder (OUD), rural communities, medication assisted treatment (MAT), geographic information system (GIS)

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Introduction

The Opioid Epidemic in the U.S.

Since 1999, over 750,000 people in the United States have died as a result of opioid overdose (CDC, 2018a). The Centers for Disease Control and Prevention (CDC) estimate that approximately 128 Americans die every day due to opioid overdose (CDC, 2018a). Opioids are a class of powerful analgesics, or pain-relieving drugs, that are considered to be highly addictive (Volkow et al., 2018). There are two types of opioids: prescription opioids (natural and synthetic opioids such as morphine, codeine, hydrocodone, oxycodone, fentanyl, and tramadol) and illicit opioids (heroin and illicitly manufactured synthetic fentanyl) (CDC, 2020a).

The prescription opioid epidemic began in the early 1990s when researchers began to question whether pain was being under-treated in patients who suffered from chronic pain (non-malignant pain), as opioids were typically only used at that time to treat pain experienced in cancer patients (malignant pain) (Jones et al., 2018). While research had shown low incidence of addictive behavior in small groups of cancer and non-cancer patients (Portenoy & Foley, 1986), there were, at that time no studies available to demonstrate the long-term effects of opioids on non-malignant pain patients (Jones et al., 2018). It was also around this same time period that, in 1995, the American Pain Society launched their “pain as the fifth vital sign” campaign. The intent of this campaign was to hold physicians accountable for “inadequate pain control” and to encourage physicians to utilize therapeutic opioid use (Baker, 2017). Concurrently, in 1996, OxyContin (oxycodone hydrochloride) was introduced by pharmaceutical giant Purdue Pharma. The aggressive marketing of OxyContin, which was initially labeled as non-addictive, led to a sharp increase in prescriptions in the following years. From 1997-2002, prescription rates of OxyContin increased from 670,000 to over 6.2 million (Jones et al., 2018). Additionally, the

overall prescription opioid consumption in the U.S. changed dramatically throughout the 2000s, increasing from 46,946 kg consumed in 2000 to a staggering 165,525 kg consumed in 2012 (Jones et al., 2018).

Prescription opioids are widely considered to be the main culprit of the initial opioid epidemic. In recent years, however, the medical community has also seen sharp increases in overdose deaths from heroin use, as well as overdose deaths involving synthetic opioids, particularly those involving illicitly manufactured fentanyl (CDC, 2018b). Furthermore, in addition to risks of fatal drug overdoses, those who suffer from opioid use disorder (OUD) are also at an increased risk of experiencing trauma, suicide, and contracting infectious when compared to members of the general population (Madras et al., 2020).

Opioid Overdose Risk Factors

In order to determine risk factors for opioid overdose deaths, one study analyzed residential, demographic, and socioeconomic status (SES) data from the Mortality Disparities in American Community Study (MDAC), which included data from nearly 4 million individuals (Altekruse et al., 2020). Findings from this study determined that the socioeconomic groups that are most at risk for fatal opioid overdose are middle age individuals aged 40-59 (43.8%) who are considered to be low-income (69.5% at or above the Federal Poverty Level) with low education levels (high school diploma/GED only and less than high school level education making up 59.1% of the surveyed population) (Altekruse et al., 2020). Additionally, it was determined that Whites have the highest risk for opioid overdose compared to other racial groups as they accounted for 80.7% of opioid overdose deaths, followed by Blacks and Hispanics who accounted for 8.2% and 7.3% of these deaths, respectively (Altekruse et al., 2020). Finally, men

accounted for 60.5% of fatal opioid overdoses while women accounted for 39.5% (Alketruse et al., 2020).

Opioid Use in Rural Communities

Opioid overdose deaths have remained a significant public health concern throughout all areas of the United States for decades; however, 2016 data from the Health Resources and Services Administration (HRSA) found that rural areas are disproportionately affected by drug related deaths, as they experience 45% more drug related deaths than non-rural areas, specifically, from prescription opioid abuse (Lenardson et al., 2016). In addition, data from the National Center for Health Statistics (NCHS) found that rates were higher in rural areas compared to urban areas for drug overdose deaths involving natural and semisynthetic opioids (oxycodone, hydrocodone, morphine, and codeine) (Hedegaard et al., 2019). Rural areas are typically sparsely populated and have low housing density (Ratcliffe et al., 2016). According to the CDC (2017), individuals who live in rural areas can be at greater risk for death in emergency situations due to their limited access to care, higher poverty rates, and lower health insurance rates (CDC, 2017). In regard to drug overdose situations, overdose deaths typically occurred in homes where rescue efforts may fall on loved ones who have limited knowledge of how to react in an emergency situation or may not have access to naloxone (an opioid antagonist medication used to reverse opioid overdoses) and overdose follow-up care (SAMHSA, 2020).

While it is difficult to determine an exact definition for a rural population, the U.S. Census Bureau considers the term “rural” to encompass all population, housing, and territories not included within an urban area (U.S. Census Bureau, 2020). Conversely, the U.S. Census Bureau defines an “urban area” as a “densely developed territory” that encompasses “residential, commercial, and other non-residential urban land uses” (U.S. Census Bureau, 2020). The U.S.

Census Bureau often refers to geographical areas as either being rural or urban. “Suburban” is another term that often used to describe a geographical area but that is neither rural nor urban. Suburban is not so easily defined but is typically used to describe an area within a certain area from an urban/metropolitan area that tend to consist of a large number of housing tracts (Airgood-Obrycki & Rieger, 2019).

