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Fatal & Non-Fatal Opioid Overdoses in Marin County: Using EMS and county data to locate the presence of fentanyl, naloxone distribution, repeated overdoses, and demographics

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Fatal & Non-Fatal Opioid Overdoses in Marin County:

Using EMS and county data to locate the presence of fentanyl, naloxone distribution, repeated overdoses, and demographics

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Abstract

Background. In recent years, the United States has been greatly affected by prescription drug overdose deaths, 68% of which are caused by opioids. Like many communities nationwide, Marin County in California is deeply affected by the opioid epidemic with accidental overdose being one of the leading causes of injury-related death. This study examines how fatal and non-fatal opioid overdoses in Marin County are associated with factors such as suspected fentanyl involvement, naloxone administration (EMS), and repeat overdose events.

Methods. A cross-sectional study was conducted by Marin County's Health and Human Services using data collected from EMS dispatch calls and vital statistical records. Logistic regression was used to study the relationship between fatal and non-fatal overdoses and factors associated with the EMS event such as suspected fentanyl involvement, use of naloxone, and repeat suspect overdose. A spatial analysis was conducted using a Geographical Information System software examining the distribution of fatal and non-fatal overdoses in Marin County in relation to three variables: suspected fentanyl involvement, presence of naloxone, and whether the incident was a repeat overdose.

Results. This multivariate regression model shows that individuals who are 45 years old and over are 6 times more likely to die from any overdose (OR=6.19, 95% CI=3.99-9.60). Individuals who did not receive naloxone at the time of the EMS event were more likely to die from an opioid overdose (OR=0.51. 95% CI=0.33-0.79). Lastly, individuals were 3 times more likely to die from their first overdose compared to individuals who had already experienced an overdose in the past (OR=3.1, 95% CI=1.19-8.20).

Discussion. EMS and death county data are helpful in examining fatal and non-fatal overdoses. The statistically significant findings show that fatal overdoses are associated with older age, first-time overdoses, and naloxone administration.

Introduction

In 2017, about 68% of overdose deaths involved opioids in the United States which is about 48,000 deaths caused by drug abuse and misuse (Centers for Disease Control and Prevention, 2019). Opioids are a class of drugs used to reduce pain (CDC, 2018). These medications, which are legally prescribed by a physician, include but are not limited to opioids such as oxycodone, hydrocodone, codeine, and morphine (U.S. of Health and Human Services, 2018) However, more often than not, some individual have access to illegal opioids such as heroin and synthetic opioids such as fentanyl (HHS, 2018). All opioids, whether prescribed or illegal, have a serious risk for addiction, abuse, and overdose. Fentanyl is highly potent, meaning that it is 50-100 times more potent than one dose of morphine (CDC, 2019). In the United States, overdoses, caused by fentanyl, increased by 426% during 2013 and 2014 (Gladden, Martinez, & Seth, 2016). Certain communities have taken action to combat these overdose deaths by distributing naloxone in areas with high prevalence of overdose. Naloxone has been proven to be a safe and effective opiate agonist that can reverse overdose either through an injection or nasal spray (Kim, Irwin, & Khoshnood, 2009). As of 2008, there are 52 naloxone distribution programs in the United States (Kim, et. al., 2009).

There are several studies that have examined EMS data and conducted spatial analysis to examine fatal and non-fatal overdoses in localized areas across North America. A number of these findings showed that individuals who were younger, between 18-40 years old, and those who experienced more than one non-fatal overdose were more likely to die of drug related causes (Lasher, et. al., 2013; Marshall, et. al., 2017; Pesarick, et. al., 2019; Ray, et. al., 2018). One study in Rhode Island, found that 46% of the overdoses during the study period were caused by acute fentanyl intoxication (Marshall, et. al., 2017). Additionally, it was common in studies to

find that a majority of the overdoses took place in a private residence (BCCDC, 2017; Marshall, et. al., 2017). Studies also suggest placing more interventions to distribute naloxone in areas of high overdose, whether fatal or non-fatal. A study which utilized spatial analysis showed that there was a decrease in overdoses with areas that had a greater concentration in recovery treatment clinics (Amram, et. al., 2019).

