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**Socio-environmental Determinants of Post-operative Inpatient Opioid Consumption in Orthopedic Trauma Patients**

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By

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B.S., Georgia Institute of Technology, 2018

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An abstract of

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## Abstract

### Socio-environmental Determinants of Post-operative Inpatient Opioid Consumption in Orthopedic Trauma Patients

By Amanda Y. Liew

**Purpose:** The opioid epidemic in the United States is a growing problem with tragic consequences. Recent studies have investigated whether post-discharge prescription opioid use has implications on long-term use and substance abuse. Orthopedic trauma patients often come in with severe injuries warranting surgical interventions and prolonged hospitalizations. Prescription opioid analgesics are often the gold standard for pain relief in an inpatient setting. There are various factors, both clinical and environmental in nature, that may increase an individual's risk for developing substance abuse behaviors. The purpose of this study is to better understand patterns of inpatient opioid consumption, as well as associations with clinical and environmental predictors.

**Methods:** The study sample consisted of 173 patients treated for operative orthopedic. Average opioid consumption over a post-surgical period (defined as the time period between the patient's last surgery and discharge) was assessed and converted into oral morphine equivalents (OME). Maximum consumption, which is the peak OME dose received in a day, was also recorded as an outcome. Socio-environmental determinants were assessed with a survey, and the variables included in analysis were gender, age, post-operative days, number of surgeries, injury severity score (ISS), use of non-narcotic adjuvants, substance abuse history, and mental illness diagnosis. Distressed Communities Index (DCI), a measure used to evaluate a community's well-being by zip code, was included as a predictor. A multivariate linear regression model was used for analysis.

**Results:** 61% of the population was male, and the mean age was 46.7 ± 17.4. Average dose was 49.7 ± 25.8 OME/day, and maximum dose was 78.5 ± 39.7 OME. A log-transformed multivariate linear regression model revealed that average daily dose was inversely correlated with age (RSE=0.63, $F(13,159)=2.98$), and maximum dosage was inversely correlated with age, and directly correlated with number of post-operative days (RSE=0.63, $F(13,159)=2.98$). No other predictors were significantly associated with either outcome.

**Conclusion:** Age was inversely correlated with both average and maximum dose, and the number of post-operative days was positively associated with maximum dose. Future studies with larger sample sizes are recommended in order to better understand inpatient opioid consumption trends and the associations with socio-environmental predictors.

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## Chapter I: Background & Literature Review

America's opioid epidemic is a growing problem, as rates of opioid addiction and opioid-related deaths have been climbing steadily over the years. The Centers for Disease Control and Prevention (CDC) reports that the number of drug overdose deaths was four times higher in 2018 than in 1999, and almost 70% of overdose deaths in 2018 involved an opioid (either prescription pain relievers, heroin, or illicit synthetic opioids)[1]. This provides tragic evidence that this class of drugs carries high risks of drug dependence and harm. The 1990s and 2000s marked the first wave of fatal overdoses, which overlapped with the increase of opioids being prescribed to patients[2]. This overlap is not coincidental, as the addictive nature of opioids indicates a high potential for abuse with significant consequences. While many opioid users may primarily use illicit opioids, studies have shown that 75 – 80% of heroin users reported a prescription drug as their first opioid[3-5]. In 2018, 128 people in the United States died daily from opioid overdose, and of those, 41 deaths (32%) involved prescription opioids, totaling almost 15,000 deaths attributed to prescription drugs alone. The high stakes involved with these drugs underscore the need for more informed prescription practices, guided by a greater understanding of the different factors that may contribute to prescription opioid abuse.

An individual's risk for developing substance use disorders is affected by many factors outside of the clinical setting. The context of the physical environment that people inhabit can have significant impacts on health outcomes. For example, living in a community with adequate and safe green space might enable one to exercise more and have better health than one who lives in a neighborhood with high crime rate where exercising outside is dangerous. An area with better designed roads and sidewalks may have lower rates of pedestrian and vehicular accidents.

It is therefore important to include built environment when investigating factors affecting health outcomes because it provides a more comprehensive overview of the context in which patients may present.

