# Analysis of Opioid Distribution Before and After Recreational Marijuana Legalization in California

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## Abstract

The opioid epidemic escalated to an all-time high this past decade. States have searched for the right harm reduction and overdose prevention policies to no avail. Due to its controversial history, marijuana has not been regarded as an analgesic therapy. However, recent investigations have shown promising data highlighting the efficacy of marijuana as an analgesic and the use of marijuana for pain reduction could decrease opioid usage for pain mitigation. The distribution of codeine, fentanyl, hydrocodone, morphine, and oxycodone was examined per capita and by zip codes for the years 2014 to 2018 in California, which legalized recreational marijuana in 2016, and was compared to Texas, where medicinal and recreational marijuana is prohibited. Drug weights were obtained from the U.S Automation of Reports and Consolidated Orders System (ARCOS) and converted to their oral morphine milligram equivalent (MME) to facilitate analyses. Heat maps were constructed from distribution by zip code data to compare gross changes from 2014 to 2018. Opioid distribution per 100K people was analyzed to observe trends accounting for population differences. Both California and Texas showed statistically significant reductions in opioid distribution from 2014 to 2018, but a 43.7% decrease was seen in California versus 27.3% in Texas. Opioid distribution per 100K people in California decreased 38.9% over this time while distribution in Texas also decreased by 26.4%. Analyses showed that during this time period, opioid distribution decreased in larger areas of California than in Texas. The evidence supports marijuana legalization as a mitigating factor to the opioid epidemic. Furthermore, it highlights the idea that various legislative measures may help alleviate this crisis and a resolution to this issue is attainable. Continued studies on safer pain management alternatives will help identify measures that have a positive impact on the opioid epidemic and can be further developed to eradicate this issue.

## Introduction

The Controlled Substance Act of 1970 has classified marijuana as a Schedule I drug along with heroin and ecstasy. Under this classification, marijuana is regarded as having high abuse potential and no medical efficacy. Various opioids are listed as schedule II drugs, which are regarded as having limited medical use with a high abuse potential. Certain opioid combination drugs are listed as Schedule III, such as acetaminophen with codeine. Here, the opioid distributions of fentanyl, oxycodone, morphine, hydrocodone, and codeine in California after legalization of recreational marijuana have been analyzed. The opioids previously mentioned are listed from most to least potent (1) and have been chosen on a basis of familiarity to the general population.

Since the passing of the Controlled Substances Act, marijuana has traditionally been disregarded as an option for analgesic treatment, but recent studies may show an alternative view. A daily regimen of cannabis was shown to be an efficacious and safe alternative to conventional treatments for chronic pain (2). Other studies have also risen showing the efficacy of marijuana in treating pain associated with neuropathy (3), fibromyalgia (4) and inflammatory bowel disease (5). With such promising data illustrating efficacy in pain management, a separate study showed a 64% decrease in opioid use and a 45% increase in improved quality of life in patients that used marijuana as an alternative treatment for chronic pain (6). Along with these promising findings is increased interest in attempting such therapy among patients. A survey of patients with gynecological malignancies reported 60 patients out of 225 began using non-prescription cannabis as therapy for symptoms related to cancer therapy and 80 out of 225 are interested in attempting forms of cannabis-related therapy (7). Among the 60 patients using marijuana for symptom management, 45% reported decrease in use of narcotic prescriptions (7).

The United States has suffered from a severe opioid epidemic dating back to the turn of the century. The opioid epidemic was characterized by an increase in opioid-related deaths following a steep increase in opioid and opioid combination prescription rates in the early 1990s. Opioid prescriptions quadrupled from 1998 to 2008 and resulted in a steady increase in medically related overdoses leading to deaths (8). With the Centers for Disease Control (CDC) reporting nationwide opioid prescription rates steadily increasing from 2006 through 2012 but showing a steady decrease from 2013 through 2018 (9), this shows there has been an effort to alleviate the crisis. These measures include removing pain as the fifth vital sign and the implementation of proper drug disposal programs, that also act in taking back unused medication (10). However, these measures, though imperative, have had little to no effect on the rate of distribution and control of opioid-related deaths. In fact, there were approximately 65,000 deaths in 2016, an increase of 21% from the year prior (8). California reported having 6 opioid-related deaths per 100K people in the year 2018 (11). Comparably, Texas reported 5 opioid-related deaths per 100K people in the year 2018 (12). The prescription rate was 35.1 prescriptions per 100 persons in California (11) and 47.2 prescriptions per 100 persons in Texas (12) during 2018. For our study, we chose to compare the states California and Texas. California has legislation in place which legalized cannabis use medicinally in 1996 and recreationally in 2016. Texas currently prohibits cannabis use medicinally and recreationally.