Marin County, California is one of the populations greatly impacted by this epidemic with accidental overdose being one of the leading causes of death (California Department of Public Health, 2019). The California Department of Public Health collected data using the Marin County EMS Database to track the location of overdoses in Marin County and also the prevalence of overdoses in prior years. Since April of 2018, there have been 78 suspect opioid overdoses among individuals in between 18 and 30 years-old, 83 suspect opioid overdoses among individuals in between 31 and 64 years-old, and 51 suspect opioid overdoses among individuals 65 years and older (CDPH). In 2019 and in just 10 months alone, there have been 166 suspect overdoses in Marin County. Since April of 2018, suspect overdoses affect 64% of males and 36% females (CDPH). Although there has been an increase in naloxone distribution in Marin County, the numbers that are presented through the database are still alarming (CDPH).

RxSafe Marin and the U.S. Department of Health and Human Services (HHS) have contributed much data to bring light to this issue in this county and have supported this study. RxSafe Marin is a community coalition committed to reducing harm from prescription drug abuse and saving lives. The organization provides extensive data on the active drug use and abuse that occurs in Marin County. The Pilot Project is a system in which Marin County HHS created to identify and examine survivors of opioid overdose with substance abuse treatment

(CDPH). Marin County Emergency Medical Services (EMS) are utilized to document these incidences on a weekly basis.

Although there are several studies focusing on opioid overdoses in the United States and globally, the academic literature lacks research in Marin County where overdose is one of the leading causes of accidental deaths. Using EMS ambulance records and death records, the purpose of this study is to examine the prevalence of fatal and non-fatal opioid overdoses in Marin County from 2015 to 2018 and demonstrate its relationship to exposure factors and demographic factors through statistical and spatial analysis.

Methods

Study oversight

The Institutional Review Board of Dominican University of California had approved this study, IRB Application #10845. The Health and Human Services of Marin County and all authors vouch for the completeness and accuracy of the data which was de-identified to preserve the privacy of each individual case.

Study design and data collection

A cross-sectional study was conducted by Marin County's Health and Human Services using EMS dispatch calls. From 2015-2018, the EMS data looks closely at the prevalence of overdoses, both fatal and non-fatal in Marin County, in relation to the location of the incident, whether naloxone was administered, the presence of fentanyl, the possibility of a repeated overdose, and the individual's demographics.

The initial county data set included 75,381 EMS and fatal incidents in Marin County from 2015 to 2018 and 106 variables. Cases and variables were eliminated due to the following criteria: 1. EMS incident was not an opioid overdose, 2. EMS incident did not take place in Marin County, 3. The case had missing necessary EMS data information, 4. Variables that were not necessary to the relationship of the outcome and objectives of the study. There were 3 cases that were excluded because the EMS incident did not take place in Marin County. In total, there were 75,380 cases and 115 variables that were excluded when following the elimination criteria. In total, there were 822 individuals that were included in the final study and were examined in relation to the variables that best describes the outcome, exposures, and demographics of the study.

Potential confounders

The data set that was be analyzed included the following variables: opioid overdose (both fatal and non-fatal), age, gender, year of overdose, type of location where incident happened, incident city, naloxone administered, fentanyl mentioned, possible repeat overdose, longitude, latitude, and possible repeat overdoses. All variables were recoded from verbal codes to numeral codes. Age was transformed into a categorical variable rather than continuous. Age was dichotomized into two age groups, 45 years old and below and 45 years old and above. The location of where the overdose incident occurred was dichotomized into two groups, home and other (jail, street/highway, rehabilitation center, residence/assisted living, residential institution, assisted living centers, place of business, nursing home, doctor's office/medical practitioner office, commercial establishment, dialysis, hospital, lake/river/ocean, and other specified place). Selected cities in Marin County were categorized based on similar geographical location and population density. The new grouped city variables included: Belvedere and Tiburon, Bolinas, Dillon Beach, Inverness, Point Reyes, and Stinson Beach, Corte Madera and Larkspur, Greenbrae, Kentfield and Ross, and Woodacre, San Geronimo, Forest Knolls, Marinwood, and Nicasio. Lastly, opioid overdoses were recoded as non-fatal or fatal overdoses. Populations of each city in Marin County were taken from the United States Census Bureau and the deaths per capita or per 100,000 were calculated by the research [(overdoses/city population) x 100,000].

