THE IMPACT OF HOSPITAL NURSING RESOURCES ON POSTSURGICAL OUTCOMES FOR PATIENTS WITH OPIOID USE DISORDER

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DEDICATION

To my family, who endlessly supports me,
to my friends, who encourage me to forge my own path, and
to those with whom I worked at Terry Reilly Health Services, who inspired this research.

"Fight for the things that you care about,
but do it in a way that will lead others to join you."
-Ruth Bader Ginsburg

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ABSTRACT

THE IMPACT OF HOSPITAL NURSING RESOURCES ON POSTSURGICAL OUTCOMES FOR PATIENTS WITH OPIOID USE DISORDER

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Opioid use disorder (OUD) is common, with the rate of opioid-related hospitalizations doubling from 2006 to 2016. Surgical patients with OUD are at significantly higher risk of prolonged length of stay, in-hospital mortality, and readmission. Postoperative care for patients with OUD is particularly challenging for nurses whose responsibilities include pain and withdrawal management, care team coordination, patient assessment, and patient teaching. A large body of evidence suggests better outcomes for surgical patients when they are cared for in hospitals with strong nursing resources. This study sought to determine whether variations in nursing resources (i.e., education, staffing, and work environment) were associated with postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) for patients with and without OUD (Aim 1). This cross-sectional analysis leveraged 2015-2016 data of nurse survey responses, patient discharge abstracts, and hospital characteristics. The final sample included 919,601 patients across 448 hospitals in California, Florida, New Jersey, and Pennsylvania. Logistic and zero truncated negative binomial regression models were used to estimate the relationships between nursing resources and surgical patient outcomes. After adjustments, we found that each 10% increase in the proportion of bachelors-educated nurses was associated with lower odds of readmission at 7 (OR 0.95, *p*-value = 0.001), 30 OR 0.95, *p*-value <0.001), 60 (OR 0.95, *p*-value <0.001), and 90 (OR 0.95, *p*-value <0.001) days for all surgical patients, and that this effect was even stronger for surgical patients with OUD (i.e., 15% lower odds for 7-day readmission; 16% for 30-day readmission; 14% for 60-day readmission; and 14% for 90-day readmission). In adjusted models, we also found that each additional patient-per-nurse was associated with higher odds of readmission for surgical patients with OUD (i.e., 13% higher odds for 7-day readmission and 10% for 30-day readmission). A substantial proportion of surgical patients with OUD are readmitted, and the odds of readmission are lessened when these patients are cared for in hospitals with better nurse education and staffing. Findings from this study can inform organizational strategies to reduce readmissions following needed surgical care for people already suffering from OUD.

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CHAPTER 1: INTRODUCTION AND SPECIFIC AIM

The Problem

The ongoing opioid and overdose crisis is one of the most pressing threats to public health in the United States (US). With 115 Americans dying from an opioid overdose daily (G. H. Jones, Bruera, Abdi, & Kantarjian, 2018), the US Government declared the opioid epidemic a public health emergency in 2017. From 1999 to 2018, over 750,000 people died from a drug overdose, making overdose the leading cause of injury-related death in the US (Centers for Disease Control and Prevention, 2020). Two thirds of overdose deaths involve an opioid (G. H. Jones, Bruera, et al., 2018). Prescription opioids like oxycodone and hydrocodone have historically been the most common cause of overdose deaths, but more recently heroin and synthetic opioids (namely illicit fentanyl) are being implicated in overdoses (Rudd, Seth, David, & Scholl, 2016). Despite representing only 5% of the world's population, Americans are the largest users of opioids, accounting for 80% of the world's oxycodone and 90% of the world's hydrocodone consumption (Gounder, 2013).

It is not uncommon for people with opioid use disorder (OUD) to require hospitalization, particularly for surgical procedures (Theisen-Toupal, Ronan, Moore, & Rosenthal, 2017). It is known that the pain of surgical patients with OUD is undertreated and that withdrawal is poorly managed, thus putting hospitalized patients with OUD at higher risk of adverse outcomes like being discharged against medical advice (AMA) or being readmitted (Choi, Kim, Qian, & Palepu, 2011; Glasgow, Vaughn-Sarrazin, & Kaboli, 2010; Jain, Phillips, Weaver, & Khan, 2018; Paschkis & Potter, 2015; Simon, Snow, & Wakeman, 2019; Southern, Nahvi, & Arnsten, 2012; Ti & Ti, 2015). Additionally, hospitalized patients with OUD, and especially those undergoing surgery for injection-related conditions like endocarditis, often experience stigma and discrimination during hospitalization that leads to suboptimal care and outcomes (Simon et al., 2019). All people, and especially those with OUD, deserve quality healthcare that addresses their unique needs.

