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Socioeconomic and geographical disparities in prescription and illicit opioid related overdose deaths in Orange County, California from 2010–2014

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ABSTRACT

Background

Reports indicate a geographic effect of socioeconomic inequalities on the occurrence of opioid-related fatal overdoses. We aim to (1) estimate the rates of opioid-related overdoses, (2) estimate the association of benzodiazepine co-ingestion with opioid-related deaths, (3) estimate associations between socioeconomic indicators and opioid-related deaths, and (4) map the distribution of fatal overdoses, in Orange County (OC), California.

Methods

We conducted an ecologic study of all opioid related deaths (1205 total) obtained from the OC Coroner Division database from 2010-2014 (1065 OC residents, 55 non-residents, 85 OC homeless) (analyzed 2016-2017). We calculated rates of opioid overdose, benzodiazepine co-ingestion prevalence and associations with SES (education, poverty, median income) using zip code analysis in the residential and homeless communities.

Results

Of 1205 deaths, 904 involved prescription type opioids, 223 involved heroin, 39 involved both, and 39 not stated. 973 were classified unintentional overdoses, 180 suicides, and 52 undetermined. 49% of cases involved benzodiazepines. Prescription type opioid and heroin death rates for residents were 5.4/100,000 person years (95% CI 5.0-5.8) and 1.2/100,000 person years respectively (95% CI 1.0-1.4). Males, age group 45-54 and Caucasian race had the highest rate (13.6/100,000) of opioid mortality. The highest death rates were seen in homeless adults at 136/100,000 person years for prescription type opioids (95% CI 99.0-185.5) and 156/100,000 person years for heroin (95% CI 116.8-209.5).

Conclusions

The burden of prescription type opioid-related death in OC affects all demographics and levels of SES, there is a disproportionately high rate of opioid-related deaths in the OC homeless population.

Keywords

Abuse; alcohol; California; heroin; opioid; public health; prescription opioid; socioeconomic status

1. BACKGROUND

In 2015 33,091 persons in the US died due to opioid overdose. Of these, 20,101 deaths were attributable to prescription opioids and 12,990 to heroin[1]. With new prescription opioid regulations (prescription opioid defined as an opioid more commonly available through prescription channels), the increase in opioid deaths in recent years has been attributed to the increasing use of heroin[2-11]. Within California, Orange County (OC) ranks 17th out of 58 counties in opioid overdose deaths[15]. A 2014 report in OC revealed that unintentional death from opioid drug overdose was the third leading cause of death in the county, behind only cancer and heart disease [16]. From 2011-2014 70% of all drug and alcohol related deaths investigated by the OC Coroner involved the use of opioids, indicating a highly specific and critical need for intervention and prevention strategies in Orange County.

Prior literature demonstrated an impact of socioeconomic inequalities among opioid misusers and occurrence of fatal opioid overdoses, but more recent publications suggest a more widely dynamic impact of socioeconomic factors that vary over region and time[9,12-14]. In San Francisco from 2010-2012, deaths among unintentional opioid related overdoses were found to be concentrated in a small, high-poverty, central area of the city[9]. A similar study in New York City found a higher prevalence of opioid-related deaths in lower-income neighborhoods[14]. Looking specifically at socio economic status (SES), another study in New York City found an association between unequal income distribution and overall drug overdose death, regardless of per capita annual income[13].

This study uses county level data obtained from the OC Sheriff's Department, Coroner Division and OC census data to examine the effect and distribution of illicit and prescription related deaths in OC, California. Our specific aims are to establish the association between indicators of SES (poverty status, income level, homelessness, and educational attainment) and fatal opioid-related overdoses (prescription and illicit) in OC, California as well as establish the extent of the opioid epidemic in this large diverse county and uncover any associations with benzodiazepine co-ingestion.