Researchers assessed the cause of overdoses, both fatal and non-fatal, due to opioids. The administration of naloxone was recorded and documented during the time of the EMS event. Additionally, the judgement of EMS workers and dispatchers was used to determine whether or not fentanyl was present at the scene and was then documented into the database. The variable

"naloxone administered" was the dose of naloxone that was administered by the EMS when they arrived at the scene of the event. The longitude and latitude and the city of the overdose incident was recorded by the EMS. The variable "possible repeat overdose" measures whether the individual had experienced an overdose prior to this incident. Lastly, the demographic and confounding factors will include gender and age.

Statistical analysis

Before continuing with any data analysis, all data was de-identified to preserve privacy for all research participants and all missing variables were ignored using the algorithm within analytic software, SPSS version 22. Chi-square descriptive analysis was run to examine the prevalence of fatal and non-fatal overdoses and their demographics and exposure factors (Table 1 and 2). Logistic regression was used to examine fatal and non-fatal overdoses and how these outcomes were associated with the administration of naloxone, year of overdose, history of overdose, and the individual's age (Table 3).

Spatial analysis

Spatial analysis was analyzed through a geographic information system called QGIS version 3.12. Before creating the descriptive maps, all excel sheets were converted to comma delimited (.csv) documents in order to properly join the excel sheet and the longitude and latitude to the map. Four excel sheets were created to analyze the rate of change of overdoses from 2015-2018. All excel sheets were joined with the default coordinate system, EPSG:4326 - WGS 84. Descriptive maps and heat maps were created through the layer styling tool box.

Results

Table 1. Relationship between of opioid overdoses and demographic and exposure factors in Marin County between 2015 and 2018

Characteristics	**Non-Fatal Overdose n(%)**	**Fatal Overdose n(%)**	**X^2(df);p-value**
Age**			96.5(1);p<0.001
Below 45	387 (59.4)	29 (17.1)	
45 and over	265 (40.6)	141 (82.9)	
Gender			0.461(1); p=0.278
Male	384 (58.9)	105 (61.8)	
Female	268 (41.1)	65 (38.2)	
Year of Overdose			7.03(3); p=0.071
2015	137 (21.0)	41 (24.1)	
2016	188 (28.8)	52 (30.6)	
2017	166 (25.5)	51 (30.0)	
2018	161 (24.7)	26 (15.3)	
Type of Location Where Incident Occurred			1.32(1); p=0.144
Home	250 (39.5)	75 (44.4)	
Other[1]	383 (60.5)	94 (55.6)	
Fentanyl Present			
Yes	18 (2.8)	6 (3.5)	0.281(1); p=0.375

No	634 (97.2)	164 (96.5)	
Naloxone Administered**			
Yes	373 (57.2)	136 (80.0)	29.7(1); p<0.001
No	279 (42.8)	34 (20.0)	
Possible Repeat Overdose*			7.51(1); p<0.05
Yes	61 (9.4)	5 (2.9)	
No	591 (90.6)	165 (97.1)	

*p<0.05
**p<0.001
1. "Other" includes jail, street/highway, rehabilitation center, residence/assisted living, residential institution, assisted living centers, place of business, nursing home, doctor's office/medical practitioner office, commercial establishment, dialysis, hospital, lake/river/ocean, and other specified places.