In the US, 48 million individuals undergo inpatient surgical procedures annually (National Center for Health Statistics & National Hospital Discharge Survey, 2010). Given that the percentage of hospitalized patients with OUD has doubled since 2006 (Owens, Weiss, & Barrett, 2020) and that approximately 4% of Americans have chronic opioid use, surgeons are increasingly operating on patients with OUD (Volkow & McLellan, 2016). In 2012, 709,500 individuals were hospitalized for an opioid-related stay, many of whom for surgery (Owens, Barrett, Weiss, Washington, & Kronick, 2014). Hospitalization is especially stressful for surgical patients with OUD whose unique care needs, like pain management, are particularly important to address during and following surgery (French, McHugh, Lake, & Brooks Carthon, 2020; Myers & Compton, 2017). The most numerous healthcare providers—bedside nurses—are well positioned to meet the needs of surgical patients with OUD, yet little research has explored nursing in the context of this population.

Nursing resources that ensure organizational support for nurses may be particularly important for hospitalized patients with OUD. Caring for patients with OUD can be challenging for nurses working in poorly resourced conditions. Nurses caring for patients with OUD need adequate time to assess and address pain and withdrawal, as well as access to an interdisciplinary team of addiction medicine specialists, peers in recovery, and social workers (French et al., 2020; Simon et al., 2019). The COVID-19 pandemic presents new risks to people with OUD given their frequently comprised respiratory status, as well as new challenges related to accessing treatment and recovery (Centers for Disease Control and Prevention, 2020; Khatri & Perrone, 2020), which further highlights the need for tailored nursing care for patients with OUD. Nursing resources such as good nurse staffing and work environments can allow nurses to have time to address the OUD-specific needs of patients and work with other clinicians to ensure that patients with OUD are receiving the services they need during hospitalization.

Compared to surgical patients without OUD, surgical patients with OUD have poorer outcomes including longer lengths of stay, and higher likelihood of mortality and readmission (Cron et al., 2017; Dewan et al., 2019; Jain et al., 2018; Menendez, Ring, & Bateman, 2015; Weick, Bawa, Dirschl, & Luu, 2018). Outcomes for surgical patients with OUD are influenced by multiple factors, including individual patient characteristics and system-level factors. Patient level factors that may influence outcomes include preexisting opioid use that complicates pain management and having Medicaid (Allen, Tomic, Smith, Wilson, & Agodoa, 2012; Cron et al., 2017; Dewan et al., 2019). Poor outcomes may also occur due to variation in quality between hospitals where surgical patients with OUD receive care. Nursing resources, such as education, staffing, and the work environment, have been linked to surgical patient outcomes (Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Lasater & McHugh, 2016). One possible explanatory factor for the disparity in outcomes between surgical patients with and without OUD may be linked to hospital-level variation in nursing resources.

The care provided by nurses for surgical patients with OUD is influenced by the organization of hospital nursing. Hospitals with strong nursing resources have higher proportions of nurses with a Bachelor of Science in nursing (BSN), lower patient-to-nurse ratios, and supportive nurse work environments. A large body of evidence substantiates that all surgical patients have better outcomes when cared for in hospitals with better nursing resources (Aiken, Clarke, Cheung, Sloane, & Silber, 2003; Lasater & McHugh, 2016). Research also documents that vulnerable populations undergoing surgery particularly benefit from better nursing resources (Brooks Carthon, Kutney-Lee, Jarrin, Sloane, & Aiken, 2012; Kutney-Lee & Aiken, 2008; White, Smith, Trotta, & McHugh, 2018). Despite this evidence base, what is known about the relationship between nursing resources and outcomes for surgical patients with OUD is limited. Bolstering nursing resources may be an untapped lever for improving the outcomes of surgical patients with OUD.

Building on a substantial evidence base linking nursing resources to patient outcomes, the purpose of this study is to determine whether variations in nursing resources (i.e., education, staffing, and work environment) are associated with disparities in postsurgical outcomes (i.e., length of stay, in-hospital mortality, and readmission) between patients with and without OUD. We hypothesized that better nursing resources would be associated with lower likelihood of adverse postsurgical outcomes among all patients and that these effects would be more pronounced for patients with compared to without OUD. Analyses that examined the interactions between nursing resources and the presence of OUD determined whether postsurgical outcomes among patients with OUD are sensitive to nursing resources while allowing for comparisons of patients with and without OUD.

Despite a growing evidence base documenting the association of nursing resources and surgical patient outcomes—especially among vulnerable populations—no studies have examined the relationship between nursing resources and outcomes among surgical patients with OUD. This study may offer a solution. This study explored the differing effect of nursing resources for surgical patients with and without OUD and provides findings that can improve outcomes for these vulnerable patients.

Study Overview, Aim, and Hypothesis

This study involved analysis of cross-sectional data on a large sample of nurses, patients, and hospitals to examine the relationships between nursing resources and outcomes for surgical patients with OUD. The 2015-2016 data for this study were derived from the RN4CAST-US survey, inpatient discharge summaries, and the American Hospital Association (AHA) Annual Survey in California, Florida, New Jersey, and Pennsylvania. Measures of nursing resources were aggregated responses of individual direct-care registered nurses to the RN4CAST-US survey. Analysis was conducted by linking nurse survey data to patient discharge summaries and administrative hospital data. This proposal builds on the literature demonstrating the association between better nursing resources and improved surgical patient outcomes, especially among vulnerable patients (Kutney-Lee & Aiken, 2008; White et al., 2018). Accordingly, the aim of this study was:

1. To determine whether variations in nursing resources (i.e., education, staffing, and work environment) were associated with disparities in postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) between patients with and without OUD.