2 METHODS

2.1 Study Design:

We conducted a retrospective ecologic study that examined deaths from 2010-2014 within OC, California. This study was approved by our Institutional Review Board and the California Department of Public Health. OC is the 6th most populous county in the United States; the 2014 census of OC reported 3,145,515 inhabitants with a density of 3,807 persons per square mile. OC consists of 86 zip codes and is demographically divided into 46% Caucasian (White), 27.5 % Hispanic, 19% Asian, 3.3% other (Table 1)[17]. The mean and median income for OC is $81,260 and $71,601 respectively and 10.3% of the population live below the poverty line[18].

2.2 Study Population:

We obtained data from the OC Coroner Division's data file and selected all deaths that occurred within county limits between 2010-2014 in which the coroner's office determined the cause to be overdose of some type of exogenous substance (medication, chemical, recreational drugs).For our analysis we included cases if opioids of any kind were indicated in the cause of death, regardless of whether there were multiple substances involved. Benzodiazepine co-ingestion data was gathered from the selected opioid positive patients and is defined as a test positive for both benzodiazepines and opioids. "Cause of death" was determined by coroner medical examination, and subjects were excluded if the cause did not include opioids as a possible contributing factor.Subsequently, based on our data analysis of the category "cause of death," cases were identified and divided into three groups: prescription type opioid involvement, illicit (heroin) opioid involvement, or mixed involvement (both prescription and illicit use). Being "homeless" was defined by the coroner as having "no fixed abode" and was determined during investigation of the deceased current living conditions usually from friends or family[19].

In addition to data regarding cause and mode of death, the coroner identified the residence of each person dying within the county and provided us with the name of the city of residence and zip code.Overdose deaths were divided into those who were county residents, residents of other areas, and homeless persons. Cases of opioid-related overdose deaths of OC residents that occurred outside of county limits were not included in the descriptive analysis as well as the socioeconomic analysis as we did not have access to this data. The coroner's office classified cases as Hispanic, Caucasian (White), Black, or Asian.No cases were classified as other or multiple race.

2.3 Orange County Coroner Testing Methods:

The circumstances in which the coroner determines whether post-mortem drug testing is necessary included any case in which drugs or alcohol are suspected as playing a part in the death. Section 27491.25 of the California Government Code directs that the coroner, or the coroner's appointed deputy, on being notified of a death occurring while the deceased was driving or riding in a motor vehicle, or as a result of the deceased being struck by a motor vehicle, shall take blood and urine samples from the body of the deceased before it has been prepared for burial and make appropriate related chemical tests to determine the alcoholic contents, if any, of the body. The coroner may perform other chemical tests including, but not limited to, barbituric acid and amphetamine derivative as deemed appropriate. The coroner will also run toxicology on all suspected sudden infant death syndrome deaths (section 27491.4)and all acute, unnatural deaths (suspected homicide, suicide or accident) receive a drug screen. Additionally, drowning deaths, fire deaths and surgical/anesthesia deaths receive robust toxicological analysis.

The default testing done by the coroner is a seven panel presumptive immunoassay. This includes screening for benzodiazepines, cannabinoids, cocaine and metabolite, methamphetamine and related substances, opiates, oxycodone, and zolpidem related compounds. If one of those presumptive screening panels is positive, the coroner completes confirmation testing by gas chromatography (GC) or mass spectroscopy (MS). Any drug reported as "detected" by the coroner has had confirmation testing. This can be done by GC or MS, but the majority is done with liquid chromatography/ tandem mass spectroscopy (LCMSMS)[19].

2.4 Measurement of Rates:

Cases identified by the coroner as OC residents, residents of other areas, and homeless were tabulated by age, sex, and race/ethnicity.Rates (per 100,000 person years) for OC residents were calculated using denominators from the 2010-2014 American Community Survey (ACS) for OC[20].For race/ethnicity, we used yearly ACS estimates of the Hispanic population and of the non-Hispanic population, corresponding to coroner's office practice. Rates for homeless persons (per 100,000 person years) in OC were calculated using denominators from biennial counts of sheltered and unsheltered homeless complying with US Department of Housing and Urban Development (HUD) requirements[21-24]. We estimated homeless person years for 2010-2014 as $0.5*n_{2009}+2*n_{2011}+2*n_{2013} + 0.5*n_{2015}$, where n is count for the years indicated by the subscript.