Issues that Affect Rural Communities

Research out of North Dakota State University has suggested that the high prevalence of opioid prescriptions in rural communities may be due largely in part to the amount of chronic pain experienced by individuals who live in these areas (Hoffman et al., 2002). Hoffman, Meier, and Council go on to suggest that the chronic pain (which they defined as constant pain or pain that flares up frequently and has been experienced for at least six months at a time) (p. 216) experienced by rural residents may be due to the labor intensive jobs (which the researchers referred to as “blue collar” jobs) held by this particular population compared to those who live in urban areas that typically work in office settings (“white collar” jobs) (Hoffman, et al., 2002).

Although the study conducted by Hoffman and colleagues showed no significant difference between chronic pain experienced between blue-and white-collar workers in both rural and urban populations, it was determined that individuals in rural areas are more likely to experience chronic pain. The results of this study also found that Quality of Life scores can have an effect on chronic pain morbidity. Those reporting experiencing chronic pain also reported lower quality of life scores on the Quality of Life scale that measures satisfaction in several areas of life, including social life and experiences, family life and experiences, and experiences of daily living (Hoffman et al., 2002; Chibnall & Tait, 1990).

Many of these aforementioned factors that affect quality of life can also be considered risk factors for illicit drug use in rural communities. A model developed by Keyes and associates to demonstrate the etiology of illicit drug use explains how, at the macro level, economic stressors can largely influence drug use. In the local context, family dynamics (including conflicts and composition), family stress (unemployment and financial stability), and peer influence can also influence drug use as well as endogenous factors at the micro level, such as genetic vulnerability, gender, and age (Keyes et al., 2014). Additionally, this model demonstrates how these three levels interact dynamically, for example, structural stress (economic deprivations) could create issues within the family dynamic (familial stress) which in turn, affects how individuals can be influenced by peers to use drugs (Keyes et al., 2014).

Accessibility of Opioids and Treatment in Rural Communities

Though prescription opioids are widely available throughout the U.S., evidence has shown that there is increased availability in rural areas, specifically areas that make up the region known as Appalachia. Appalachia is a predominantly rural region in the Eastern United States which makes up the central and southern parts of the Appalachian Mountain Range. It is comprised of parts of 13 states (Alabama, Georgia, Kentucky, Maryland, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, and West Virginia) and spans 205,000 mi² (Appalachian Regional Commission, 2020). The Appalachian region has historically faced issues with poverty and low education levels compared to the rest of the U.S. and, in recent decades, has also been disproportionately affected by the opioid epidemic (National Association of Counties & Appalachian Regional Commission, 2019). West Virginia, specifically, being the highest prescribers of opioids in this region (Keyes et al., 2014). According to recent data from the National Association of Counties (NACO) and the

Appalachian Regional Commission (ARC), in 2017 the prescription opioid rates in Appalachian counties were 45% higher than non-Appalachian counties. Additionally, the death rate for opioid overdoses in Appalachian counties was 72% higher than in non-Appalachian counties (NACO & ARC, 2019).

While the number of opioid prescriptions in Appalachia is problematic enough, inadequate access to care and social services in this region may only be exacerbating this issue. A study by Bunting and colleagues examined the effects of access to OUD treatment in rural Appalachia and determined that individuals living in this area experienced significant challenges in access to care, such as a lack of physicians and long waits to be seen (Bunting et al., 2018). Additionally, few physicians in this area offer medication for addiction treatment (MAT), which is a known effective treatment for OUD (Bunting et al., 2018). Individuals in this study also reported lack of, or limited, transportation as a barrier to access OUD treatment as well as cost of treatment, and a lack community support (Bunting et al., 2018). Furthermore, in the event of an emergency overdose situation, research has also found that those living in rural communities typically have greater distances to travel reach a hospital. According to research from the Pew Research Center, Rural Americans travel an average of 10.5 miles to reach a hospital, a much greater distance compared to those living in suburban (5.6 miles) or urban (4.4 miles) communities (Pew Research Center, 2018).

A lack of government funding may be largely to blame for the limited health resources available to those struggling with OUD. In 2012, compared to other counties, Appalachian counties generated 35% less revenue per capita and was therefore forced to spend 38% less per resident than non-Appalachian counties (NACO & ARC, 2019).

Opioid Overdose Deaths in California

According to 2018 data from the National Institutes of Health, approximately 45% of drug overdose deaths in California involved opioids (NIH, 2020). While prescription opioids accounted for the greatest amount of opioid overdose deaths in California in 2018 (45%), the state has among the lowest prescribing rates of opioids in the country (NIH, 2020). Fatal overdose rates involving synthetic opioids and heroin accounted for 36% and 32% of these deaths, respectively, increasing from previous years (NIH, 2020).

Synthetic opioids, specifically fentanyl (both prescription and illicitly manufactured), are considered to be the current driving force of the opioid epidemic according to recent data by the CDC, accounting for 67% of opioid related deaths in the U.S. in 2018 (CDC, 2020b). In California, fentanyl overdose rates nearly doubled in a year, with 786 deaths fentanyl overdose deaths occurring in 2018 and 1,513 occurring in 2019 (California Department of Public Health, 2020).

Opioid Overdose Deaths in Riverside and San Bernardino Counties

Riverside County is located in Southern California sharing borders with the neighboring Orange, Imperial, San Bernardino and San Diego Counties. As the fourth largest county in the state, Riverside County spans over 7,200 mi², from just a few miles short of the Pacific Ocean to the Colorado River (County of Riverside, 2020). Riverside County is also California's fourth largest state by population with over 2 million residents, many of whom live in the desert communities that comprise much of this geographically diverse county (County of Riverside, 2020).

Riverside County was among the top 10 California counties for fentanyl related overdose deaths in 2018 (CDPH, 2020). With a rate of 2.19 per 100,000 residents, Riverside County surpassed the overall state rate of 1.96 per 100,000 residents that same year (CDPH, 2020).