The Distressed Communities Index (DCI) is a measure created by the Economic Innovation Group (EIG), that evaluates several socioeconomic metrics to create an assessment of the social and economic well-being of zip codes throughout the United States. The DCI takes into account the social and environmental conditions of each area by accounting for significant indicators such as education level, poverty rate, unemployment rate, housing vacancy rate, and median income ratio. Based on each performance indicator, an area is classified as: prosperous, comfortable, mid-tier, at risk, and distressed. According to the EIG, distressed counties have 64% higher mortality rates from mental health disorders and substance abuse than do prosperous counties[6]. A report published in 2019 found that DCI was positively correlated with fatal opioid overdoses, suggesting that distressed communities may be more at risk for prescription opioid abuse[7]. A 2014 study on low-income communities noted that geography is a significant driver of morbidity and mortality from noncommunicable diseases[8]. Another 2014 study found that adults in urban areas are more likely to misuse prescription opioids compared to rural adults[9]. It is posited that the concentration of drug misuse in urban areas is due to higher population density, which increases access to purchase drugs[10].

Other factors, such as history of substance abuse, mental health disorders, or support from family and friends can also contribute to a patient's potential for developing a substance use disorder (SUD). History of substance abuse (illicit or prescription) is the strongest predictor of high-risk for developing opioid use disorder (OUD)[11]. Mental health disorders are associated with long-term opioid use, as an estimated 16% of Americans with mental health conditions

receive more than half of all opioids prescribed in the country[12]. Social environment also plays an important role in health outcomes, as social support tends to positively impact maintenance or recovery of different health conditions, including substance abuse[13]. A 2014 paper investigated barriers to substance abuse treatment, and found that the disparity of substance use disorder treatment programs in rural and urban areas was due to various social and environmental variables[14]. There are many factors—both internal and external, that play a role in risk of developing an opioid addiction as a result of prescription opioid therapy.

Gaining a better understanding of the factors contributing to risks related to prescription drug abuse is crucial for developing informed prescription guidelines. There is substantial variability in opioid prescribing patterns across healthcare providers, suggesting that there are inadequate guidelines in place for prescription opioid therapy. Variations exist between physicians of different training (residents versus attendings)[15], as well as across geographical regions[16], and specialties[17]. Family medicine, internal medicine, and orthopedics were identified as the top specialties to have high-volume prescribing practices.

Although the United States accounts for 4.6% of the world's population, Americans consume over 80% of the global supply of opioids[18]. This statistic highlights the reality that opioid use in the US is unnecessarily high, and that alternatives used in other countries may not be being fully considered. While there are different types of medications that can be used for pain relief, such as local anesthetics, nonsteroidal anti-inflammatory drugs (NSAIDs and other nonopioid pain relievers), and certain psychoactive drugs, opioids have remained the first choice for pain management. While there have been efforts in recent years, to administer nonopioid adjuvants as an alternative either in substitution of, or alongside opioids, it remains unclear whether there is sufficient evidence to support the claim that the use of non-narcotic adjuvants

effectively addresses pain levels and reduces overall opioid consumption[19]. This underscores an important knowledge gap in current research. When responsibly prescribed, opioids are powerfully effective in addressing acute and severe pain—especially cancer-related or post-operative pain. However, high-dose or long-duration prescribing in inpatient settings may cause a patient to develop tolerance, consequently leading them to require a higher dose for the same effect, which can increase the risk of becoming dependent post-discharge. Irresponsible outpatient over-prescribing can lead to an excess of unused pills that may either fall into the wrong hands or be abused by the patients they were initially prescribed for.

One of the drivers of opioid over-prescription is suggested to be patient satisfaction—access to an opioid prescription is associated with higher patient satisfaction[20], which may lend an explanation to excessive prescribing practices. A physician's commentary[21] published in 2017 shed light on the reasons behind what is normally well-intentioned opioid prescription that appears to be irresponsible once patients become addicted. The doctor credits excessive prescribing (30-day supply instead of 5 or 10) to convenience because the electronic prescription system may have defaults, and round numbers make for easier pharmacy filling. The commentary also goes on to posit that a significant stakeholder in the opioid crisis is the pharmaceutical industry, because the first upsurge in rate of opioid prescriptions in the 1990s was a result of pharmaceutical marketing that overemphasized the efficacy of narcotics but failed to be transparent about its negative effects. In recognition that motivations of pharmaceutical companies may be misaligned with prioritizing patient care, it is even more crucial for administrative interventions to be implemented at the provider level—by providing physicians with patient data that can facilitate more informed and optimized prescription opioid therapy and pain management.