Table 1 shows the compares fatal and non-fatal overdoses and their relationship to demographics, possible repeat overdoses, whether fentanyl was documented as present, and whether naloxone was documented as being administered during the time of the incident. There was a significant relationship between age and opioid overdose (96.5 (1);p<0.001). Those between the ages under 45 years old had the highest rate of non-fatal opioid overdoses, 59.4% (n=387). Those that were 45 years old and over had the highest rate of fatal opioid overdoses, 82.9% (n=141). There was a statistically significant relationship between naloxone administered at the event and opioid overdoses, (29.7 (1); p<0.001). Individuals who received naloxone at the time of the incident, 57.2% (n=373), survived the overdose whereas 80% (n=136), did not survive the overdose. Additionally, the relationship between possible repeat overdoses and opioid overdoses proved to be statistically significant (7.51(1); p<0.05). These results showed

that 90.6% (n=591), of the non-fatal overdoses and 97.1% (n=165) of the fatal overdoses had never experienced an overdose in the past.

Other variables such as gender, the year of the incident, location type, and the presence of fentanyl did not present to be significant. Males generally had a higher risk of overdose both non-fatal (58.9%, n=384) and fatal (61.8%, n=105) compared to females. The years 2016 and 2017 had the most fatal overdoses (30.6%, n=52; 30.0%, n=51) compared to 2015 and 2018. However, all 4 years presented to have more non-fatal overdoses compared to fatal overdoses with 2016 having the most non-fatal overdoses (28.8%, n=188). At the time of the overdose, 60.5% (n=383) of the individuals who survived were found in other[1] places rather than in a home. On the other hand, 55.6% (n=94) of individuals who did not survive the overdose were found in other places rather than in a home. EMS reports that documented the presence of fentanyl at the time of the overdose showed that 2.8% (n=18) were non-fatal overdoses and 3.5% (n=6) were fatal overdoses.

Table 2. Relationship between fatal and non-fatal opioid overdoses and the incident city in Marin County between 2015 and 2018

Incident City	Total Population	Overdoses per 100,000	Non-Fatal Overdose n(%)	Fatal Overdose n(%)	X^2(df);p-value
San Quentin	3,418	819	20 (3.2)	8 (4.7)	16.9(12); p=0.154
Sausalito	7,100	492	28 (4.5)	7 (4.1)	
San Rafael	58,704	463	221 (36)	51 (30)	
Mill Valley	14,295	454	53 (8.5)	12 (7.1)	
Marin City	3,115	385	6 (1.0)	6 (3.6)	
Novato	55,655	357	156 (25)	43 (25)	
Fairfax	7,598	329	22 (3.5)	3 (1.8)	
Bolinas, Dillon Beach, Inverness, Point Reyes, Stinson Beach*	3,765	293	9 (1.4)	0 (0.0)	
Corte Madera, Larkspur*	22,002	277	43 (6.9)	18 (11)	
Belvedere, Tiburon*	11,222	214	17 (2.7)	7 (4.1)	
San Anselmo	12,619	174	18 (2.9)	4 (2.4)	
Greenbrae, Kentfield, Ross*	21,808	119	18 (2.9)	8 (4.7)	

Woodacre, San Geronimo, Forest Knolls, Marinwood, Nicasio*	10,263	117	10 (1.6)	2 (1.2)	
*Smaller cities were collapsed with neighboring cities of similar geographical characteristics					

Table 2 shows the prevalence of fatal and non-fatal overdoses across 26 cities in Marin County between 2015 and 2018 (16.9(12); p=0.154). The cities were organized from greatest overdose per capita to least overdose per capita. This relevance rate helped control for any trend that may be seen with population density. Although the number of overdoses and population density are greatest in San Rafael, the city with the greatest overdose per capita is San Quentin with 819 overdoses per 100,000. Sausalito follows with 492 overdoses per 100,000, with 28 non-fatal and 7 fatal overdoses. San Rafael follows as the third most affected city with 463 overdoses per capita with 221 non-fatal and 51 fatal overdose.