Due to the controversial history of marijuana, there has been little research deciphering the effects of adult use of marijuana

in a recreationally legalized state on opioid distribution trends. However, there have been recent changes with California legalizing medicinal marijuana in 1996 and recreational marijuana in November of 2016. With this change, recreational dispensaries began opening to individuals who were at least 21 years of age in January 2018. Accompanied by previous data concerning its effects as an alternative analgesic (2, 3, 4, 5, 6, 7), we can now begin to analyze the effects the change in legislation could have on the distribution of opioids. Our study analyzed the medical opioid distribution rates in California, where medical marijuana and recreational marijuana use is legalized, by zip code and per capita as compared to Texas, which has not legalized recreational or medical marijuana. We hypothesize that there will be a greater decrease in opioid distribution in California following this change in legislation than in Texas.

## Methods

### Procedure

The Drug Enforcement Agency's ARCOS Database is used to track controlled substances from manufacture, through distribution channels to point-of-sale at the level of hospitals, pharmacies, practitioners, and teaching institutions. The data is organized in several reports summarizing drug distribution by zip code, per 100K population gathered and includes summaries of purchases. Report 1, which reports drug distribution by zip code, and Report 3, which reports quarterly drug distribution by state per 100 000 population by gram were selected for analysis (13, 14).

### Data analysis

The weight of each opioid was converted to oral Morphine Milligram Equivalents (MME) using the following factors: codeine 0.15, fentanyl base 75, oxycodone 1.5, morphine 1, and hydrocodone 1 (15). Heatmaps and graphs were made using Microsoft Excel and GraphPad Prism 8. Two-tailed paired equal variance t-tests were performed using GraphPad Prism 8 software on zip code distribution data to determine statistical differences with $p<0.05$ considered significant. Outliers were tested for using Grubbs' Test on GraphPad Prism.

## Results

### Opioid distribution by zip code

In both 2014 and 2018, California showed much more widespread and substantial cumulative opioid distribution as seen in Figure 1A and 1B. In 2014, portions of California surrounding the Bay Area had cumulative opioid distributions as high as 1 388 000 MME and 900 000 MME in portions of Southern California. In contrast, the highest distribution in Texas was 790 000 MME in the surrounding Dallas area. Most of Texas had a distribution of approximately 100 000 or less while most zip codes in California ranged from 150 000 to 650 000, visualized in Figure 1A. However, in 2018, the largest distributions in California dropped to approximately 720 000 MME in the Bay Area and 525 000 MME in Southern California, decreases of approximately 50% and 40% respectively (Figure 1B). The surrounding Dallas area saw a decrease of 25%, while most of Texas did not show a comparable decrease relative to California as depicted in Figure 1C. Both California and Texas showed statistically significant decreases in opioid distribution ($p<0.0001$, $p<0.0001$), but California had a greater mean difference (162,476 versus 62,808) over this 5-year span. This represents an approximately 27.3% decrease in Texas and


**Figure 1.** (A) 2014 cumulative opioid distribution in California and Texas by zip code (MME). (B) 2018 cumulative opioid distribution in California and Texas by zip code (MME). (C) Comparison of the cumulative change in MME of the selected opioids with darker green showing a greater decrease and darker red showing a greater increase.