In addition to external socio-environmental elements, it is necessary to consider the clinical context in which the patients present. The use of inpatient opioid therapy can range widely, based on the nature of the initial clinical presentation, the number of procedures needed to address the initial condition, and the potential development of any complications—either as a result of the primary injury, surgical interventions, or any pre-existing health conditions. Patients with severe injuries and lengthy hospital stays have increased likelihood for access to opioids and may be at increased risk for opioid abuse and addiction. The risk for addiction and long-term opioid use can increase quickly over a timeline as short as 5 days of treatment[22]. Injury Severity Score (ISS) is a standard measure that is used to assess the severity of traumatic injuries. It assesses the injuries present on the body in 6 different regions and calculates an additive score ranging from 1–75, with 15 being the general threshold for defining major trauma[23]. It is well-documented that ISS has been correlated with length of hospitalization as well as the need for major surgical intervention. As a result, in addition to ISS, it is also important to account for length of stay and number of surgeries, because these clinical variables can significantly influence opioid consumption during hospitalization. Inpatient opioid consumption is calculated in Morphine Milligram Equivalent (MME), which is a cumulative measure of drugs in the opioid class that a patient has consumed in the past 24 hours, standardized by opioid strength. All drugs are converted, based on dosage and route of delivery, into this standard MME index, which is based on levels of orally administered morphine. MME has been shown to reflect clinical dosing efficiently, thus making it a good measure to use in opioid studies[24], and inpatient opioid consumption can be a significant predictor of long-term use and opioid abuse[3,25].

The significant associations of prescription abuse risk with various socio-environmental determinants, in conjunction with clinical factors, emphasizes the importance for more structured

prescription guidelines that holistically account for all the factors that may uniquely increase an individual's risk for high-consequence opioid abuse. Assessing patients' social and physical environments and incorporating the findings into the clinical context of patient care, especially with the initiation of opioid therapy, can help reduce the risk of opioid dependence or abuse.

# Chapter II: Manuscript

## Introduction

While prescription opioids may be effective for pain management, the benefits of pain relief come with substantial costs, such as drug misuse and fatal overdoses. The severity of the opioid crisis in the US is highlighted by the substantial burden resulting from prescription opioid misuse. A 2013 report estimated the total economic burden to be around $78.5 billion, which includes the costs of healthcare and criminal justice[26]. The financial costs, along with associated social issues and the tragic health burden of fatal overdoses emphasize that the opioid epidemic is a significant public health concern.

The field of orthopedics has been recognized as one of the top high-volume opioid prescribing specialties[17]. The traumatic injuries encountered in orthopedics vary in severity, as well as mechanism (ballistic, motor vehicle collision, fall, assault, etc.). While certain populations may be at increased risk of encountering different types of trauma (e.g. gun violence), trauma-related injuries are largely accidental in nature—for example, the presence of an existing health condition does not necessarily increase or decrease one's chance of getting into a car accident. Due to the unpredictability of these injuries, the social and environmental contexts in which orthopedic trauma patients present are diverse. The variability of these factors signals the need to comprehensively understand the socio-environmental determinants of patient populations, because doing so can provide more informed care—especially when opioid therapy is administered. Identifying the possible associations between inpatient opioid consumption and both clinical and non-clinical variables is a research area that should be expanded upon. Recent studies have focused on associations between inpatient opioid consumption and post-discharge

outpatient opiate use, and the risks of addiction in relation to opiate prescribing practice. Not many studies have focused on the patterns of opioid consumption during inpatient hospitalization, specifically in the post-operative period, as the emphasis of existing studies has been on outpatient post-discharge opioid use. While clinical factors related to opioid consumption have been relatively well-established in literature, the impacts of social and environmental factors have been poorly studied.

Our objective in this study was to identify and assess clinical variables, such as injury severity and length of hospitalization, along with socio-environmental factors, such as community distress and mental health and substance use history, to determine whether these factors may translate to the larger picture of post-operative inpatient opioid consumption. The individuals in this study are orthopedic trauma patients at a Level-1 Trauma Center who have had severe and painful injuries that warrant treatments with opiates. Many of them may have social and environmental circumstances that increase not only their risk for traumatic injuries, but also their risk for substance abuse. Therefore, it is important to assess the socio-environmental determinants that are affecting the target patient population in order to better understand standards for orthopedic injury care and guidelines for outpatient prescription.