Though overall fatal opioid overdose rates in Riverside County (5.74 per 100,000 residents) were slightly below the state rate (5.82 per 100,000 residents), 34 zip codes within the county surpassed the state fatal opioid overdose rates, many of which are rural mountain or desert communities (CDPH, 2020).

San Bernardino County is the largest county in the U.S. stretching across over 20,000 mi², most of which is considered to be “vacant,” or undeveloped desert land (San Bernardino County, 2014). Like Riverside County, San Bernardino County is also geographically diverse, consisting of valley, mountain, and desert regions. The most recent data from the county listed San Bernardino County as the fifth most populous county with over 2 million residents (San Bernardino County, 2014).

San Bernardino County as a whole did not experience the same opioid overdose death rates as neighboring Riverside County with 4.77 per 100,000 residents for overall opioid death rates and 1.38 per 100,000 residents for fentanyl overdose deaths (CDPH, 2020). Similar to Riverside County, however, specific zip codes within San Bernardino County also surpassed state fatal opioid overdose rates (26 zip codes) (CDPH, 2020). Like Riverside County, many of these zip codes within San Bernardino County with high fatal opioid overdose rates were also rural mountain or desert communities (CDPH, 2020).

Summary

While the opioid epidemic continues to be a threat to public health throughout the United States, research has shown that rural populations tend to be disproportionately affected. This is most apparent in regions such as rural Appalachia where there are significantly higher rates of fatal opioid overdose compared to the rest of the country. Research suggests socioeconomic factors in rural areas, such as median household income, average education levels, and access to

treatment and social support, are largely to blame for the extent of the opioid epidemic experienced in those regions.

Although counties such as Riverside and San Bernardino have urban centers where much of their populations reside, the geographical diversity of these counties also creates smaller rural communities that experience much of the same challenges as other rural regions throughout the U.S. Many of these mountain and desert communities were shown to have rates of fatal opioid overdose that surpassed overall county rates. Like other rural communities in the U.S., it is likely these rates of fatal opioid overdose in Riverside and San Bernardino Counties are due to limited access to care and services.

Purpose of Study

The purpose of this study is to examine the access to opioid use disorder (OUD) facilities in Riverside and San Bernardino Counties zip codes that experience high rates of fatal opioid overdose. Additionally, this study also will examine the types of communities (rural or urban) that experience the highest rates of fatal opioid overdose in Riverside and San Bernardino Counties. The results from this study can be used to address health disparities experienced in rural communities within these counties that may be disproportionately affected by fatal opioid overdoses due to limited access to treatment. In doing so, public health officials within Riverside and San Bernardino Counties could potentially advocate for increased treatment options for underserved communities.

Research Questions

The research questions for this study are as follows:

1. How prevalent are OUD facilities in Riverside County zip codes that experience higher rates of fatal opioid overdose?

2. How prevalent are OUD facilities in San Bernardino County zip codes that experience higher rates of fatal opioid overdose?
3. What type of communities in Riverside and San Bernardino Counties (rural or urban) experience the highest rates of fatal opioid overdose?

The first question hypothesizes that zip codes in Riverside County which experience higher rates of fatal opioid overdose will have a lower prevalence of OUD facilities. The second question hypothesizes that zip codes in San Bernardino County which experience higher rates of fatal opioid overdose will have a lower prevalence of OUD facilities. The third question hypothesizes that a particular type of community will experience the highest rates of fatal opioid overdose in both Riverside and San Bernardino Counties.

Method

Design

This study is descriptive in nature, using geographic information system (GIS) software and crosstabulation analyses to compare the rates of opioid overdoses that occur in each zip code and substance abuse treatment facilities available in these same zip codes in Riverside and San Bernardino Counties.

Procedures

Data from the Substance Abuse and Mental Health Administration's (SAMHSA) National Survey of Substance Abuse Treatment Services (N-SSATS) was used to gather information about the locations of OUD treatment facilities in Riverside and San Bernardino counties within each zip code. According to research conducted by the Pew Research Center (2018), the average distance that individuals from rural (10.5 miles), suburban (5.6 miles), and urban (4.4 miles) traveled in order to access care. The mean of these distances was calculated

and is 6.83 miles. For each of the zip codes for Riverside and San Bernardino Counties, it was determined how many OUD treatment facilities were available within that zip code. For the zip codes that did not have OUD facilities, it was instead determined if there were OUD treatment facilities located within a 6.83 mile radius of that same zip code.

N-SSATS collects an annual census of treatment facilities in order to provide up to date information on the availability and location of OUD facilities throughout the U.S. as well as the services they provide (SAMHSA, 2020). According to the most recent data from N-SSATS, there are 82 substance abuse facilities located in Riverside County and 60 substance abuse facilities located in San Bernardino County (SAMHSA, 2020).

Fatal opioid overdose data for Riverside and San Bernardino Counties was available through the California Department of Public Health's (CDPH) California Opioid Overdose Surveillance Dashboard (Table 3 & Table 4). This data visualization tool incorporates non-fatal and fatal opioid-involved overdose data and opioid prescription data, emergency department visits, hospitalizations, fatalities, and prescriptions related to opioid overdoses among California residents. This data is enumerated as raw counts, crude rates, and age-adjusted rates at the state, county, and zip code levels. Data is also available by age, sex and ethnicity (CDPH, 2020). For the purpose of this study, age-adjusted rates for opioid overdose deaths in zip codes within Riverside and San Bernardino Counties year 2018 were examined.

GIS software makes it possible for users to visualize the geographic aspects of data, such as area concentrations or spatial patterns. The purpose of using GIS software for this study was to visualize areas in Riverside and San Bernardino Counties that are disproportionately affected by fatal opioid overdoses, while simultaneously visualizing the locations of OUD facilities in these same areas. Environmental Systems Research Institute's (ESRI) ArcGIS software 10.1 was

used to create maps which included data points from the aforementioned data sources (Environmental Systems Research Institute, 2020). ArcGIS software was used to summarize the central locations of OUD facilities within the two counties. Seventy eight of the 142 OUD facilities located in Riverside and San Bernardino Counties are concentrated within a 2,476.8 mi² area that consists of a mainly metropolitan area and neighboring suburban communities.