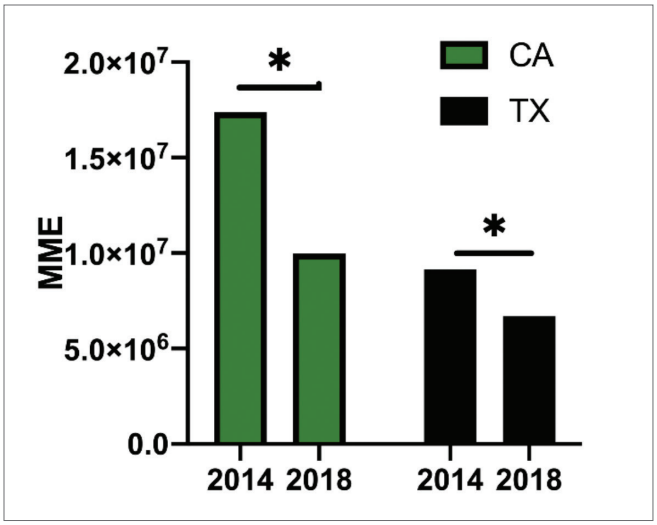


**Figure 2.** Net opioid distribution by zip code in California and Texas for the years 2014 and 2018.

43.7% decrease in California (Figure 2). There was an increase of approximately 6,000 MME in a 16-zip-code area of southern California near Glendale and Burbank. In this area, fentanyl, morphine, and oxycodone saw approximately 1.5, 2.4, and 1.8-fold increases respectively, while codeine and hydrocodone did not undergo appreciable changes (Figure 1C).

### Opioid distribution per capita

Cumulative opioid distribution per capita decreased in both California and Texas from 2014 to 2018 (38.9% and 26.4% percent respectively). The change in California was more linear for all drugs while Texas experienced more variable change (Figure 3).

Individual opioid distribution changes in Texas showed much more variability with hydrocodone, fentanyl, and morphine distribution decreasing (42.3, 36.7, and 27.8 percent), oxycodone remaining essentially unchanged, and codeine distribution showing a slight upward trajectory (Figure 3). Distribution of all 5 opioids in California decreased to a greater extent than their Texan counterparts (hydrocodone 65.4%, fentanyl 50.3%, morphine 42.7%, oxycodone 32.4%, and codeine 19.1%) (Figure 3).

## Discussion

Evidence from our research showing retail distributions by zip code and per capita in California and Texas supports recreational marijuana legalization as a possible alternative to chronic pain in order to help reduce opioid distribution. The years analyzed show a greater decrease in California than in Texas (Figure 2). Opioid distribution per 100K people in California decreased 38% (Figure 1A) from 2014 through 2018, while distribution in Texas decreased by only 26% (Figure 1B). Analysis of our heat maps in (Figure 1C) illustrate a greater decrease in opioid distribution over large areas of California compared to Texas pre/post recreational legalization years. These findings are consistent with previous investigations demonstrating fewer opioid prescriptions written in states with access to medical marijuana (7). A similar study showed a significant correlation between marijuana use as an alternative treatment for chronic pain and a reduction in opioid use and medication side effects indicating a potential health benefit of replacing opioids with cannabis (6).

Results from our MME per 100K population in Texas seen in (Figure 3), shows a drop in distribution for hydrocodone and an increase in codeine and oxycodone distributions. This is consistent with previous data showing that oxycodone and codeine increased by weight distribution in 2014 to 2017 specifically in Texas (12). This is possible due to 2014's reclassification of hydrocodone combination products being moved from a Schedule III to a Schedule II classification by the Drug Enforcement Administration (12, 16). This reclassification controlled the use and misuse on hydrocodone, however potentially room for less-regulated Schedule III drugs like oxycodone and codeine to increase.

Previously mentioned from 2014 to 2018 Figure 3 shows California's steady decline across all 5 opioids assessed in our study. California's trends may be explained by their approaches to mitigating pain and the opioid crisis by legalizing marijuana both medicinally and recreationally. To support this idea, the most recent study on women with gynecologic malignancies and the use of cannabis products specifically state their increased interest in guidance from physicians in the use of cannabis derivatives, since recreational marijuana has been legalized, and that significant numbers of these patients may already be using non-prescription cannabis products to manage pain (7).