H1: We hypothesized that better nursing resources would be associated with lower likelihood of adverse postsurgical outcomes among all patients and that these effects would be more pronounced for patients with compared to without OUD.

Significance

In the US, more than 2 million people are living with OUD (National Academies of Sciences Engineering and Medicine, 2019), with nearly 50,000 opioid overdose deaths in 2019 (National Institute on Drug Abuse, 2021; Strang et al., 2020). In 2015, the Centers for Disease Control and Prevention (CDC) estimated that the amount of opioids prescribed per person was three times higher than it was in 1999 (Guy et al., 2017), yet today the use of heroin and synthetic opioids such as fentanyl are perpetuating the opioid and overdose crisis (National Institute on Drug Abuse, 2021). This crisis not only impacts the health of the public, but also the social and economic welfare of individuals (National Institute on Drug Abuse, 2021).

Opioids, however, remain a first-line treatment for postoperative acute pain management (Hah, Bateman, Ratliff, Curtin, & Sun, 2017). A growing percentage of hospitalized patients have OUD (Owens et al., 2020). Unfortunately, these patients have longer lengths of stay and higher rates of mortality and readmission compared to surgical patients without OUD (Cron et al., 2017; Dewan et al., 2019; Jain et al., 2018; Menendez, Ring, et al., 2015; Weick et al., 2018).

The substantial proportion and poor outcomes of surgical patients with OUD has implications for patients, hospitals, and the organization of nursing. Surgical patients with OUD are apprehensive before and during hospitalization given their potential for undertreated pain and relapse postoperatively (Myers & Compton, 2017). Additionally, these patients often lack social supports during and following hospitalization, making postoperative recovery particularly challenging (Wyman, Kallio, Allred, & Meyer, 2014).

Compared to those without, patients with a substance use disorder, including OUD, are up to three times more likely to be discharged AMA (Ti & Ti, 2015), often because of unmanaged withdrawal, uncontrolled pain, and stigma from hospital staff related to substance use (Simon et al., 2019). This increased rates of discharge AMA is concerning not only because it represents missed opportunities to provide high quality hospital care to patients with substance use disorders, but also because of the association between being discharged AMA with mortality and readmission (Choi et al., 2011; Glasgow et al., 2010; Simon et al., 2019; Southern et al., 2012; Ti & Ti, 2015). It is also known that having OUD is a risk factor for readmission within 90 days of discharge, showing how OUD has an impact on patients for extended periods of time following discharge (Jain et al., 2018).

Hospitals are concerned about caring for surgical patients with OUD given their high costs and extensive resource use (Jain et al., 2018; Oderda et al., 2003). Each additional day of a postsurgical hospital stay costs $1,649 and the average cost of each readmission after surgery is estimated to be $16,000-18,000 (Blumberg, Woelber, Bellabarba, Bransford, & Spina, 2018; Goel et al., 2018; Kent, Sachs, Callery, & Vollmer Jr, 2011). Given the intensive nursing needs of surgical patients with ORD—like care team coordination—the organization of nursing has the potential to either hinder or facilitate care delivery and potentially outcomes for these patients.

Limited evidence about the role of the most numerous healthcare providers—bedside nurses—in improving outcomes for surgical patients with OUD exists. Nursing care for surgical patients with OUD is intensive and likely contributes to outcomes for these patients. Surgical patients with OUD perhaps have prolonged lengths of stay due to difficulty in achieving adequate pain control (Keller, Tahilramani, Flores-Gonzalez, Ibarra, & Haas, 2016; Menendez, Ring, et al., 2015; Sinatra, 2010); nurses are well equipped to facilitate adequate pain management. Some evidence suggests that greater rates of mortality among surgical patients with OUD may be due to this population's tolerance for the analgesic effects of opioids, something that nursing care can prevent through thorough patient assessment (Menendez, Ring, et al., 2015). Readmission among surgical patients with OUD may also be prevented through adequate pain management as well as thorough discharge teaching by nurses (Jain et al., 2018). Nursing care is essential in achieving optimal outcomes for surgical patients with OUD, yet the optimal organization of hospital nursing resources to achieve the best possible outcomes for these patients is largely unexplored.