Data from each data source was used to create individual layers for the map. OUD facility data collected was used to create one layer (SAMHSA, 2020). N-SSATS provided addresses for each facility, which were all entered onto the GIS map as individual points that included information about the OUD facility such as the name and address. After each facility address was located, the address was searched in ArcGIS and a marker was placed in that location to represent each of the 142 OUD facilities.

Another layer was created using county data provided via public map databases available on ArcGIS to illustrate zip code boundaries within Riverside and San Bernardino Counties (ESRI, 2020). While the zip code boundaries were made available by using an existing ArcGIS layer, these zip codes were individually filled in with color by the investigator to correspond with the respective fatal opioid overdose rates for that zip code using the data from the CDPH (CDPH, 2020).

Results

In 2018, the average age adjusted fatal opioid overdose rate in the state of California was 5.82 per 100,000 residents (CDPH, 2020). Of the 70 zip codes within Riverside County, 34 exceeded the California age adjusted average rate for fatal opioid overdose in 2018. The zip codes that had the highest fatal opioid overdose rates include 92549 (88.8), 92241(39.0), and 92501 (22.5). The zip code 92549 lies within the mountain community of Idyllwild, which has a

population of 3,926 and a land area of 27.5 mi² (U.S. Census Bureau, 2010). This area has no OUD facilities within the zip code or within 6.83 miles of the zip code. The closest OUD facility to this area is 22.57 mi. in the nearby community of San Jacinto. The zip code 92241 lies within the desert community of Desert Hot Springs. The zip code 92241 has a population of 8,803 and a vast land area of 138.1 mi² (U.S. Census Bureau, 2010). There are no OUD facilities located within this zip code or within a 6.83-mile radius of this zip code. However, the city of Desert Hot Springs is comprised of two zip codes, the additional zip code being 92240 (population of 34,722 and land area of 36.6 mi.²) which has seven OUD facilities within that area. The zip code 92501 is located in the city of Riverside, an urban area. The population for this zip code is 20,970 and has a land area of 5.7 mi² (U.S. Census Bureau, 2010). There are four OUD facilities located within this zip code and several others located within the city of Riverside. The city of Riverside is comprised of nine zip codes as it is a densely populated metropolitan area with a population of 303,871 according to 2010 Census data and a land area 81.14 mi.² (U.S. Census Bureau, 2010).

San Bernardino County consists of 82 zip codes, 24 of which exceed the California age adjusted rates per 100,000 residents (5.82) for fatal opioid overdose in 2018. The zip codes 92285 (112.3), 92327 (72.78), and 92256 (59.21) had the highest fatal opioid overdose rates in the county. The zip code 92285 is located within the desert community of Johnson Valley, which has a population of 2,632 and a land area of 171.0 mi² (U.S. Census Bureau, 2010). This area has no OUD facilities located within 6.83 miles of the zip code and the closest facility is 13.93 miles away in the community of Yucca Valley. The zip code 92327 is located in the desert community of Daggett, which has a population of 632 and a land area of 28.2 mi² (U.S. Census Bureau, 2010). There are no OUD facilities located within 6.83 miles of this zip code and the closest facility is located 7.45 miles away in the community of Barstow. The zip code 92256 is located

within the desert community of Morongo Valley. Morongo Valley has a population of 3,588 and a land area of 78.0 mi² (U.S. Census Bureau, 2010). There are no OUD facilities located within 6.83 miles of this zip code. The closest OUD facility to this area is 8.72 miles away in the adjacent community of Desert Hot Springs (92240 zip code).

Discussion

Summary

The purpose of this study was to examine the prevalence of opioid use disorder (OUD) facilities in Riverside and San Bernardino County zip codes that experience high rates of fatal opioid overdose. It was hypothesized that zip codes in both counties that experience higher rates of fatal opioid overdose will have less access to OUD facilities. It was also hypothesized that the zip codes with higher rates of fatal opioid overdose within Riverside and San Bernardino Counties would be located within a particular type of community (rural or urban).

Results from the study found that the two of the three zip codes in Riverside County that had the highest rates of fatal opioid overdose (92549 and 92241) did not have OUD facilities located within the zip code or within 6.83 miles of the zip code. Additionally, these zip codes that had the highest rates of fatal opioid overdose are in communities that are considered rural, or outside of an urban area, with 92549 located within a mountain community (Idyllwild) and 92241 located within a desert community (Desert Hot Springs). The zip code 92501, however, is located within an urban community (Riverside) that does have four OUD facilities located within that area. Results also showed that three zip codes in San Bernardino County with the highest rates of fatal opioid overdose (92285, 92327, and 92256) did not have OUD facilities located within the zip code or within 6.83 miles of the zip code. All three of these zip codes are located in rural desert communities.

About 83% of the zip codes with the highest rates of fatal opioid overdoses (92549, 92241, 92285, 92327, and 92256) were shown to not have access to OUD within the zip code or within a 6.83-mile radius. Furthermore, each of these zip codes are located in rural desert or mountain communities. Previous literature has shown those who live in rural areas are more likely to experience poverty and familial stress which have been shown to influence drug use (Keyes et al., 2014). Additionally, rural communities have been shown to be disproportionately affected by fatal opioid overdose and typically lack the health care resources that are afforded to more metropolitan communities (Lenardson et al., 2016; Hedegaard et al., 2019; CDC, 2017).