2.4 Measurement of OC Zip-Code Data:

We used US census Zip Code Tabulation Areas (ZCTA) to calculate rates for small areas, and to assess the relationship between zip code level socioeconomic data from the ACS and opioid overdose deaths in OC. Some zip codes are limited to post office box addresses, and thus cannot be linked toany area or population data in the ACS.Cases with these zip codes were excluded from this portion of the analysis. Zip codes do not exactly correspond to any civil boundaries or to census block or tracts and they are changed due to changes in the delivery of mail[25-26]. The US census classifies each census block according to the zip code of the majority of residences and aggregates these into ZCTAs that correspond roughly to the post office zip code[27]. An examination of post office publications from the study period determined that there were no major adjustments of OC zip codes during the study period[28].

We used 2010 US Census ZCTA data to confirm population counts for each zip-code with one exception. Each Orange County ZCTA included at least 99% OC residents, and all adjacent ZCTAs include less than 1% OC residents. The exception is ZCTA 90631, which includes the OC city of La Habra and the smaller Los Angeles County city of La Habra Heights. For this ZCTA we used population data for the city of La Habra. In the US 2010 census, the population of La Habra city was 97.8% of the population of the OC portion of ZCTA 90631.

2.5 Geographic Mapping:

Magic Maps (evanmiller.org) software was used to show geographic distribution by OC zip code of rates for overall opioid overdose deaths, prescription type opioid deaths, and heroin deaths. For combined opioid and prescription type opioid rates the distribution was divided into quintiles and quartiles for heroin quartiles due to overall lower rates.

2.6 Analysis of Socioeconomic Association:

We used negative binomial regression to examine the association between overdose deaths and ZCTA-level education, poverty, and median income, controlling for age, race, and ethnicity. Data was analyzed using Stata, version 14.2.We divided the zip codes into quartiles for the percentage of residents age 25 and older with 4-year college degrees, the percent of residents with incomes below the federal poverty level, and the median household income. We used person-years as the exposure variable (calculated as 5 times the ACS population) and entered age and race/ethnicity as the percent in each of the categories (Table 1).For each of these education and income variables the mortality ratio was calculated separately for prescription type opioid deaths and heroin deaths, controlling for age,race, and ethnicity. For the multivariate analysis, due to the strong co-linearity of the variables education, poverty rate, and income level (r=.49-.78) it was not possible to examine the effect of all three simultaneously in the model and each was done individually.

3 RESULTS

3.1 Descriptive Analysis:

There were 1205 total deaths in OC due to combined opioid overdose from 2010-2014 (904 involved prescription type opioids). Of 1205, 1065 of these were OC residents which were used for our analysis (Table 1); 55 out of 1205 (5%) were nonresidents and excluded from further analysis. Eighty-five out of 1205 (7%) were homeless and analyzed separately. Seventy-five percent (904) of overdose deaths involved prescription type opioids, 20% (240) involved heroin, 3.2% (39) involved both, and 1.8% (24) were not stated. Nine hundred seventy-three overdoses (81%) were classified as unintentional, 180 (15%) were deemed suicides, and 52 (4.3%) were undetermined (Table 1). Analysis of annual opioid-related overdose deaths shows a steadily increasing rate from 6.8 to 7.1 per 100,000 persons from 2010-2014 respectively (Table 2).