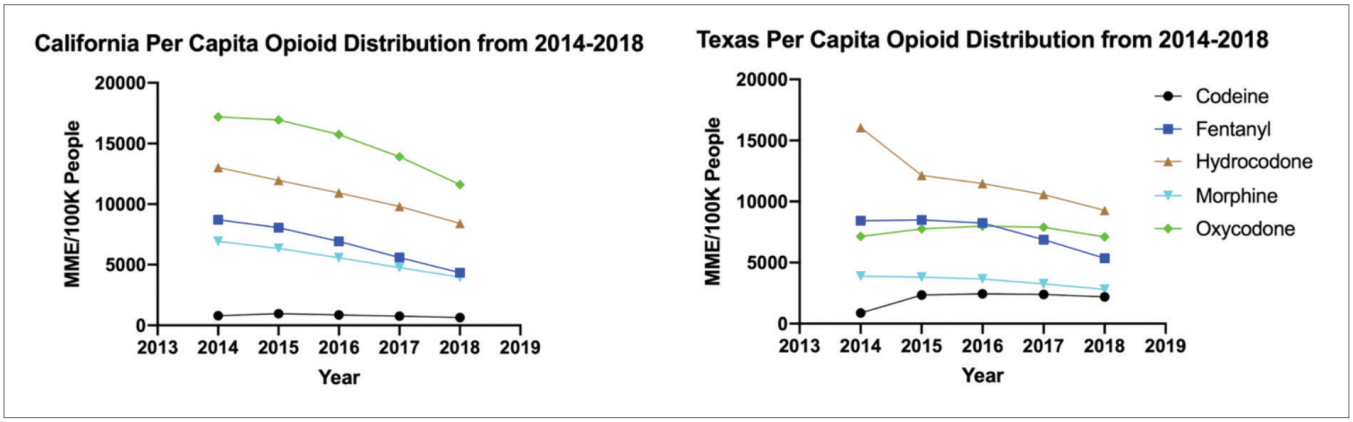


**Figure 3.** Distribution of selected opioids in California and Texas from 2014 to 2018

Harm reduction and medication-assisted treatments for opioid dependence have increased and become more available to help combat the staggering rate of overdose, like methadone and buprenorphine used as effective medications in the treatment of opioid dependence (17). Preparations should be made before individuals get to the level of dependence and overdose by promoting more natural preventive ways to initially treat pain. To strengthen the findings from our research, a recent study shows that states that enact medical cannabis laws have a 25% reduction in opioid overdose mortality, with this association strengthening each year after implementation (18). The goal moving forward with this research is to promote more natural, less addictive alternatives for analgesic relief, and to destigmatize labels placed on the safety and efficacy of marijuana, encouraging legalization in all states.

There were a variety of limitations to our study. Due to the limited research on recreational marijuana for analgesic effects makes it difficult to distinguish the purpose for recreational use. Most findings on cannabis and chronic pain adhere to medical cannabis. Surveys taken for the use of recreational marijuana on dispensary records, although time-consuming for buyers, would aid in research for pain management data correlation, helping to differentiate between medical and recreational marijuana use for chronic pain (19).

Secondly as we factored in ways to use our 3-digit zip code and per capita data for comparison during the years 2014 through 2018. Across our two states, we took into consideration that ARCOS only accounts for the annual estimation of the resident population for the United States. Being that Texas and California are two states with very rapid population growth, the population numbers that we used are most likely underestimated for the years 2014 through 2018. Expanding on our study by including more control comparison states with a population size closer to California's population would be advantageous, showing multiple comparisons in distribution changes (20).

Lastly although zip code data was accounted and extracted from ARCOS Report 1, this does not account for mail-order pharmacies and internet pharmacies that could ship different prescription opioids across state lines, including the 5 opioids used in our study (11).

## Conclusion

In our study, we discovered that the opioid distribution in the experimental state, California, showed a significant decrease of 43.7% compared to the control state of Texas (27.3%). These findings support our hypothesis by suggesting a correlation between California's legislation legalizing recreational marijuana and the decreased opioid distribution when compared to a state that has legislation prohibiting medicinal or recreational marijuana use. However, these preliminary results should be followed with additional testing, including comparable states and legislation to further define the relationship. From our research, we hope to promote the research of natural, less addictive alternatives for analgesic relief to aid in alleviating the opioid epidemic. Also, we are advocates of providing accurate information and public availability of marijuana as an alternative analgesic therapy.

## Author Contributions

Michelle N. Anyaehie conceived and designed the study, performed literature search and review, authored drafts of the paper, and approved the final manuscript.

Elijah J. Johnson conceived and designed the study, performed literature search and review, authored drafts of the paper, and approved the final manuscript.

Christian Pardo conceived and designed the study, analyzed the data, prepared figures, authored drafts of the paper, and approved the final manuscript.

## Disclosures

The authors do not report any conflicts of interest.

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