One zip code, however, diverged from the hypotheses. The city of Riverside, in which the zip code 92501 is located, is a metropolitan area which has numerous OUD facilities located within the city and four located within the zip code. Despite having access to many OUD facilities, this zip code still experienced one of the highest rates of fatal opioid overdose in 2018 (22.5 per 100,000 residents). This may be due to the increasing rates of fatal fentanyl overdoses reported in urban and metropolitan areas surpassing rates of fatal fentanyl overdose in rural counties (CDC, 2018b). In 2016, the age-adjusted fatal drug overdose rates involving synthetic opioids other than methadone ranged from 4.1 in rural areas to 8.2 in large metropolitan areas (CDC, 2018b).

Public Health Implications

These findings suggest that there are inadequate resources available for those suffering from OUD that live in the rural communities of Riverside and San Bernardino Counties. Figure 1 illustrates that some of the areas hardest hit by fatal opioid overdose are well outside the 2,476.8 mi² area where over half of the OUD facilities in these two counties are located. This implies that those individuals living in these areas may not have access to the care they need as they struggle

with opioid addiction. If this issue is not addressed, these rural communities may see further exacerbation of the opioid epidemic and fatal opioid overdose rates. This may be especially true as we continue to see rural areas face increasing rates of fentanyl use (CDC, 2018b).

In order to improve opioid abuse related mortality rates for those living in rural areas of Riverside and San Bernardino Counties, there are changes in public health policies that could be made. First, communities most affected by fatal opioid overdose that do not currently have access to OUD facilities should have increased access by adding more of these facilities throughout rural regions. While it may be unrealistic to expect county governments to install these facilities in every community, a free transportation service could perhaps be provided to take individuals to and from neighboring communities that do have facilities. Additionally, emergency departments of hospitals in these communities could increase medication assisted treatment (MAT) for those experiencing OUD and allow for extended hospital stays for long-term MAT. Finally, naloxone availability could be increased to first responders as well as individuals living in these communities. In addition, these individuals could also receive training on how to administer the medication, improving their self-efficacy naloxone administration and increasing the likelihood they would actually use it in an emergency overdose situation.

In addition to proposed policy changes for the rural areas of Riverside and San Bernardino Counties, many of these same proposed changes could serve to be equally effective in the urban areas of these counties affected by high rates of fatal opioid overdose. An additional recommendation would be to increase the availability of drug take-back programs. Drug take back programs have been shown to help reduce the supply of prescription opioids in homes and raise awareness about the opioid epidemic to the general public (National Academies of Sciences, Engineering, and Medicine, 2017).

Study Limitations

Methodology

There are potential limitations present in this study. From a methodological standpoint, this study is descriptive in nature, using GIS software to visualize zip codes that have experienced high rates of fatal opioid overdose and compare them to the locations of OUD facilities in Riverside and San Bernardino Counties. Future research in this area may use analytic strategies, such as latent profile analysis, to determine which population groups in these areas may be at the greatest risk of developing OUD in order to better target these groups with educational materials and prevention strategies. Additionally, data from the California Department of Public Health (CDPH) uses age-adjusted rates to compare relative risks over time or between geographic areas. The CDPH cautions that these rates should be viewed as relative indexes rather than as actual measures of risk (CDPH, 2020). Another limitation is that the CDPH did not include fatal opioid overdose data for every zip code in each county as this data was not made available to them. Zip codes with fatal opioid overdose data were not compared to those that had missing data. Furthermore, the zip codes that had high fatal opioid overdose rates with no access to OUD facilities were not compared to those with lower rates of fatal opioid overdose and more access to OUD facilities. Future research might examine the effects that greater access to OUD facilities has on areas with lower rates of fatal opioid overdose. Finally, the CDPH also cautions that mortality indicators are not mutually exclusive, and that even though drug overdose may be have been listed as the primary cause of death for individuals included in the data, there may have been other contributing factors (CDPH, 2020).

Geographical Biases

Geographical bias may exist among the counties studied and could serve as additional limitations. San Bernardino County is the largest county in the country at over 20,000 mi.² and much of the land in this county is considered to be undeveloped desert land (San Bernardino County, 2014). Riverside County is also considered to be one of the largest counties in the country, spanning over 7,200mi², much of it also being large desert and mountain areas (County of Riverside, 2020). Because of the remote locations and vastness of some of these areas, it is simply not realistic to expect access to specialty services throughout these regions.

Another limitation is that the geographical terms “rural,” “urban,” and “suburban” do not have objective definitions. Most federal agencies use different definitions and criteria to determine whether a community falls under a certain geographical category (Ratcliffe et al.,2016).

Additionally, the use of zip codes as a means of collecting data also has its limitations. Zip codes were created by the United States Postal Service to serve as “administrative units” to create the most efficient means of mail delivery. They are not used in congruence with statistical area boundaries created by the U.S. Census Bureau, and they can often overlap different city or even county boundaries (Krieger et al., 2002). Therefore, due to the various differences in size for each zip code, they are not comparable.

Conclusion

This research aimed to examine the access to substance abuse treatment facilities in Riverside and San Bernardino Counties zip codes that experience high rates of fatal opioid overdose. GIS mapping technology helped to visualize the areas of these counties that experienced greater rates of fatal opioid overdose in comparison to the locality of OUD facilities in these same areas. It was observed that rural communities within these counties experienced

some of the highest rates of fatal opioid overdose deaths while simultaneously lacking access to treatment facilities that were abundant in metropolitan areas of these same counties. While the observational nature of this research cannot be used to determine if there was a correlation between the limited access to OUD facilities and opioid overdose rates, future research in this area may choose to examine these effects. In doing so, or by using analytic strategies to analyze population groups that may have greatest risk of developing OUD, more effective educational materials or prevention strategies can be developed for at-risk populations.