Improving outcomes for surgical patients with OUD is a priority, yet few actionable solutions exist. The Behavioral Intervention Team (BIT) is an integrated multidisciplinary model of care focused on acute psychiatric needs for patients hospitalized on general medical floors (Tolarba, 2015). This model may improve outcomes and reduce hospital costs by mitigating the impact of acute psychiatric needs, including OUD, in the management of the medical diagnoses (Katella, 2015; Sledge, Bozzo, White-McCullum, & Lee, 2016). The implementation of this model is expensive, requiring an embedded full-time nurse practitioner, full-time social worker, and part-time psychiatrist on individual units. Additionally, given its expense, only certain units within a hospital that use this model have access to the services from the embedded team, leaving the needs of many patients, including surgical patients, unmet. Another care model that has been implemented in emergency departments focuses on hospital-initiated buprenorphine/naloxone treatment for OUD (D'Onofrio et al., 2015). This model can improve outcomes for patients with OUD, but again is its implementation requires a significant investment of finances and time (D'Onofrio et al., 2015). Additionally, this model only targets patients presenting to the emergency department with a diagnosis related to OUD and fails to address the needs of patients hospitalized with general medical or surgical diagnosis (D'Onofrio et al., 2015). Both models are only focused on a specific population, so they are not generalizable for all surgical patients. In contrast, examining the relationship between surgical patients with OUD and outcomes across hospitals with varying nursing resources represents a potential mechanism for improving outcomes for this population as well as for all surgical patients. Given the large body of evidence showing the relationship between improved nursing resources and better patient outcomes, it is essential to explore this relationship in a novel population: surgical patients with OUD. Higher proportions of BSN nurses, lower patient-to-nurse ratios, and supportive work environments improve the ability of nurses to provide essential nursing care such as patient assessment and patient education that facilitate better outcomes (Finney, 2010; Jackman, 2019; Kutney-Lee & Aiken, 2008; Lake, Riman, & Sloane, 2020; Sloane, Smith, McHugh, & Aiken, 2018; White et al., 2018).

The conceptual model that framed this study was the Quality Health Outcomes Model. This model acknowledges that multiple factors, including patient and hospital characteristics, affect quality of care and outcomes (Mitchell, Ferketich, Jennings, & American Academy of Nursing Expert Panel on Quality Health Care, 1998). Patient and hospital characteristics, interventions, and outcomes are reciprocally influenced by each other, thus allowing for an accurate understanding of complex hospital systems (Mitchell et al., 1998). For this study, nursing resources were considered modifiable system characteristics.

Gaps

This work addressed a knowledge gap about how nursing resources relate to outcomes for surgical patient with OUD. While efforts to improve care and outcomes for surgical patients with OUD exist, it was unclear whether these efforts hinge on the distribution of nursing resources across hospitals. This gap was a critical barrier in improving public health and the outcomes of surgical patients with OUD. We addressed this gap by examining modifiable organizational characteristics that influence nursing care and patient outcomes.

The urgent needs of this population are evident from multiple national and state efforts to address issues related to the opioid overdose and crisis (National Academies of Sciences Engineering and Medicine, 2019, 2020; Saunders, Jarlenski, Levy, & Kozhimannil, 2018; Wickramatilake et al., 2017).

From a public health perspective, the outcome disparities for surgical patients with OUD compared to surgical patients without OUD demand answers. In addition to affecting the patients themselves, poor outcomes impact the families and communities of individuals with an OUD. When a surgical patient with OUD is readmitted, for example, hospital care may disrupt stable medication assisted treatment from a primary care provider which can cause relapse and overdose (Bentzley, Barth, Back, & Book, 2015). Improving outcomes also has benefits (e.g., reimbursements, rankings, reputation) for hospitals caring for patients with OUD. Given what is known about how nursing resources affect outcomes for surgical patients, nursing resources likely have an impact on the outcomes of surgical patients with OUD. Higher proportions of BSN nurses, lower patient-to-nurse ratios, and a supportive work environment likely enhance a nurse’s ability to provide essential nursing care activities such as assessment and pain management support that have been theorized to produce better outcomes (French et al., 2020; Kutney-Lee et al., 2009). Bolstering nursing resources provides a potential mechanism to meet the needs of surgical patients with OUD, their families and communities, and hospitals.

Innovation

This study was the first to explore relationships between nursing resources and outcomes in hospitalized surgical patients with OUD. The sampling and linking of patient and nurse data at the hospital level is reproducible and able to provide findings that are actionable, such that results can be compared over time when newer data becomes available. Nurse survey data are a strength of this design as they provide a consistent assessment across institutions for a population where nurse reports have been underutilized. Nurses are considered valid and reliable informants about clinical settings as they experience the care system intimately. Nurse assessments of care quality align with objective patient record data (M. D. McHugh & Stimpfel, 2012). This approach allowed for identification of a patient population that can be difficult to identify, i.e., surgical patients with OUD. This study filled a much-needed gap in understanding how to improve outcomes for these patients.

Summary

The overarching goal of this research was to improve outcomes of surgical patients with OUD by developing actionable evidence about the influence of nursing resources on outcomes. Findings from this study provide information for hospital administrators and policy makers seeking to improve the outcomes of surgical patients with OUD in a cost-effective manner. This evidence is of interest to nurses, nurse managers, hospital administrators, and other stakeholders. Chapter 2 of this proposal describes the conceptual framework underlying this study, as well as provides thorough background and significance based on a review of the literature. In Chapter 3 of this proposal, we detail the methods that we will utilize to conduct the analyses for the aim.