Table 3. Multivariate logistic regression with statistically significant demographic and exposure factors of fatal and non-fatal overdoses

Variable	**B(SE)**	**OR (95% CI)**	**Model Fit**
Constant	-3.34 (0.55)		R^2=0.22
Age in Years			
Below 45		1.00 (ref)	
45 and over	1.82 (0.22)	**6.19 (3.99-9.60)**	
Year of Overdose			
2015		1.00 (ref)	

2016	0.14 (0.26)	1.1 (0.69-1.9)	
2017	0.55 (0.26)	1.1 (0.64-1.8)	
2018	-0.48 (0.30)	0.62 (0.35-1.1)	
Naloxone Administered			
Yes		1.00 (ref)	
No	-0.68 (0.22)	**0.51 (0.33-0.79)**	
Possible Repeat Overdose			
Yes		1.00 (ref)	
No	1.14 (0.49)	**3.1 (1.19-8.20)**	

Table 3 shows the relationship between both fatal and non-fatal overdoses and demographics, predictors, and exposures. The year of the overdose is the confounder that is controlling for the analysis in order to hold all of the factors constant in the regression model. This multivariate regression model shows that individuals who are 45 years old and over are 6 times more likely to die from any overdose **(OR=6.19, 95% CI=3.99-9.60)**. Individuals who did not receive naloxone at the time of the EMS event were more likely to die from an opioid overdose **(OR=0.51. 95% CI=0.33-0.79)**. Lastly, individuals were 3 times more likely to die from their first overdose compared to individuals who had already experienced an overdose in the past **(OR=3.1, 95% CI=1.19-8.20)**.

Figure 1. Fatal and non-fatal opioid overdoses in Marin County in 2015

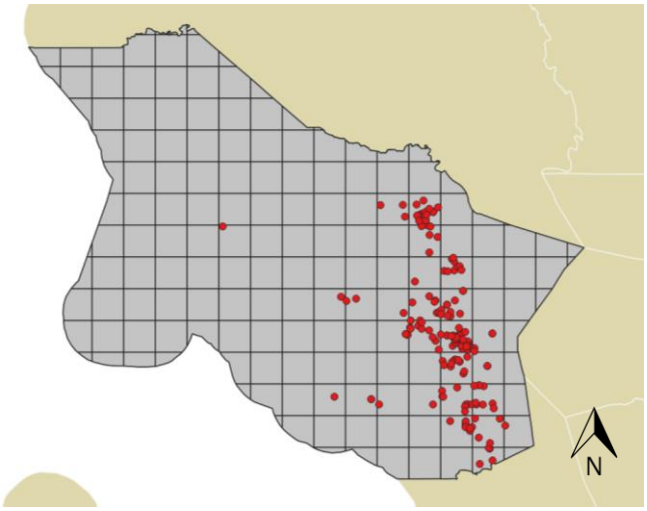
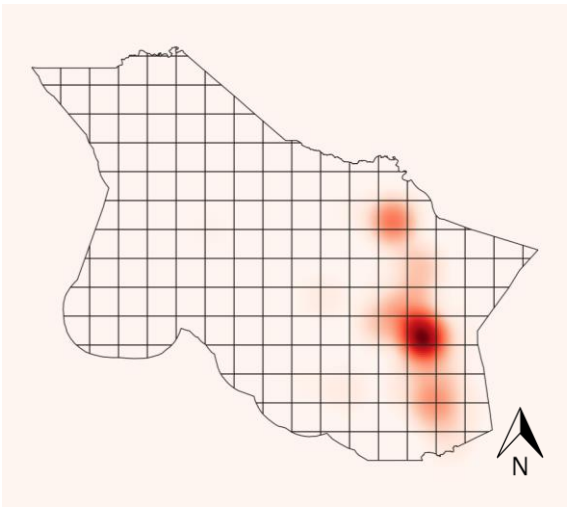