In the resident population (non-homeless), the death rate was 5.2/100,000 (95% CI 5.0-5.8) person-years for deaths involving prescribed opioids, and 1.2/100,000 (95% CI 1.0-1.4) person years for heroin (Table 1). Prescription overdose deaths comprised 70% of total opioid-related deaths for ages 15-44, but 92% of the total for ages 45 years and older. Males accounted for 73% of overdose deaths among ages 15-44 years (Figure 1), but only 48% of overdose deaths among ages 45 years and older. Figure 1 demonstrates that as both men and women age the prescription type opioid mortality rates are much more similar. By race, Caucasians (White) had the highest rates for both prescription type opioid and heroin deaths (Table 1) in OC. The homeless population were found to have the highest rates of overdose deaths, with rates of 136/100,000 (95% CI 99.0-185.5) for prescription type opioids and 156/100,000 (95% CI 116.8-209.5) for heroin (Table 3). For benzodiazepine co-ingestion, of the total OC homeless and OC residents (1150), 1148 had complete data for descriptive analysis (two OC residents had missing co-ingestion data for all four groups but still included opioids in their coroner reports). Out of 1148 (1063 OC resident, 85 OC homeless) cases, 573 (49.9%) involved benzodiazepine co-ingestion. For OC residents specifically, 537/1063 (50.5%) involved benzodiazepines. For the OC homeless population, 42.3% of cases (36/85) involved benzodiazepines (Table 4).

3.2 Association of SES and Opioid Overdose Deaths:

SES and education statistics are never specific to the person being analyzed but solely to the person being analyzed. In zip codes in which the residents had a higher percentage of bachelors or advanced degrees there was an associated reduction in rates of opioid-related overdose deaths (mortality ratio 0.59 95% CI 0.39-0.89), as compared to in zip codes with lower levels of education (mortality ratio 0.45 95% CI 0.28-0.72). We found a statistically significant association with poverty level with increased mortality rates for prescription type opioid related overdose when poverty level is > 6.36% and for heroin when poverty level was > 16.86%. In zip codes in which more of the residents had lower quartile median incomes, we noted a higher rate of opioid-related deaths compared to zip codes with successively higher quartiles of median income (Table 5).

3.3 Geographic Analysis:

Figures 2a-c show the geographic distribution, by zip code, of deaths due to combined opioids, prescription type opioids alone and heroin alone. The geographic distribution does not appear to have a particular epicenter within one particular zip code, but rather more of a diffuse distribution. Additionally, zip codes with higher opioid-related death concentration appear to be prevalent among many affluent communities along the Pacific coast.

4 DISCUSSION

Within the last decade, due largely to prescription type opioid reduction efforts, there has been a modest reduction in the supply of prescribed opioids and diversion for non-therapeutic purposes[6]. It was discovered that these reduction efforts likely fueled conversion to heroin usage amongst prior prescription type opioid abusers and new users. One study found a four-fold increase in the use of heroin by initiates to opioid abuse from 2005 to 2015[3]. It is likely that despite the fact that prescription type opioids may be less available, we see an increase in overall opioid death rates in our study in both OC residents and homeless from 2010-2014 possibly due increased heroin use and availability.

Looking specifically at the association of SES and opioid-related deaths in OC. In prior reports in large urban areas, though opioids related deaths were widespread amongst affluent and poorer areas, the highest concentration of deaths occurred in lower SES areas[8]. This is different in the OC, in which we found higher education and income were protective against opioid related deaths yet similar in that there was a higher burden of opioid-related deaths among patients living in lower SES areas in the county. Despite a somewhat "protective" effect or lower odds among the higher SES, in looking at the geographic distribution of deaths in the county it is clear that no zip code is immune to this epidemic and there is more nuance to the SES and death association.

The demographics of opioid-related deaths in OC, show that among younger victims, males have a much higher rate than females. However, in our sample the highest risk age group was ages (45-55) and as age increases the discrepancy or difference among males and female decreases. This is similar to a recent CDC data brief stating that the highest opioid related deaths occurred in Caucasian adult males aged 45-54[9].

Additionally, co-ingestion with benzodiazepines was very common in almost half the cases in our database. Studies have shown that benzodiazepines in combination with opioids act synergistically increasing the likelihood of fatal overdose[29-30]. While the opioid epidemic has been a major focus in the literature over the last several years, only recently has polysubstance abuse been addressed[31]. This suggests that focusing only on opiate prescribing may be a simplistic approach, and in attempts to stem the opiate epidemic we need to consider these co-ingestions in targeting our interventions.