CHAPTER 2: BACKGROUND AND SIGNIFICANCE

Introduction

This study examined the association between outcomes for surgical patients—specifically for those with OUD—and nursing resources such as nurse educational preparation, patient-to-nurse ratios, and the nurse work environment. Chapter 2 details the context for this study and presents an integrated literature review of the current research on the relationships between nursing, hospital, and surgical patient with OUD characteristics with outcomes. First, the adapted Quality Health Outcomes Model (QHOM) for this study is detailed. Next, background on surgical patients with OUD is described. A literature review detailing the outcomes and nursing resources of interest is presented. Rationale for covariates is presented based on existing literature. Finally, significance from this study is derived from the social, financial, and political implications of hypothesized findings.

Conceptual Framework

The conceptual framework that guided this study is the American Academy of Nursing's QHOM (Mitchell et al., 1998). This model describes the relationships between four interrelated concepts: system, intervention, client, and outcome (Mitchell et al., 1998). The QHOM has served as a foundational framework for nursing health services research and continues to be integral for national and international nursing research (Gunther & Alligood, 2002; Kunaviktikul et al., 2001; Mitchell & Lang, 2004; Neale, 2001) . Nurse researchers led by Dr. Pamela Mitchell adapted the QHOM from Donabedian's linear structure process outcome model (Donabedian, 1966, 1988) in order to account for interrelationships between system and patient characteristics that mediate the success of clinical interventions (Mitchell & Lang, 2004). The QHOM proposes that the same intervention can affect similar patients differently depending on the system context and that care delivery is more reciprocal than linear (Mitchell et al., 1998).

Adapting the QHOM is advantageous for nursing research. As the healthcare providers most frequently at the bedside, nurses interact with patients at every phase of acute care. They serve as anchors at the center of a complex and interconnected healthcare system. The QHOM suggests that the success of an intervention depends on system and patient characteristics. This conceptual framework validates this research strategy seeking to determine the relationship between system characteristics and postsurgical outcomes for patients with OUD, while accounting for other interrelated factors.

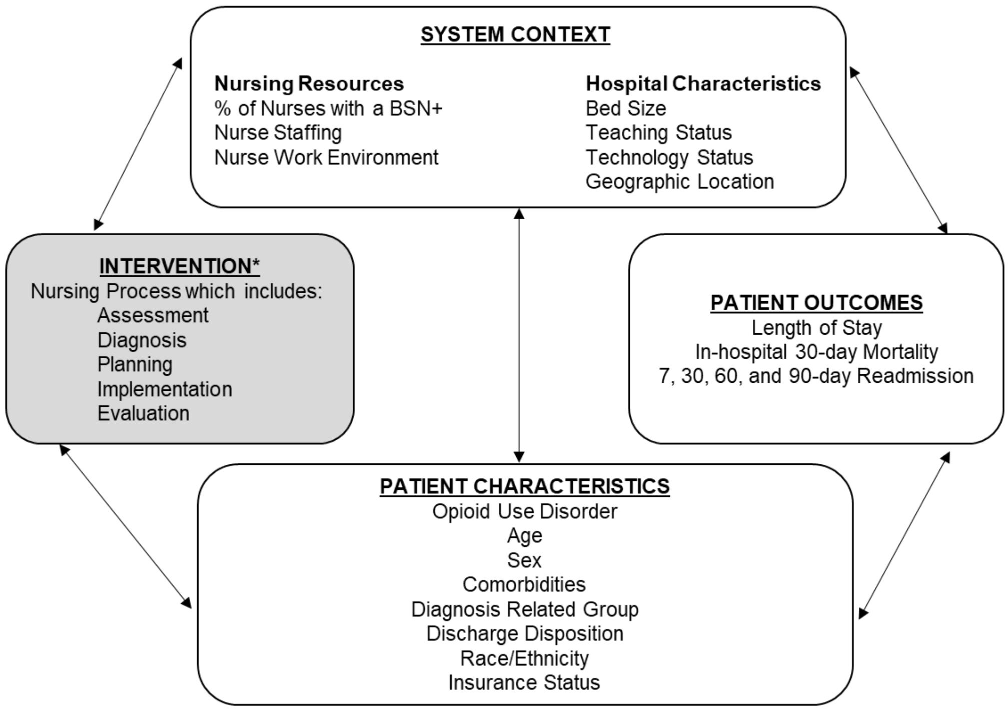
The variability in surgical patient outcomes across hospitals has multiple explanations. One explanation is that variation in outcomes results from clinical conditions and patient characteristics (Gani, Lucas, Kim, Schneider, & Pawlik, 2015). A second explanation is that procedure volume drives outcomes (J. D. Birkmeyer et al., 2002). A third and related explanation is that outcomes are improved for patients when a surgeon performs a procedure often (Hoehn et al., 2017). Another explanation posits that organizational characteristics, including nursing resources and hospital quality, drive outcomes (Kutney-Lee et al., 2015; Lake et al., 2016; Lasater & McHugh, 2016). Given that surgical patients with OUD require surgery across hospitals and specialties, it is likely that variation in organizational characteristics is driving variation in patient outcomes. As the opioid overdose crisis persists, surgical patients with OUD continue to require hospitalization for general, orthopedic, and vascular surgery. These patients have poorer outcomes, including longer lengths of stay and higher rates of mortality and readmission (Cron et al., 2017; Dewan et al., 2019; Jain et al., 2018; Menendez, Ring, et al., 2015; Weick et al., 2018), and their care needs are intensive (French et al., 2020). The confluence of care needs and poor outcomes yields an urgent need to determine the influence of nursing resources and hospital characteristics on patient outcomes.