Figure 2. Fatal and non-fatal opioid overdoses in Marin County in 2016



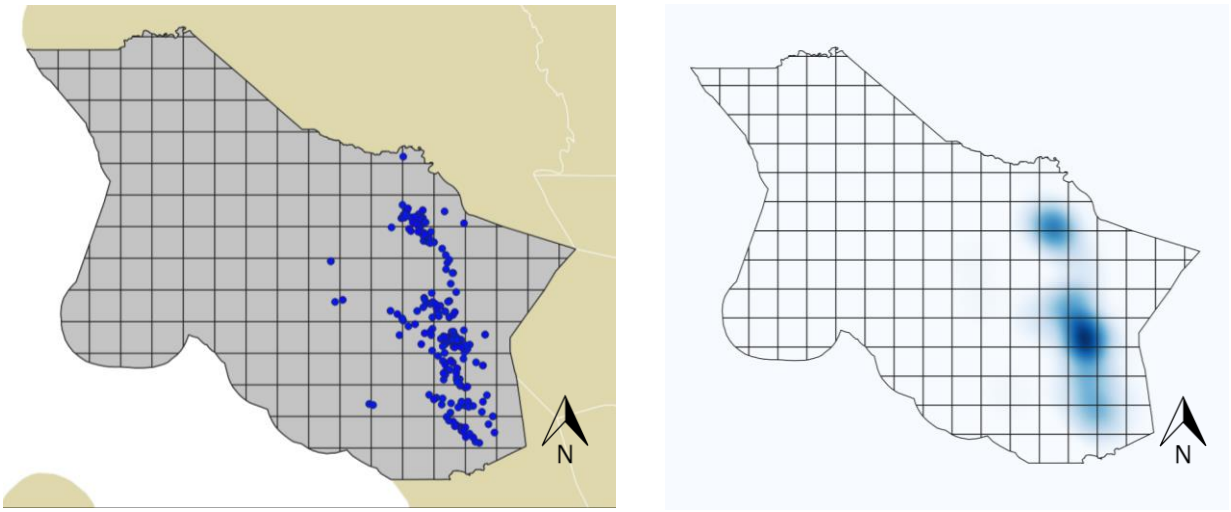


Figure 3. Fatal and non-fatal opioid overdoses in Marin County in 2017

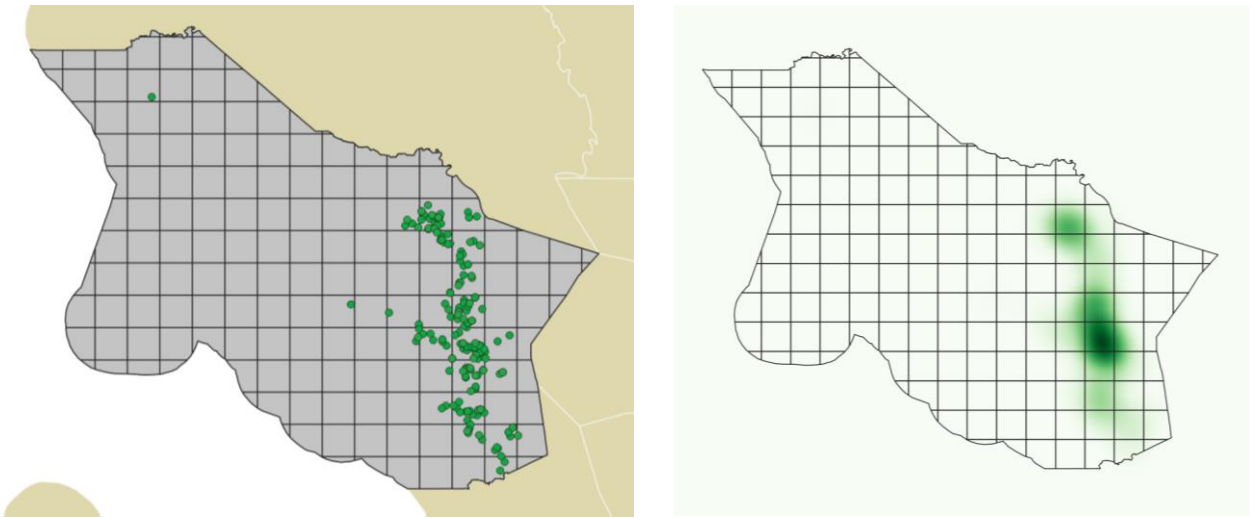
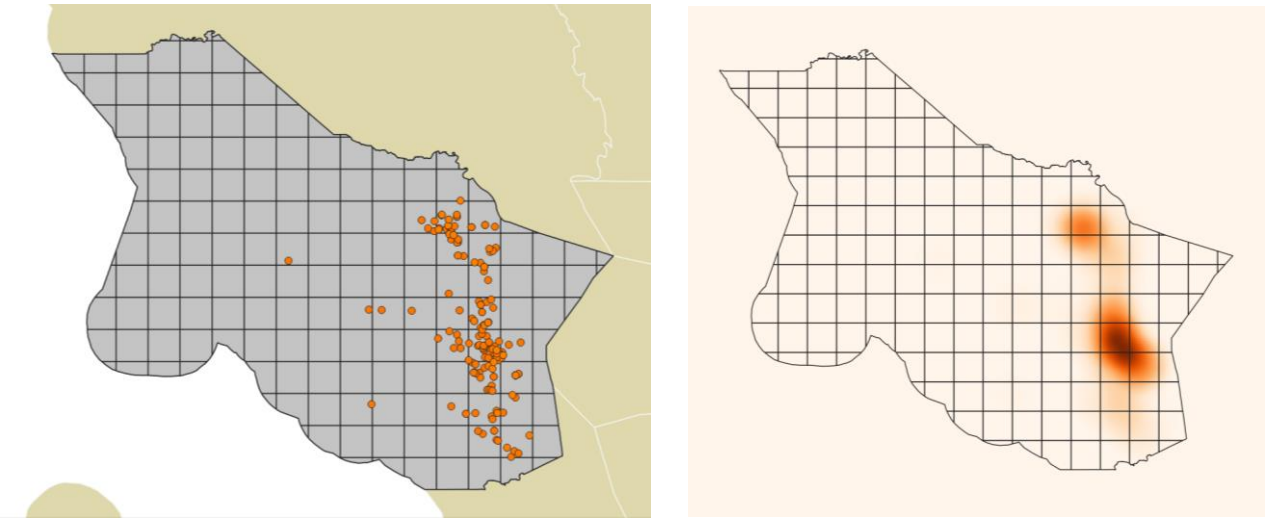