## Methods

This retrospective cohort study recruited 196 patients from 2018–2019 who were treated in the orthopedic trauma department at Grady Memorial Hospital, which is a Level-1 Trauma Center in Atlanta, Georgia. Based on the inclusion criteria that patients must have received at least one surgical intervention warranting a minimum hospital stay of one day, 188 patients were eligible. Of the eligible patients, we excluded 8 individuals in order to eliminate outliers and

skew: 1 patient had a pre-existing immunocompromised condition that significantly increased length of stay, and the other 7 had inpatient opioid-consumption that was abnormally and unexplainedly higher than that of other patients in the cohort. 7 additional patients were further excluded due to incomplete clinical data. The final size of the cohort used for analysis was 173 individuals. Patients were recruited during their inpatient stay with an extensive survey assessing various demographic and environmental factors, as well as life experiences. Clinical data was obtained either through electronic medical records on the EPIC platform or through the hospital's trauma registry records.

*Clinical Variables*

The goal of this study was to assess the outcome of inpatient opioid consumption, which was converted into Oral Morphine Equivalents (OME). OME is a cumulative measure that uses conversion factors[27,28] for the different opioid drugs (e.g., morphine, hydromorphone, oxycodone, hydrocodone, tramadol, meperidine, and fentanyl) with varying routes of delivery to calculate the equivalent dose in orally administered morphine. OME is often a standard way to track opioid consumption over the course of hospitalization. In this study, we measured average OME consumed per day, as well as the maximum OME consumed in one day over the course of the post-operative period.

Due to the severe nature of many of the injuries observed in this study, some patients required more than one surgical intervention. We aimed to capture opioid consumption in the post-operative recovery period, which we defined as the time between the last surgery and discharge. This transition point to recovery is a time period where all surgical issues have been

addressed, and the goal is to treat post-surgical pain and eventually taper from medications. It was hypothesized that a longer post-operative period might contribute to higher recorded OME.

The clinical variables of interest in this study included injury severity score (ISS), as well as number of surgeries and number of days in the post-operative period. These variables were predicted to be associated with greater average and maximum opioid consumption. We also included a variable to assess whether the presence of a non-narcotic adjuvant (any medication used for pain relief that is not an opioid), might reduce OME administered. We report this variable as a proportion, by calculating number of days where the patient received any sort of non-narcotic analgesic (such as acetaminophen, procedural sedatives, or nerve blocks) out of total post-operative days. Some drugs (e.g. Percocet or Vicodin) combined opioids with non-narcotic analgesics such as acetaminophen. We considered the simultaneous administration of acetaminophen along with the opioid as the presence of a non-narcotic analgesic, because the assumption is that the presence of the adjuvant still has an effect on pain, even if it is delivered in tandem with an opioid.

*Demographics and Socio-Environmental Factors*

Demographic variables such as age, sex and zip code were obtained through patients' electronic medical records. Sex was coded as (0 = male, 1 = female). Zip code was used to obtain the Distressed Communities Index (DCI) score[6], which is a measure used to assess community well-being by accounting for social and environmental conditions in each area. The index ranges from 0–100, with higher numbers representing greater distress, which was hypothesized to be directly correlated with OME consumption. This subset of patients was obtained from a larger prospective social determinants of health study; patients in this cohort took a comprehensive

survey on initial inpatient admission that assessed a large inventory of factors related to social environment and built environment. The survey included questions about familial or social support, presence of green spaces or grocery stores in patients' communities, as well as self-reported substance abuse and mental health. The survey administered to patients recruited in 2018 was revised and improved before being used for recruitment in 2019. As a result, certain variables were not uniformly available across the entire sample population due to the difference in surveys. We chose to focus on the data available for substance abuse and mental health as our socio-environmental variables, which we hypothesized would be predictors of higher inpatient consumption. Both substance abuse and mental health were coded as (0 = no, 1 = yes).

*Statistical Analysis*

All statistical analyses were performed in R software[29] (R Foundation for Statistical Computing, Vienna, Austria) while data processing was accomplished in Python[30] (Python Software Foundation, Beaverton, Oregon). Spearman correlations were run between the outcome variables and each predictor. Normality and skewness of all continuous variables were assessed, and skewed variables were log transformed, while non-skewed continuous variables were divided into quartiles to better understand the distribution of the data. After logarithmic transformation, a multivariate linear regression was run on both outcomes of interest (average and maximum OME dose) with age, sex, DCI, ISS, post-operative days, number of surgeries, and use of non-narcotic adjuvants. All analyses were based on a significance level of $p<0.05$.