The limitations of this study include a potential for measurement error.Some cases of unintentional or intentional injury death may be missed if an autopsy was not performed by the OC coroner as in patients with end stage cancer or other terminal illness. In the multitude of cases with polysubstance co-ingestion it is impossible to discern which drug was the actual cause of death, and also likely that the combination of the drugs together increased the likelihood of death. Regarding the coroners testing of fentanyl, there is no presumptive screening for fentanyl. The coroner attempts to control this based on observations made on scene, testing of drug paraphernalia, or past history. In certain scenarios where the deceased has died of pulmonary edema with no obvious cause of death, the coroner's lab analyzes both the postmortem blood and tissues. This additional testing is the alkaline drug screening and pain management panel which detect fentanyl and analogs[19].

During the time period data was gathered, changes were made in the coroner's practice of recording data for heroin overdoses which may have lead to an underestimation of cases attributable to heroin. Prior to 2011 there was no specific toxicology test to identify cases as "heroin users." The coroner would deduce that the decedent had overdosed under the influence of heroin by labeling the case mode subtype as "misuse" with cause of death as "morphine and codeine" (common metabolites of heroin).

There were 19 of these cases in total. After late 2011, the coroner began identifying and tabulating "cause of death" as "heroin use," directly. We trusted cases of heroin use were faithfully recorded by the coroner's office after late 2011, however we still made similar assumptions as before 2011 if there were discrepancies in data. For example, if a case was labeled as "misuse" plus morphine and codeine, yet for some reason marked as "false" for heroin involvement the case was classified as a heroin death (n=2). Given this number is small we do not believe it has a significant effect on the overall outcome. Some cases could not be differentiated between prescription drug opioid or heroin and grouped into the unknown category (n=9).

Geographically and socioeconomically, we recognize what is found in this study may not necessarily be reproducible in other counties throughout the US. We recognize that given the data is ecologic, we may have some errors in our estimates of the association with SES, however it is clear that no group is immune and the need for opioid interventions need to address all socioeconomic levels. Our findings still shed light on the severity of the prescribed opioid-related overdose death epidemic in both residents and especially the homeless.Given our goal is to develop interventions to improve our community, we focused on this area to determine how our data compares to that of other urban areas. We may potentially underestimate the mortality rates of OC residents if they experienced an opioid-related overdose death occurring outside of county limits. There is potential for error as we have assigned SES and demographics to case fatalities based on their zip code of residence, which may not be true, and the risk of the ecologic fallacy exists. Regarding our analysis of the homeless population, the individual counts of cases were less than one may expect, and thus the mortality rate estimates per person years have wider confidence intervals. Homeless individuals that were unsheltered may also be missed in census counts, resulting in an overestimates of rates[32]. Finally, while we contrast our results to those of other urban areas, it is possible that because the data is ecologic and this affects our estimates about SES, our data is similar to other urban areas.

4.1 Conclusion

In conclusion, we found that the rate of opioid overdose death in OC is increasing. This may be largely attributed to the increase availability of cheaper heroin fueled by increased diversion efforts to stem prescription opioids. Regarding SES, we found that opioid overdose death is a serious cause for concern among areas with a high burden of poverty and uncovered an alarming need to address the heroin problem in the OC homeless population. It is evident that supply reduction efforts alone in regards to prescription opioid abuse is likely not enough to solve the current epidemic of opioid overdose in orange county homeless and non-homeless population. This ecologic study sheds light on the need for large scale, population specific opioid misuse intervention strategies. In summary, successfully combating the prescription and heroin opioid epidemic requires a thorough understanding of the socioeconomic factors of the population targeted. Additionally, opioid addiction is a disease that does not recognize geographic boundaries and treating this epidemic will require expanding intervention areas and including a more diverse population than once prior thought.