The opioid epidemic is one that has plagued the U.S. for the last few decades, resulting in hundreds of thousands of lives lost (CDC, 2018a). In order to help reduce the rates of fatal opioid overdose, especially in disproportionately affected areas, such as rural communities, future efforts can be made to increase access to care by creating low-cost public transportation programs to OUD facilities and increasing availability of MAT in rural health care centers.

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Appendix

Table 1. San Bernardino County Population Data by Zip Code

Zip Code	Total Population	Land Area in Mi. ²	Population Per Mi. ² (Land Area)
91701	38,976	7.3	5,361
91708	3,369	9.6	352
91709	74,796	34.2	2,188
91710	80,358	21.5	3,736
91730	66,925	14.5	4,624
91737	24,740	8.4	2,953
91739	34,794	29.4	1,184
91759	476	82.3	6
91761	56,913	29.2	1,951
91762	55,857	13.6	4,100
91763	36,375	5.2	7,034
91764	54,086	8.0	6,756
91766	71,599	10.2	7,043
91784	25,938	9.1	2,846
91786	51,165	9.0	5,715
92242	1,539	31.3	49
92252	9,647	89.9	107
92256	3,588	78.0	46

92267	126	16.3	8
92277	23,911	1,395.0	17
92278	3,846	0.8	4,804
92280	14	166.1	0
92284	25,095	110.2	228
92285	2,632	171.0	15
92301	32,725	170.5	192
92304	17	41.2	0
92305	535	100.0	5
92307	37,630	169.9	222
92308	39,837	93.2	427
92309	763	160.2	5
92310	8,845	3.1	2,871
92311	31,894	248.4	128
92313	12,025	3.5	3,448
92314	10,162	30.8	330
92315	5,094	12.7	401
92316	30,830	11.0	2,805
92321	1,522	6.5	234
92322	1,257	3.0	420
92324	56,505	29.5	1,915
92325	9,391	10.1	931

92327	632	28.2	22
92332	65	894.7	0
92335	95,397	17.3	5,506
92336	88,419	24.9	3,555
92337	37,849	13.9	2,718
92338	12	241.3	0
92339	885	10.6	84
92342	6,379	105.5	60
92344	20,769	38.5	539
92345	78,715	82.0	960
92346	54,923	25.4	2,161
92347	1,692	146.6	12
92352	8,004	9.6	830
92354	21,559	4.9	4,417
92356	6,455	393.8	16
92358	707	19.8	36
92359	8,103	16.7	486
92363	5,321	198.2	27
92364	90	514.2	0
92365	2,637	172.6	15
92368	1,113	27.9	40
92371	16,763	139.7	120

92372	6,220	27.9	223
92373	33,423	40.7	821
92374	40,267	18.7	2,150
92376	81,516	13.5	6,031
92377	19,989	10.2	1,958
92382	5,268	15.1	349
92385	313	8.4	37
92392	54,858	37.3	1,470
92394	33,237	27.3	1,218
92395	42,400	17.1	2,479
92397	4,894	10.3	475
92399	52,606	53.0	992
92401	1,932	0.9	2,235
92404	58,271	28.6	2,040
92405	28,873	4.7	6,113
92407	56,689	62.9	901
92408	15,271	10.6	1,438
92410	49,410	8.2	6,011
92411	26,214	4.1	6,407
93555	32,560	81.6	399
93562	1,818	39.5	46

Table 2. Riverside County Population Data by Zip Code

Zip Code	Total Population	Land Area in Mi. ²	Population Per Mi. ² (Land Area)
91752	30,047	15.1	1,992
92201	61,827	22.7	2,729
92203	25,605	17.5	1,462
92210	4,677	13.1	358
92211	24,294	15.1	1,614
92220	31,638	124.2	255
92223	43,605	43.4	1,005
92225	24,310	599.1	41
92230	2,550	15.1	168
92234	51,151	15.7	3,251
92236	41,083	21.9	1,877
92239	223	143.4	2
92240	34,722	36.6	949
92241	8,803	138.1	64
92253	37,262	35.0	1,066
92254	12,768	46.7	273
92260	31,753	28.4	1,118
92262	26,179	36.6	714
92264	19,383	52.3	371

92270	17,220	26.7	646
92276	7,585	29.3	259
92282	1,239	71.1	17
92320	7,788	10.7	728
92501	20,970	5.7	3,678
92503	84,519	29.9	2,830
92504	53,778	23.4	2,298
92505	47,672	12.2	3,900
92506	44,001	16.2	2,716
92507	58,002	20.2	2,870
92508	35,000	10.7	3,262
92509	75,196	31.1	2,418
92518	1,162	11.9	98
92530	50,216	53.9	932
92532	18,644	18.1	1,031
92536	3,810	124.8	31
92539	4,734	131.3	36
92543	33,555	17.7	1,899
92544	44,734	135.7	330
92545	39,457	32.1	1,228
92548	6,643	9.8	676
92549	3,926	27.5	143

92551	30,815	5.9	5,247
92553	73,722	10.1	7,277
92555	39,076	80.7	484
92557	50,320	18.8	2,676
92561	1,661	158.2	11
92562	62,079	109.4	568
92563	53,892	20.3	2,650
92567	9,459	29.5	321
92570	53,697	97.3	552
92571	52,516	22.6	2,328
92582	15,649	18.5	846
92583	30,236	28.4	1,063
92584	43,400	29.8	1,457
92585	17,797	20.3	877
92586	19,815	7.1	2,806
92587	16,675	7.9	2,110
92590	3,660	53.4	68
92591	38,272	16.5	2,324
92592	72,492	97.2	746
92595	29,851	21.1	1,418
92596	23,172	61.2	379
92675	34,731	34.5	1,008

92860	27,198	14.0	1,946
92879	46,745	10.0	4,653
92880	58,763	24.7	2,380
92881	30,991	27.7	1,120
92882	67,917	25.8	2,638
92883	29,301	55.7	526

Table 3. Fatal Opioid Overdose Rates and OUD Facilities by Zip Code, Riverside Co.