## Results

### *Demographics & Descriptive Statistics*

Of the 173 patients, 61% of the population identified as African American, and 34% identified as Caucasian (Table 1a). 61% of the population was male, with a mean age of 46.7 ± 17.4 (range 18–98). The range of DCI was 1.5–98.2 with a mean of 55.7, and the mean number of post-operative days was 8.9, with a range of 1–81. The number of surgeries ranged from 1 to 10, where 61 (35.3%) patients required more than one surgical intervention, and the mean ISS was 11.5 (range 4 – 50). 36 (20.8%) patients reported history of substance abuse, and 47 (27.2%) reported having at least one mental health diagnosis. Spearman correlations revealed that significant associations were found between maximum dose and age, post-operative, surgeries, and ISS ($ps<0.05$) (Table 2a). Significant correlations were also found between average dose and age and surgery ($ps<0.05$) (Table 2b).

### *Post-Operative Opioid Consumption*

Average inpatient opioid consumption was 49.7 ± 25.8 (range 1.2–146) OME per day, whereas mean maximum consumption was 78.5± 39.7 (range 7.5–222) (Table 1b, Figure 1a, 1b). On average, non-narcotic adjuvants were used 80.5% of the time in the post-operative period. Shapiro-Wilk tests for normality of the outcome variables yielded $ps<0.001$, indicating that neither average OME nor maximum OME were distributed normally. We tested for skewness in all continuous variables and found that number of surgeries, post-operative period, and ISS were right skewed, while adjuvant use was left skewed, and DCI and age were not notably skewed in either direction. To address these trends, the data were logarithmically transformed.

After transformation, multivariate linear regression produced models for average and maximum dose with some significant associations (Table 3). The average dose model (RSE=0.63, F(13,159)=2.98, Adjusted $R^2$= 0.13) produced significant associations with the upper quartiles of age. Controlling for all other predictors, the third (p=0.03) and the fourth (p<0.001) quartiles of age were inversely correlated with average daily dose. The maximum dosage model (RSE=0.56, F(13,159)=3.95, Adjusted $R^2$= 0.18 ) yielded similar findings to the average dose model. The third and fourth quartiles of age also were negatively correlated with maximum dosage, with significant p-values (0.02 and <0.001, respectively). With the maximum dose model, the number of post-operative days was found to be positively correlated with maximum dose (p<0.001). No other variables were significantly associated with either outcomes.

**Discussion**

As this study and many others have shown, opioid consumption can be affected by a number of different factors—both clinical and socio-environmental. Certain variables may be associated with increased or decreased opioid consumption during the inpatient hospitalization. Increased exposure to prescription opioids, especially during lengthy hospital stays can put patients at risk for developing drug dependence, and consequently drug abuse. Identifying possible risk factors can not only help inform improved care, but also reduce the risk of long-term opioid use and addiction.

In our study, we assessed the associations among different clinical and socio-environmental variables and inpatient opioid consumption. We found significant inverse associations between the upper quartiles of age and OME dose in both the average and maximum

dose models. Older patients had lower average and maximum OME consumption. In addition to being associated with age, the maximum dose model was also significantly correlated with the number of postoperative days, which posits that a prolonged post-operative hospital stay may increase a patient's daily dose. Our study did not find significance with any other variables, which could be due to the small sample size that was limited in its ability to account for so many predictors. Predictors that had significant Spearman's coefficients were not significant in the overall regression model, because the presence of other predictors may have dampened its effect in the model. This suggests that a larger sample size could provide greater power to detect significance for the numerous predictors in the study. While the lack of significant associations with other variables could be due to a number of reasons, our findings are in agreement with trends found in existing literature.