Figure 4. Fatal and non-fatal opioid overdoses in Marin County in 2018



The spatial maps created show more of a visual representation of the change and density of both fatal and non-fatal opioid overdoses throughout the years. The heat maps were created to

better understand the areas concentrated with opioid overdoses. The darker areas show a higher concentration of opioid overdoses whereas the lighter areas show a lower concentration of opioid overdoses. Although the diagrams only show a slight change in overdoses throughout the years, it is still apparent that 2016 has more overdoses compared to the other years. Additionally, it is a trend throughout the diagrams that there is a high concentration of overdoses in San Rafael and Novato.

Discussion

Summary and public health significance

For several years, the United States has been greatly affected by the opioid epidemic (CDC, 2019). Although California's overdose incidence rate is one of the lowest in the country, Marin County has greatly suffered from opioid overdose being one of the leading causes of accidental death in the county (California Department of Public Health, 2019). Fentanyl has been a main contributor to the increase of opioid overdose deaths in the country (CDC, 2019). However, naloxone, a pharmaceutical drug, can help reverse opioid overdose and has proven to save many lives (CITE). EMS data provides great insight into the effects that opioid has in a specific county. Additionally, it can inform the public on interventions that can be taken to combat such a crisis. This study uses both EMS and death county data to identify the exposure factors and demographic factors that affect fatal and non-fatal opioid overdoses.

This study found that individuals of older age were more likely to die from an opioid overdose and younger individuals are more likely to experience a non-fatal overdose. These results vary throughout prior studies and data resources. Studies conducted in Rhode Island, Indiana, and West Virginia, found that younger individuals at least below 35 years old were more likely to die from overdose rather than older individuals (Lasher, et. al., 2015; Ray, et. al., 2018; Warfield, et. al., 2019). In other counties in California, such as Los Angeles and San Diego, there are similar trends in that older individuals are more likely to die from an overdose compared to younger individuals (California Department of Public Health). Naturally, the older an individual, the greater risk for mortality which compares to the results of this study. Additionally, the older an individual the more likely their health will decline due to chronic

illnesses and other medical complications. An individual using opioids with compromised health will most likely not be in the best position to be using such potent drugs such as opioids.