Author contributions

John R. Marshall contributed to idea context, literature review, data gathering, analysis, formation of text body tables and figures, editing text, submission of article, and is the corresponding author. Stephen F. Gassner contributed to literature review, data gathering, analysis of data, and text. Craig L. Anderson contributed to data analysis and interpretation, geo-mapping of data. Richelle J. Cooper contributed to literature review, contribution to text, and editing of text. Shahram Lotfipour contributed to the literature review, idea context, and editing of text. Bharath Chakravarthy, the senior author, contributed to the idea context, literature review, data gathering, and editing text.

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Table 1: Demographics of Opioid Overdose Deaths Among Orange County Residents Averaged from 2010-2014[a,b]

	Category	Deaths (%)	Population (%)	Rate (95% CI) Per 100,000 person years
Opioid Type	**Prescription**	**830 (78%)**	**3,086,311**	**5.4 (5.0-5.8)**
	Heroin	**183 (17%)**	**3,086,311**	**1.2 (1.0-1.4)**
	Both	**35 (3.2%)**	**3,086,311**	**0.2 (0.2-0.3)**
	Not Classifiable	**17 (1.6%)**	**3,086,311**	**0.1 (0.1-0.2)**
Intent	**Unintentional**	**854 (80)**	**3,086,311**	**5.5 (5.2-5.9)**
	Suicide	**164 (15)**	**3,086,311**	**1.1 (0.9-1.2)**
	Undetermined	**47 (4.4)**	**3,086,311**	**0.3 (0.2-0.4)**
Age	**0-14 years**	**2 (.02)**	**598,069 (19)**	**0.1 (0.0-0.3)**
	15-24 years	**130 (12)**	**444,525 (14)**	**5.8 (4.9-6.9)**

	25-34 years	**207 (19)**	**428,055 (14)**	**9.7 (8.4-11.1)**
	35-44 years	**181 (17)**	**433,257 (14)**	**8.4 (7.2-9.7)**
	45-54 years	**299 (28)**	**452,475 (15)**	**13.2 (11.8-14.8)**
	55-64 years	**181 (17)**	**347,786 (11)**	**10.4 (9.0-12.0)**
	65 years +	**65 (61)**	**382,162 (12)**	**3.4 (2.7-4.3)**
Gender	**Female**	**420 (39)**	**1,561,260 (51)**	**5.4 (4.9-5.9)**
	Male	**645 (61)**	**1,525,071 (49)**	**8.5 (7.8-9.1)**
Race/ Ethnicity	**Hispanic**	**123 (12)**	**1,050,771 (34)**	**2.3 (2.0-2.8)**
	White	**898 (84)**	**1,323,581 (43)**	**13.6 (12.7-14.5)**
	Asian	**26 (2.4)**	**569,625 (18)**	**0.9 (0.6-1.3)**
	Black	**18 (1.7)**	**47,072 (1.5)**	**7.6 (4.8-12.1)**
	Other or 2 or more	**0**	**95,282 (3.1)**	**0**
Total		**1065**	**3,086,331**	**6.9 (6.5-7.3)**

[a]Homeless and non-Orange County residents excluded (n=140)

[b]Numbers shown in population column represent average estimate over 4 years based on the 2010-2014 Orange County Census

Table 2: Annual Rates of Opioid-Related Overdose Deaths Among Orange County Residents from 2010-2014[a]

Year	Deaths (%)	Population	Annual Rate (95% CI) per 100,000 person years
2010	206 (19)	3,018,963	6.8 (6.0-7.8)
2011	211 (20)	3,055,745	6.9 (6.0-7.9)
2012	204 (19)	3,090,132	6.6 (5.8-7.6)
2013	220 (21)	3,114,363	7.1 (6.2-8.1)
2014	224 (21)	3,145,515	7.1 (6.2-8.1)
Total	1065		

[a]Homeless and non-Orange County residents excluded (n= 140)

Table 3: Data on Orange County Homeless Population Prescription Opioid and Heroin Overdose Death Rates per 100,000 Person Years[a]