A 2018 paper[31] by Flanagan et al. assessed different predictors of inpatient and post-discharge prescription opioid consumption in orthopedic trauma, and reported age to be negatively correlated with inpatient use, which is supported by our findings. This is important to note, because opioid epidemic trends reveal that the greatest nonmedical opioids use is in young adults aged 18–25, and the great use of prescription opioids is in adults 26 and older[32]. Therefore, the younger demographic is a high-risk group for prescription drug abuse, and this should be considered when implementing opioid therapy. Flanagan et al. also found a significant positive correlation with injury severity score, which was not supported by our results. Although our sample populations were similar in size and characteristics, the difference could be explained by our outcome variable. We chose to look at opioid use in the post-surgical period instead of the overall hospitalization. This may have impacted results, because some patients with lengthier hospital stays received surgeries throughout their stay—some underwent their last operative

procedure several days before discharge. While this may have eliminated the datapoints of opioid consumption leading up to the last surgery, we chose to report our outcome variable in this manner, because we wanted to capture the recovery period, where the goal is to manage post-operative pain and begin to wean the patients off opioids before discharge. We felt that including pre-operative and inter-operative opioid consumption would significantly impact pain levels and opioid use because surgical repair has not been complete.

One of the limitations of this study was our reliance upon surveys for socio-environmental variables such as substance abuse and mental health abuse, which could have been under-reported. Administering two different versions of the survey between 2018 and 2019 patients led to incomplete data for certain variables, which then had to be excluded from analysis. We also were unable to control for comorbid conditions, which could have impacts on our findings, as some patients may have pre-existing conditions outside of the trauma injury that cause significant pain. Our study's limitations open up opportunities for future studies. While we focused on how clinical and external variables affected post-operative inpatient opioid use, applying the study outside the hospital stay may give us a better understanding of the predictors of long-term opioid use and dependence. Post-discharge follow-up appointments could be valuable opportunities to evaluate outpatient opioid use by asking patients to bring in pill bottles for a pill count, to determine how much medication they have consumed since discharge. If patients are still using prescription opioids past a certain time point where pain level (unexplained by another condition) should no longer warrant opioids, then proper referrals to pain management specialists can be made—in order to reduce the risk of opioid abuse.

## Chapter III: Conclusions & Recommendations

In response to the tragic opioid epidemic that has claimed many lives, opioid studies like this one are critical, as improved understanding of opioid use can provide valuable information to help develop policies and guidelines that prevent substance abuse and overdose. While we did not report any significant associations with our other variables of interest, our findings still have many significant implications in the field. OME trends are not typically monitored in inpatient settings, as there is no ceiling effect for prescription opioids that are administered under controlled healthcare supervision. While inpatient opioid consumption may be safe, potential drug dependence can have detrimental effects on post-discharge consumption, where outpatient settings cannot control how much of the drug is taken, and how often—which leads to risk of prescription abuse.

This study emphasizes the need for more control and monitoring in the inpatient setting. For example, if OME calculators and trends were incorporated into electronic medical records systems, healthcare providers can monitor the OME patterns, and if a patient seems to be trending in the wrong direction, an early intervention can be made. Improved monitoring can also help inform more appropriate prescription guidelines specific to each patient. Our findings of insignificant associations could suggest that inpatient opioid consumption is not as predictable as previously thought. This underscores the importance of approaching inpatient opioid consumption in a comprehensive way—not only by looking at clinical presentation, but also by considering social and environmental factors that may increase a patient's risk for developing substance dependence. This holistic approach, in addition to increased monitoring and improved prescription guidelines, can help fight the opioid epidemic.

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## Tables & Figures

**Table 1a -** Population Demographics

| | Overall (N=173) |
|---|---|
| **Sex** | |
| Male | 106 (61.3%) |
| Female | 67 (38.7%) |
| **Race** | |
| White or Caucasian | 58 (33.5%) |
| Black or African American | 107 (61.8%) |
| Hispanic, Latino, or Spanish | 4 (2.3%) |
| Asian | 3 (1.7%) |
| Other | 1 (0.6%) |
| **Previous or Current Substance Abuse** | |
| Yes | 36 (20.8%) |
| No | 137 (79.2%) |
| **Mental Health Disorder Diagnosis** | |
| Yes | 47 (27.2%) |
| No | 126 (72.8%) |