Zip Code	Rates per 100K	95% LCL	95% UCL	Treatment Facilities in Zip Code	Treatment Facilities <3 mi. (if not in ZC)
91752	2.97	0.08	28.12	0	0
92201	13.35	6.05	26.93	6	.
92203	11.4	2.23	36.34	0	2
92210	0	0	0	0	1
92211	9.81	1.28	58.43	0	1
92220	4.51	0.11	27.04	4	.
92223	2.6	0.07	14.47	0	0
92225	10.98	2.23	40.49	0	0
92230	0	0	359.29	0	0
92234	3.5	0.4	14.99	1	.
92236	7.28	1.4	29.03	2	.
92239	0	0	25477.57	0	0
92240	13.62	3.68	36.73	6	.
92241	39.02	3.43	169.65	0	0
92253	3.84	0.1	22.81	0	0
92254	0	0	381.5	0	0
92260	3.05	0.08	23.95	1	.
92262	11.76	1.42	44.85	8	.

92264	4.97	0.13	60.12	1	.
92270	0	0	119.66	0	4
92276	20.67	2.5	144.64	0	0
92282	0	0	0	0	0
92320	12.56	0.32	149.59	0	0
92501	22.51	7.21	70.93	4	.
92503	7.27	2.88	16.58	1	.
92504	5.4	1.03	17.25	1	.
92505	9.93	3.59	24.71	0	1
92506	1.8	0.05	13.87	2	.
92507	7.34	1.46	24.72	1	.
92508	6.99	1.42	29.23	1	.
92509	3.39	0.67	12.35	3	.
92518	0	0	0	0	.
92521	0	0	0	0	4
92530	10.26	3.62	30.93	1	.
92532	20.13	7.37	83.05	0	1
92536	10.58	0.27	334.46	0	0
92539	22.86	0.58	400.92	0	0
92543	12.24	3.83	34.89	3	.
92544	2.44	0.29	14.05	0	0
92545	5.17	0.44	23.46	0	1

92548	8.8	0.22	85.03	0	0
92549	88.83	2.25	576.22	0	0
92551	0	0	0	0	0
92553	3.26	0.66	16.27	3	.
92555	6.87	1.41	31.18	0	0
92557	13.12	5.08	32.6	1	.
92561	0	0	0	0	0
92562	6.89	1.88	19.56	4	.
92563	4.96	1.02	19.09	1	.
92567	10.33	0.26	93.26	0	0
92570	1.26	0.03	10.81	1	.
92571	2.69	0.33	25.23	0	0
92582	5.21	0.13	64.34	0	1
92583	16.55	5.21	40.43	3	.
92584	9.74	3.09	24.07	0	0
92585	11.8	1.42	50.1	0	0
92586	0	0	47.32	0	0
92587	6.96	0.18	45.81	0	0
92590	0	0	0	1	.
92591	8.72	1.8	27.68	1	.
92592	1.56	0.04	9.66	2	.
92595	9.59	1.91	31.83	1	.

92596	2.61	0.07	49.96	1	.
92675	11.97	2.4	36.21	0	0
92860	10.1	2.08	36.64	1	.
92879	3.99	0.45	17.9	1	.
92880	1.34	0.03	14.25	0	0
92881	3.79	0.1	25.06	1	.
92882	0	0	10.02	1	.
92883	0	0	16.81	3	.
California	5.82	5.59	6.06		
Riverside	5.74	4.83	6.79		
County					

Table 4. Fatal Opioid Overdose Rates and OUD Facilities by Zip Code, San Bernardino Co.

Zip Code	Rates per 100K	95% LCL	95% UCL	Treatment Facilities in Zip Code	Treatment Facilities <3 mi. (if not in ZC)
91701	5.02	0.61	20.85	0	0
91708	0	0	388.36	0	0
91709	5.48	1.48	15.7	0	0
91710	2.08	0.25	10.47	1	.
91730	8.23	2.98	21.04	2	.
91737	0	0	0	0	0
91739	0	0	34.06	0	0
91759	0	0	0	0	0
91761	2.54	0.31	23.69	0	0
91762	3.53	0.43	16.28	2	.
91763	0	0	15.08	0	10
91764	3.33	0.37	17.43	0	5
91766	5.29	1.37	16.88	0	4
91784	17.26	3.44	53.39	0	1
91786	0	0	9.65	3	.
92242	0	0	0	0	2
92252	11.55	0.29	108.11	1	.
92256	59.21	7.14	385.81	0	0

92267	0	0	0	0	0
92277	0	0	34.97	0	0
92278	0	0	0	0	0
92280	0	0	0	0	0
92284	13.93	3.6	51.45	1	.
92285	112.38	2.85	710.57	0	0
92301	3.84	0.1	35.9	0	0
92304	0	0	0	0	0
92305	0	0	0	0	0
92307	4.57	0.12	25.47	0	0
92308	2.46	0.06	18.05	0	0
92309	0	0	0	0	0
92310	0	0	0	0	0
92311	9.1	1.76	31.6	2	.
92313	0	0	45.45	2	.
92314	25.84	3.12	95.17	0	0
92315	34.34	0.87	191.35	0	0
92316	3.2	0.08	22.61	2	.
92322	0	0	0	0	0
92324	4.11	0.85	15.15	1	.
92325	11.75	0.3	101.68	0	0
92327	72.78	1.84	2006.72	0	0