	Number of Overdose Deaths	Eligible Person Years of Observation	Rate/100,000 person years (95% CI)
Adult Males	59	16826.4	350.6 (271.7-452.6)
Adult Females	26	7029.1	369.9 (251.8-543.3)
All Adults	85	23855.5	356.3 (288.1-440.7)
Persons less than 18	0	4917.0	0
Total	85	28772.5	295.4 (238.8-365.4)
All Males	59	19284.9	305.9 (237.0-395.0)
All Females	26	9487.6	274.0 (187.0-402.0)

Prescription Opioid	**39**	**28772.5**	**135.5 (99.0-185.5)**
Heroin	**45**	**28772.5**	**156.4 (116.8-209.5)**

[a]Denominators for calculation obtained from a point in time survey conducted by the US Department of Housing and Urban development for homeless person years for 2010-2014 as $0.5*n_{2009}+2*n_{2011}+2*n_{2013}+0.5*n_{2015}$, where n is count for the years indicated by the subscript.

Table 4: The Prevalence of Benzodiazepine with Opioid Overdose in OC Residents and Homeless 2010-2014[a]

	OC Residents		**OC Homeless**	
	Frequency	%	Frequency	%
Opioid + Benzodiazepine	537	50.5	36	42.3
Total	1063[a]	100.00	85	100.00

[a]n< 1065, due to missing data on 2 cases

[b] polypharmacy defined distinctly as testing positive for opioid (heroin and prescription type opioid) as well as for either a benzodiazepine, stimulant, other drug, or ethanol.

Table 5: **Effects of Neighborhood-Level Socioeconomic Variables by Quartile on Mortality from Overdoses of Prescription Opioids and Heroin, Orange County, CA, 2010-2014[a,b]**

Neighborhood Characteristics (according to percentage of population with characteristics)	Mortality ratio for prescription opioid deaths (95% CI)	Mortality ratio for heroin deaths (95% CI)
Education **(% Bachelor or advanced degree)**		
<28.1%	1.00	1.00
28.2-41.5%	0.76 (0.56-1.03)	0.97 (0.58-1.62)
41.6-56.7%	0.59 (0.39-0.89)	0.65 (0.32-1.32)
≥56.8%	0.45 (0.28-0.72)	0.53 (0.23-1.23)
Percentage below poverty level		
<6.35%	1.00	1.00
6.35-9.99%	1.45 (1.10-1.89)	1.52 (0.88-2.62)
10.00-16.85%	1.72 (0.81-2.74)	1.49 (0.81-2.74)
≥16.86%	2.90 (1.02-4.68)	2.18 (1.02-4.68)
Median household income		
<$59,410	1.00	1.00
$59,410-83,900	0.65 (0.52-0.81)	0.76 (0.51-1.12)
$83,910-97,460	0.58 (0.42-0.80)	0.66 (0.38-1.17)
≥$97,470	0.50 (0.33-0.74)	0.33 (0.15-0.70)

[a]Negative binomial regression was used to control for age (% 0-14, 15-24, 25-44, 45-64, and 65 and older), ethnicity (% Hispanic or Latino), and race (%non-Hispanic white, non-Hispanic black, non-Hispanic Asian, and all other non-Hispanics [includes 2 or more races]). 825 deaths involved prescription opioids, 182 involved heroin, 35 involved both and were included in both regression models, and 17 did not specify the type of opioid and were not included in either model.

[b]Neighborhoods defined as 86 Orange County zip-codes.

Figure 1: Annual Mortality rate per 100,000 Person Years of Heroin and Prescription Opioid-Related Deaths by Age and Gender in Orange County 2000-2014.