**Table 1b -** Descriptive Statistics

| | Overall (N=173) |
|---|---|
| **Age** | |
| Mean (SD) | 46.7 (17.4) |
| Median [Min, Max] | 44.0 [18.0, 98.0] |
| **Distressed Communities Index** | |
| Mean (SD) | 55.7 (27.4) |
| Median [Min, Max] | 58.6 [1.50, 98.2] |
| **Number of Post-Operative Days** | |
| Mean (SD) | 8.90 (10.4) |
| Median [Min, Max] | 6.00 [1.00, 81.0] |
| **Number of Surgeries** | |
| Mean (SD) | 1.71 (1.35) |
| Median [Min, Max] | 1.00 [1.00, 10.0] |
| **Injury Severity Score** | |
| Mean (SD) | 11.5 (8.59) |
| Median [Min, Max] | 9.00 [4.00, 50.0] |
| **Proportion of Non-Narcotic Adjuvant Use** | |
| Mean (SD) | 0.805 (0.305) |
| Median [Min, Max] | 1.00 [0, 1.00] |
| **Maximum Dose** | |
| Mean (SD) | 78.5 (39.7) |
| Median [Min, Max] | 75.0 [7.50, 222] |
| **Average Dose** | |
| Mean (SD) | 49.7 (25.8) |
| Median [Min, Max] | 49.6 [1.15, 146] |

**Table 2a –** Spearman Correlation Coefficients for Maximum Dose

| | **Sex (F)** | **Age** | **DCI** | **Post-op** | **Surgeries** | **ISS** | **Substance Abuse** | **Mental Health** | **Adjuvant Use** |
|---|---|---|---|---|---|---|---|---|---|
| *p-value* | 0.167 | **<0.0001*** | 0.958 | **<0.0001*** | **<0.0001*** | **0.012*** | 0.498 | 0.468 | 0.516 |
| *Rho* | -0.106 | -0.394 | -0.004 | 0.308 | 0.329 | 0.191 | 0.052 | 0.056 | -0.049 |

**Table 2b –** Spearman Correlation Coefficients for Average Dose

| | **Sex (F)** | **Age** | **DCI** | **Post-op** | **Surgeries** | **ISS** | **Substance Abuse** | **Mental Health** | **Adjuvant Use** |
|---|---|---|---|---|---|---|---|---|---|
| *p-value* | 0.138 | **<0.0001*** | 0.857 | 0.135 | **0.002*** | 0.619 | 0.714 | 0.878 | 0.194 |
| *Rho* | -0.113 | -0.414 | -0.014 | 0.114 | 0.229 | 0.038 | -0.028 | 0.012 | 0.099 |

**Table 3 –** Log-Transformed Linear Regression Model Results

| | **Maximum Dose** | | | | **Average Dose** | | | |
|---|---|---|---|---|---|---|---|---|
| ***Predictors*** | *Estimates* | *std. Error* | *Statistic* | *p* | *Estimates* | *std. Error* | *Statistic* | *p* |
| *Intercept* | 3.74 | 0.30 | 12.52 | **<0.001*** | 3.68 | 0.34 | 10.89 | **<0.001*** |
| *Sex* | -0.06 | 0.09 | -0.63 | 0.531 | -0.04 | 0.11 | -0.41 | 0.683 |
| *Age Q2* | 0.06 | 0.12 | 0.47 | 0.637 | 0.10 | 0.14 | 0.72 | 0.473 |
| *Age Q3* | -0.27 | 0.13 | -2.14 | **0.033*** | -0.30 | 0.14 | -2.08 | **0.039*** |
| *Age Q4* | -0.55 | 0.13 | -4.25 | **<0.001*** | -0.62 | 0.15 | -4.17 | **<0.001*** |
| *DCI Q2* | 0.01 | 0.13 | 0.09 | 0.926 | -0.11 | 0.14 | -0.79 | 0.430 |
| *DCI Q3* | -0.08 | 0.13 | -0.65 | 0.514 | -0.13 | 0.14 | -0.89 | 0.373 |
| *DCI Q4* | -0.03 | 0.12 | -0.26 | 0.795 | -0.10 | 0.14 | -0.68 | 0.500 |
| *ISS* | -0.04 | 0.09 | -0.40 | 0.691 | -0.08 | 0.10 | -0.79 | 0.432 |
| *Postoperative* | 0.23 | 0.08 | 3.04 | **0.003*** | 0.04 | 0.09 | 0.53 | 0.600 |
| *Number of Surgeries* | 0.19 | 0.14 | 1.33 | 0.185 | 0.20 | 0.16 | 1.24 | 0.218 |
| *Substance Abuse* | 0.10 | 0.11 | 0.93 | 0.353 | -0.01 | 0.12 | -0.05 | 0.957 |
| *Mental Health* | 0.08 | 0.10 | 0.79 | 0.431 | 0.17 | 0.12 | 1.43 | 0.155 |
| *Adjuvant Use* | 0.22 | 0.23 | 0.98 | 0.328 | 0.42 | 0.26 | 1.63 | 0.106 |
| *Observations* | 173 | | | | 173 | | | |
| $R^2$ / $R^2$ adjusted | 0.244 / 0.182 | | | | 0.196 / 0.130 | | | |