Central Concept

The central concept of this research is that hospital nursing resources (system context) relate to postsurgical length of stay, mortality, and readmission (patient outcomes) for patients with OUD. Hospital characteristics like teaching status, technology status, bed size, and geographic location are also part of the system context. In addition to the organization of nursing care influencing outcomes, nurses affect patient outcomes through the delivery of nursing care, conceptualized for this study as the nursing process (intervention), which is reciprocally related to the system context, patient outcomes, and patient characteristics. The nursing process is a systematic guide to nursing care delivery that includes the sequential steps of assessment, diagnosis, planning, implementation, and evaluation (Toney-Butler & Thayer, 2019). While system modifications are not a substitute for clinical interventions, addressing system features provides an actionable approach for hospital administrators who can shape this context of care through hiring decisions, policymaking, and governance structure.

This study posits that hospital nursing resources impact postsurgical outcomes for patients with OUD, and that this relationship is influenced by other system factors and patient characteristics, as well as the nursing process. While the regression models will not include intervention variables, this concept yields a testable hypothesis with multiple propositions. Proposition 1 is that modifiable nursing resources (i.e., nurse education level, nurse staffing, and the nurse work environment) are associated with postsurgical outcomes for patients with OUD. Proposition 2 is that surgical patients with OUD are more sensitive to nursing resources than all surgical patients.

Figure 2.1: ***The Quality Health Outcomes Model Adapted for Surgical Patients with Opioid Use Disorder***



The Relationship between Nursing and Surgical Patient with OUD Outcomes: A Conceptual Framework
Adapted from the Quality Health Outcomes Model (Mitchell et al., 1998)
*The conceptual model includes the nursing process, but the regression models will not include any specific intervention variables.

The understanding that system-level variation contributes to variation in patient outcomes underlies the conceptual framework. The bidirectional arrows in this study's conceptual framework (Figure 2.1) represent another underlying assumption: that healthcare delivery systems are interconnected. This framework allows researchers to test theoretical relationships, including patient outcomes that are sensitive to interventions and system characteristics. This framework captures concepts from existing research on nursing resources and patient outcomes, as well as of hospital characteristics to surgical patient outcomes (Aiken et al., 2011; Aiken, Clarke, Sloane, Sochalski, & Silber, 2002; Aiken et al., 2014; M. D. McHugh & Ma, 2013; M. D. McHugh et al., 2016).

The QHOM serves as a framework to explain relationships between nursing resources (system context) and length of stay, in-hospital mortality, and readmission (patient outcomes) in surgical patients with OUD, while accounting for influential patient characteristics like age, sex, and insurance status. This model acknowledges that these relationships are also influenced by patient and hospital characteristics. Therefore, variables to isolate the effect of nursing resources on postsurgical outcomes for patients with OUD—hospital and patient characteristics that are conceptually and empirically relevant for surgical patients with OUD—were used as control variables. Validated risk adjustment methods were used to account for patient comorbidities (Elixhauser, Steiner, Harris, & Coffey, 1998; Epstein & Dexter, 2017).

Overview

This section provides context on the evolution of the opioid and overdose crisis and background about surgical patient with OUD outcome studies. It summarizes existing evidence about the relationships of postsurgical outcomes with nursing resources. The chapter ends with significance highlighting the social, financial, and political implications of this work.

The Evolution of the Opioid and Overdose Crisis

The US opioid epidemic was originally influenced by the over-prescription of opioids by medical professionals who were led to believe by the pharmaceutical industry that they were non-addictive therapeutics to treat multiple kinds of pain complaints, including chronic pain. Also since the 1980s, influential organizations like the World Health Organization (World Health Organization, 1996), the American Pain Society (Campbell, 1996), the Veteran's Health Administration (Mularski et al., 2006), and the Joint Commission (D. W. Baker, 2017) have sought to address the undertreatment of pain though initiatives like "pain as the fifth vital sign" and hospital reimbursement for pain management (M. R. Jones, Viswanath, et al., 2018). Such initiatives are now regarded as profound contributors to the opioid and overdose crisis because they encouraged the prescription of opioids at staggeringly high rates (M. R. Jones, Viswanath, et al., 2018).

Recognizing the crisis at hand, the CDC released the "Guideline for Prescribing Opioids for Chronic Pain" in 2016 (Centers for Disease Control and Prevention, 2016). While this guideline is intended for primary care clinicians treating patients with chronic pain in outpatient settings, it also holds relevance for acute care settings as it brought awareness to opioid prescribing and prompted state legislation (Dowell, Haegerich, & Chou, 2016; National Conference of State Legislatures, 2017). The guideline supports using the lowest efficacious dose and using caution when prescribing above 50 or 90 morphine milligram equivalents per day for chronic pain (Centers for Disease Control and Prevention, 2016).