Another finding in this research showed that individuals were more likely to die from their first overdose rather than their second, third, or even fourth overdose. A majority of studies found that the more overdoses an individual experiences, the more likely they will die on their next overdose (Lasher, et. al., 2015; Ray, et. al., 2018; Warfield, et. al., 2019). Because it is difficult to tell what happened prior to the overdose incident, there are a plethora of reasons as to why the first overdose may be the most fatal. One reason for this finding may be that people are not only taking opioids during that time but they are also mixing other substances such as alcohol, cocaine, benzodiazepines which has proven to increase mortality (SAMHSA). Additionally, some individuals may not be properly using the drugs meaning they could be taking too great of a dose at one time whether they were aware of it or not. Although the presence of fentanyl was not significant in the study, this still may be a reason as to why so many individuals were dying from their first overdose.

The results in this study also showed that individuals were more likely to die even though they were administered naloxone at the time of the event. To clarify, these results do not show that naloxone fails to work, rather it shows that there must be other factors outside of this impacting the mortality of these individuals. For example, if people are mixing drugs or have taken too much at one time, it is very unlikely that naloxone can reverse something already so severe. If older individuals are using opioids with an already compromised immune system then it is less likely that naloxone can reverse an overdose. Additionally, the time frame between the initial 911 call and the EMS arrival time can greatly affect the mortality of an individual. If there

is a larger lag time from the time the overdose occurs to the time that the EMS arrive at the scene then the individual is more likely to die.

Strengths and limitations

There are both strengths and limitations when using county data. Because this data is taken at an EMS incident, it is likely that there is missing and incorrect information due to the fast-pace nature of the event. For example, much of the race and ethnicity was not recorded in addition to whether fentanyl was present at the event. With this in mind, EMS data may not be the best tool to measure if fentanyl was present at the incident. Other options of fentanyl documentation could be hospital and coroner data when analyzing the blood work and/or other body samples for the presence of fentanyl (Kellermann, et. al., 1987; Slavova, et. al., 2015)

Additionally, there were very limited confounders because much of the data was missing and incorrect. In previous research, studies that have focused on opioid overdose have often looked at race/ethnicity, mental health history, marital status, socioeconomic status, and medication history (Roxburgh, et. al., 2019; Altekruse, et. al., 2020). These are some confounders that would have added to this specific research. This study is also a cross-sectional study which means that this data was only taken at one point in time, therefore, it is difficult to know the details of the follow-up care of the individuals or reasons as to what led up to their overdose.

Despite the limitations, county data provided the study with a sufficient sample size. This dataset was also a linked dataset of both EMS and death county data allowing for more thorough analysis. To the researcher's knowledge, this study is possibly one of the first studies to look at

both fatal and non-fatal overdoses in Marin county along with all of the exposure factors. Prior studies have only focused on non-fatal overdoses with similar exposure factors.

Future direction

The results presented in the study have great potential for further exploration. Although Marin county has a live surveillance dashboard for opioid overdoses, it only looks at suspected opioid overdoses in the county meaning that it does not specify on whether these overdoses are fatal or non-fatal. The fatal data in this study should be brought to light because it shows who is really affected by these overdoses and possible reasons as to why.

Future implications should focus on understanding the time it takes to get to the incident after the initial 911 call to address the rate of fatal overdoses among individuals who experience their first overdose or those who are being administered naloxone. For older individuals, there can be greater care coordination among this age group to treat not only a possible substance use disorder but also any other medical conditions they currently have. EMS responders and providers during the follow-up care can coordinate a whole person care approach to increase the individual's overall health and well-being. For non-fatal overdoses and fatal-overdoses, follow-up and research needs to be done to understand what happened prior to the overdose. This will help better understand how the individual misused drugs, especially if they mixed multiple potent substances. Lastly, more research needs to be done to examine repeat and first time overdoses in Marin county and also in other counties around the United States. This implication can help better understand the results shown in this study on first time fatal opioid overdoses.

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