**Figure 1a-** Frequency Distribution of Maximum OME Dose

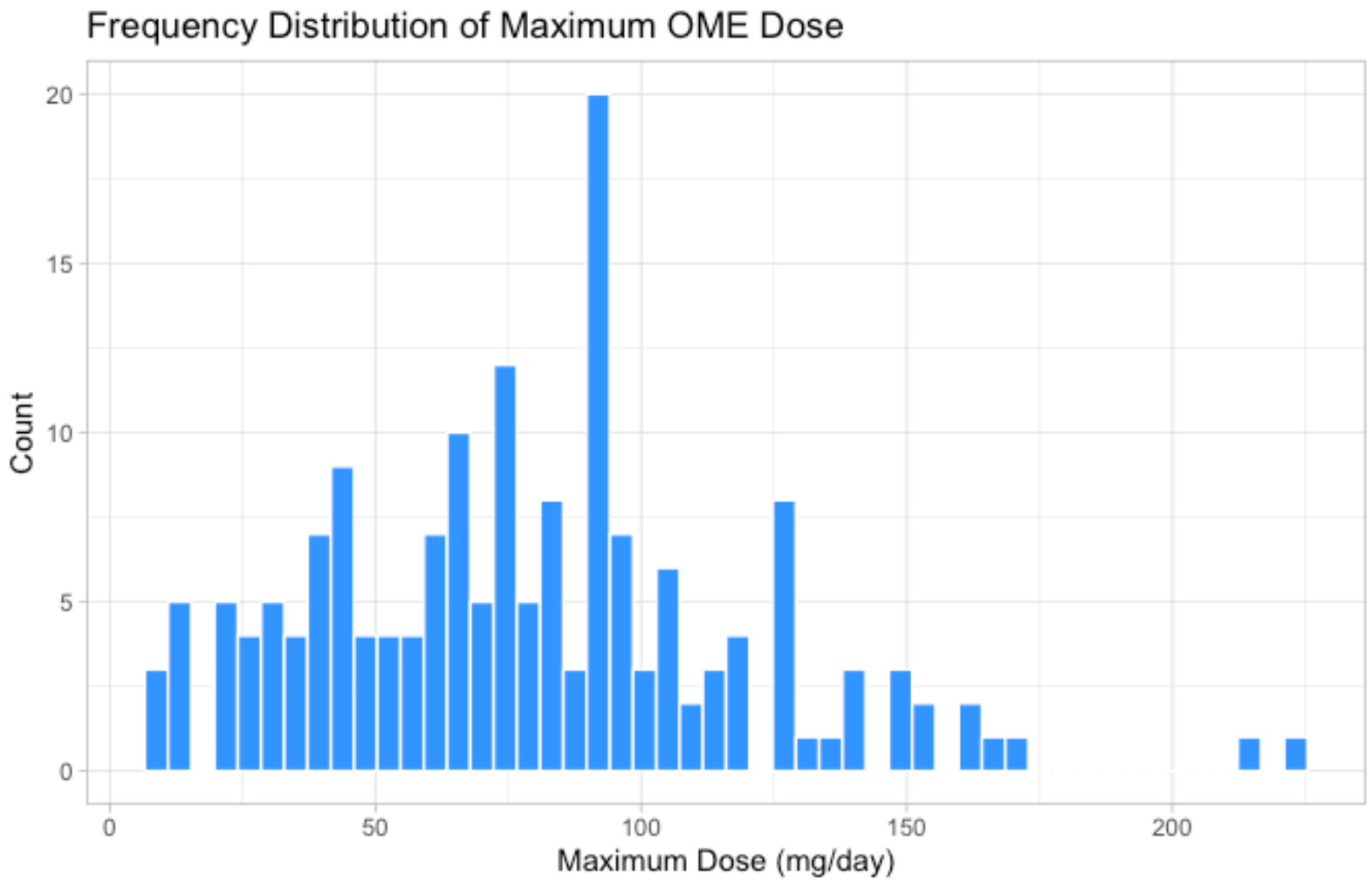

**Figure 1b-** Frequency Distribution of Average OME Dose