92332	0	0	0	0	0
92335	4.52	1.21	13.68	2	.
92336	6.14	2.23	18.3	1	.
92337	0	0	38.42	0	0
92338	0	0	0	0	0
92339	0	0	0	0	0
92342	0	0	0	0	0
92344	0	0	53.69	0	0
92345	4.48	1.18	13.36	1	.
92346	8.44	2.7	21.2	0	0
92347	0	0	1700.24	0	0
92352	0	0	152.6	1	0
92354	6.14	0.16	37.16	0	0
92356	0	0	139.1	1	.
92358	0	0	0	0	0
92359	0	0	0	0	0
92363	15.84	0.4	175.91	1	.
92364	0	0	0	0	0
92365	0	0	349.62	0	0
92368	0	0	1519.71	0	0
92371	10.5	1	53.15	0	0
92372	0	0	128.93	0	0

92373	3.42	0.09	22.07	2	.
92374	1.99	0.05	16.17	2	.
92376	4.88	1.29	14.38	1	.
92377	4.03	0.1	36.41	0	0
92382	0	0	0	1	0
92385	0	0	0	0	0
92392	1.81	0.05	16.68	3	.
92394	9.14	1.77	69.01	1	.
92395	2.02	0.05	16.38	2	.
92397	17.78	0.45	283.82	0	0
92399	5.96	1.48	18.31	2	.
92401	295.67	7.49	1647.39	1	.
92404	13.31	5.63	27.92	0	0
92405	9.58	1.89	39.04	1	.
92407	2.11	0.26	18.35	0	0
92408	13.37	1.39	86.04	3	.
92410	6.79	1.31	27.9	11	.
92411	7.42	0.9	31.54	0	14
93555	8.59	1.72	28.59	2	.
93562	0	0	380.26	0	0
California	5.82	5.59	6.06		
SB County	4.77	3.89	5.82		

Figure 1. Map of Riverside and San Bernardino County OUD Facilities and Fatal Opioid Overdose Rates

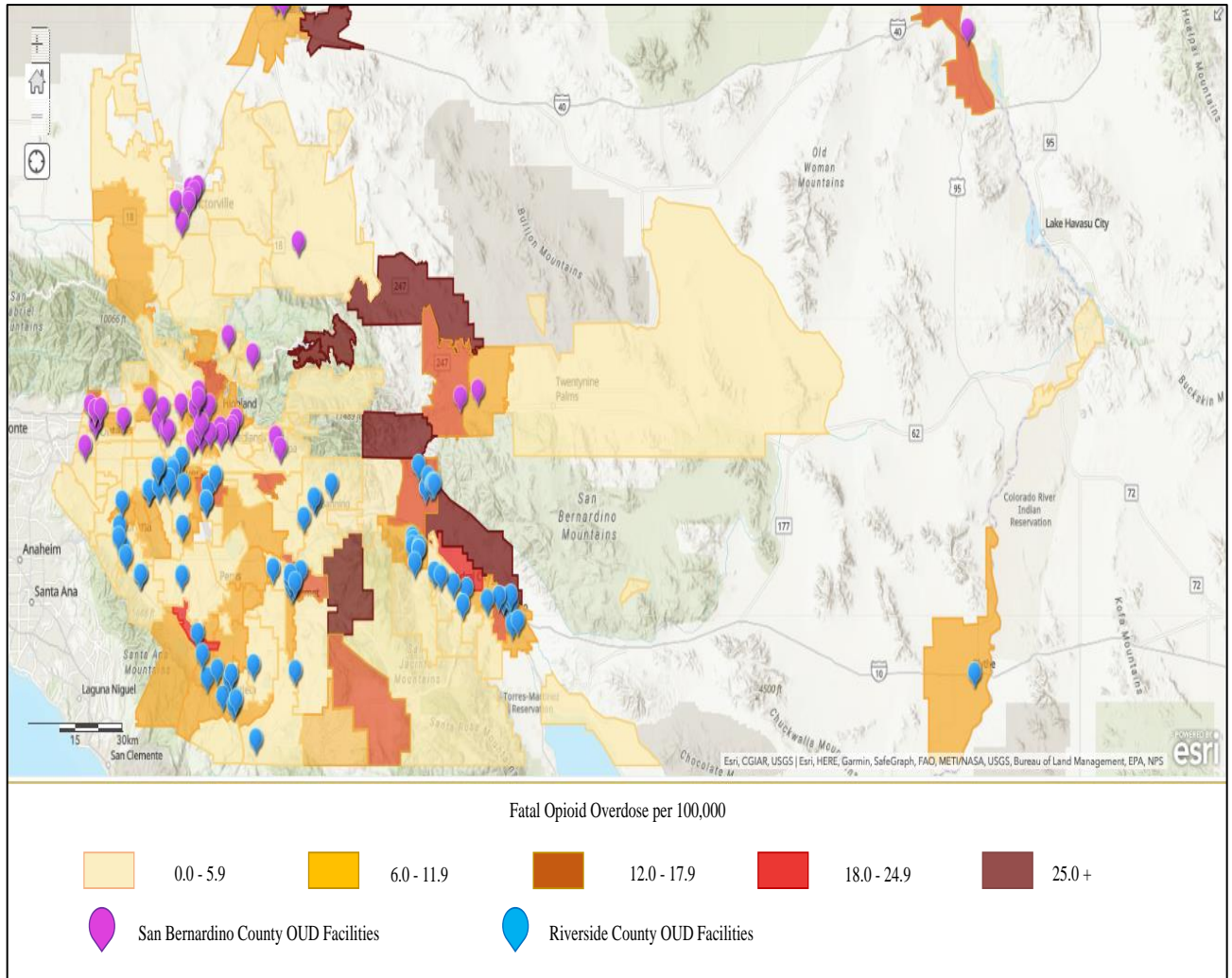


Figure 2. Central Location of OUD Facilities in Riverside and San Bernardino Counties