Improving hospital care delivery for patients with OUD has garnered recent attention (Herzig et al., 2018; National Academies of Sciences Engineering and Medicine, 2019, 2020) given the immense individual and public health burdens of OUD. In acute care, for example, the guideline suggests typically prescribing opioids for three days or fewer and rarely prescribing for more than seven days (Centers for Disease Control and Prevention, 2016). Additionally, many hospitals have adopted an evidence-based strategy that has implications for surgical patients with OUD called Enhanced Recovery after Surgery (ERAS). This strategy seeks to facilitate patient recovery and focuses on wide-ranging topics including the use of multimodal analgesia with appropriate use of opioids (American Association of Nurse Anesthetists, 2018; Jackman, 2019). While hospitals have guidance about how to provide tailored and evidence-based care for surgical patients with OUD, there is notable variation across hospitals regarding care and outcomes for this vulnerable population.

As the negative effects of the over prescription of opioids became clear, getting an opioid prescription became more challenging, even for people for whom long-term opioid use was indicated (Zoorob, 2019). People began using non-prescribed opioids and other combinations of drugs (Ciccarone, 2019). A commonly injected opioid is heroin, and since 2013, the synthetic opioid fentanyl has often been found in the heroin supply given fentanyl's relatively potent yet inexpensive nature, increasing the risk of overdose (Zoorob, 2019). Today, the US opioid and overdose crisis is characterized by use of a combination of prescription opioids, heroin, and fentanyl (Ciccarone, 2019). While the opioid epidemic has historically been associated with White, middle-class suburban and rural communities, opioid-related deaths have risen more steeply among Blacks in recent years (Scholl, Seth, Kariisa, Wilson, & Baldwin, 2019) including during the COVID-19 pandemic (Khatri et al., 2021), revealing the varied demographics of people using opioids. Polysubstance use is increasingly common as well, with the rate of hospital stays involving both opioids and stimulants (e.g., amphetamines, cocaine) on the rise (Fingar & Owens, 2021).

Background on Surgical Patients with OUD

The substantial number of patients with OUD undergoing surgery is a relatively new phenomenon spurred by the increase in opioid overprescribing in the 1990s and subsequent illicit opioid use (Centers for Disease Control and Prevention, 2013). Today, more than two million people in the US have OUD (National Academies of Sciences Engineering and Medicine, 2019) and many of these people are admitted for surgery. Improving nursing resources provides a promising mechanism to meet the urgent needs of hospitalized patients with OUD.

OUD is defined as" a problematic pattern of opioid use leading to clinically significant impairment or distress" per the Diagnostic and Statistical Manual of Mental Disorders, fifth edition (DSM-5). Many Americans today have opioid abuse or dependence that is not in remission, which was the definition of OUD used for this study (Gupta et al., 2018). Opioids include any substance that acts on opioid receptors, including prescription medications, such as morphine, and illicit drugs, such as heroin. Surgical patients with and without OUD are different in a variety of ways. Compared to surgical patients without OUD, surgical patients with OUD are younger, more likely to be on Medicaid and White, and have fewer comorbidities (Dewan et al., 2019; Gupta et al., 2018; Moreno et al., 2019). Surgical patients with OUD have a higher prevalence of acquired immunodeficiency syndrome, psychoses, alcohol abuse, depression, chronic lung disease, and liver disease than patients without OUD (Dewan et al., 2019; Gupta et al., 2018). Comparatively, surgical patients without OUD have higher rates of hypertension, obesity, and renal failure than surgical patients with OUD (Gupta et al., 2018).

The poor outcomes of surgical patients with OUD (National Drug Intelligence Center, 2011) have prompted increased national attention to improving the hospital care for these patients (National Academies of Sciences Engineering and Medicine, 2019, 2020). In response to these challenges and resultant initiatives, hospital administrators are increasingly interested in understanding how to improve postsurgical outcomes for patients with OUD. The following review of the literature describes current evidence on outcomes following surgery for patients with OUD.

Literature Review

Outcomes for Surgical Patients with OUD

Length of stay. Patients with OUD more frequently experience a longer hospital stay (Armaghani et al., 2016; Cron et al., 2017; Menendez, Ring, et al., 2015; Waljee et al., 2017). A 2019 study by Song and colleagues using the National Inpatient Sample that included 376,467 patients, 1,096 of whom had

OUD, reported that patients with OUD had a two day longer length of stay compared to patients without OUD (12.4 vs 10.6 days; p-value=0.015) after major abdominal surgery (Song et al., 2019). Another study by Gupta et al. in 2018 that used the National Readmission Database with 16 million surgical patients, 95,000 of whom were diagnosed with OUD, found that the unadjusted mean hospital length of stay was longer for surgical patients with OUD compared to those without (10 vs. 5 days; p-value<0.0001). After adjustment for potential confounders including age, surrogates for socioeconomic status, and hospital characteristics, surgical patients with OUD still had a longer mean length of stay (6 vs. 4 days; p-value<0.0001).