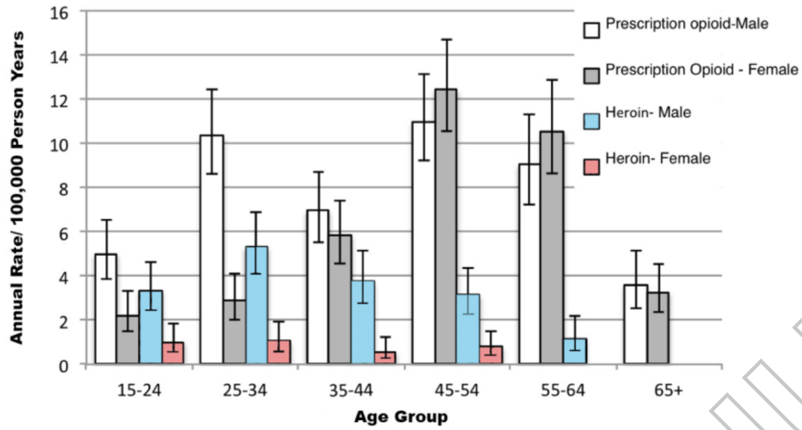

Figure 2a: Annual Rates of Orange County Resident Total Heroin and Prescribed Opioid Overdose Deaths by Orange County Zip Code boundary per 100,000 Person Years

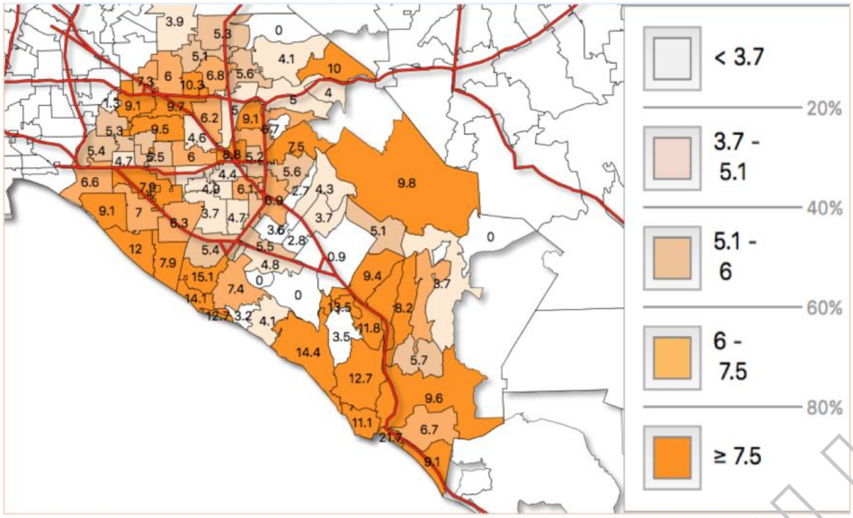

Figure 2b: Annual Rates of Orange County Resident Prescribed Opioid-Related Overdose Death Rate by Orange County Zip-Code Boundary per 100,000 Person Years

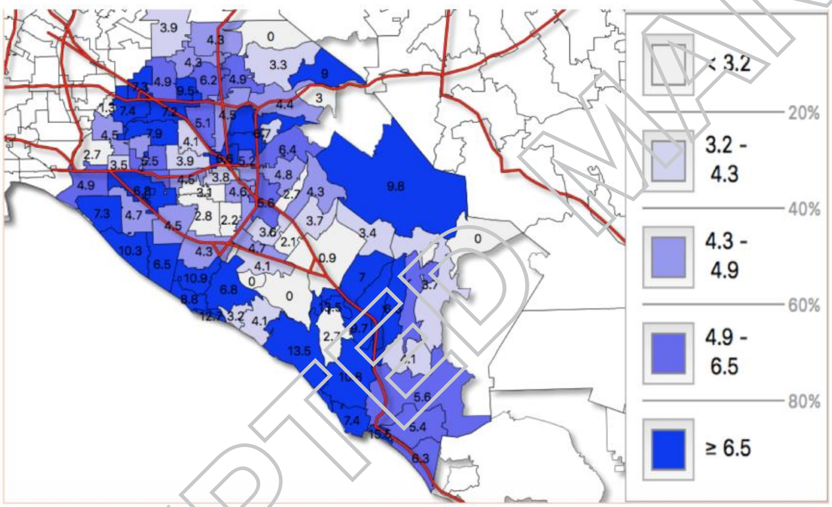

Figure 2c: Annual Rates of Orange County Resident Heroin Related Overdose Death Rates by Orange County Zip-Code Boundary per 100,000 Person Years