A substantial number of studies cite a similar increased length of stay for patients with OUD compared to those without (Dewan et al., 2019; Gulur, Williams, Chaudhary, Koury, & Jaff, 2014; Menendez, Ring, et al., 2015; National Drug Intelligence Center, 2011; Rozell, Courtney, Dattilo, Wu, & Lee, 2017). While surgical patients with OUD are younger and have fewer comorbidities, patient level factors that may result in a longer length of stay for patients with OUD include having Medicaid and comorbid alcohol use disorder (Dewan et al., 2019; Menendez, Ring, et al., 2015). No studies, however, document that hospital characteristics explain differences in length of stay between surgical patients with and without OUD and much variation in length of stay between these two groups is unexplained. One possible explanatory factor for this observed variation is variation in nursing resources across hospitals, though the interpretation of length of stay is not always clear. Hospitals with longer length of stay may be less efficient but provide care of equal quality. Another possible explanation is that hospitals with longer length of stay may be providing better quality of care that simply requires more time. Finally, hospitals with longer length of stay may have longer length of stay because of complications resulting from poor quality of care. Therefore, while understanding and addressing prolonged length of stay is essential to providing high quality healthcare for patients with OUD, the etiology of a longer this outcome must be considered in interpretation.

Mortality. Over the past decade, a dramatic increase in opioid use has driven a corresponding increase in opioid-related mortality, which has implications for hospitals seeking to limit mortality among surgical patients with OUD (Rudd et al., 2016). This increase has resulted not only from greater illicit opioid use but also from an increase in prescribed opioids (Gupta et al., 2018). A 2015 study by Menendez and colleagues of over 9 million patients (16,000 OUD patients) undergoing elective orthopedic surgery that used data from the Nationwide Inpatient Sample found that having OUD was associated with increased inpatient mortality (OR 3.7; 95% CI, 2.7–5.1) (Menendez, Ring, et al., 2015). In contrast, Song and colleagues' 2019 study using this same data source that included 376,467 patients and 1,096 OUD patients found that in-hospital mortality did not differ between surgical patients with and without OUD (OR 2.4, p-value = 0.10). (Song et al., 2019). Other empirical literature documenting the relationship between surgical patients with OUD and mortality is limited. Some of the mortality risk for patients with OUD is explained by the high rates of infective endocarditis among this population, but the remaining difference is unexplained (Menendez, Ring, et al., 2015). Hospital characteristics, including hospital nursing resources, may explain this difference.

Readmission. Among hospitalized surgical patients, having OUD is a documented risk factor for hospital readmission (Donroe, Holt, & Tetrault, 2016; Gupta et al., 2018). Readmission after discharge for an acute care hospital discharge is an outcome of interest to clinicians, hospitals, and payers like The Center for Medicare & Medicaid (CMS) because it is associated with quality of care and increased health care costs (Centers for Medicare and Medicaid Services, 2018; Hatipoğlu et al., 2018; Zuckerman, Sheingold, Orav, Ruhter, & Epstein, 2016). In a study of over 12,000 Medicare beneficiaries undergoing surgery, Brooke and colleagues found that postsurgical readmission is often due to lack of primary care (Brooke et al., 2014). Additionally, research about hospitalized medical and surgical patients highlights the importance of examining readmission at multiple timepoints, including 7, 30, 60, and 90 days (Brom, Brooks Carthon, Sloane, McHugh, & Aiken, 2021; Lasater & McHugh, 2016; Lasater et al., 2020; Merath et al., 2020).

Despite being younger and having fewer comorbidities, surgical patients with OUD experience a 46% higher risk of 30-day and 15% higher risk of 90-day readmission compared to surgical patients without OUD (Jain et al., 2018; Weick et al., 2018). Two retrospective 2017 studies noted higher 30-day readmission rates in patients with OUD who underwent elective abdominal surgery (Cron et al., 2017; Waljee et al., 2017). A 2018 study using the National Readmission Database by Gupta and colleagues of 16 million surgical patients, 95,000 of whom were diagnosed with OUD, found that patients with OUD are 25% more likely to be readmitted to hospital within 30 days than patients without (Gupta et al., 2018). This association persisted after adjustment for confounders including age, surrogates for socioeconomic status, and hospital characteristics (Gupta et al., 2018). In this study, the most common reason for readmission for surgical patients with and without OUD was infection, but infection was a more common reason among surgical patients with OUD (27.0% vs. 18.9%; $P < 0.0001$). Certain infections associated with injecting opioids, like cellulitis and endocarditis, were more common in patients with OUD. While surgical patients with OUD had higher rates of psychiatric diagnoses and acute pain compared to patients without OUD, rates of device- and procedure-related infections, pneumonia, abdominal abscess, and peritonitis were similar in both groups (Gupta et al., 2018).

In a 2018 study of 25,000 commercially insured surgical patients, 5,500 of whom had OUD, Jain and colleagues found that surgical patients with OUD are not only more likely to be readmitted within 90-days for pain symptoms related to surgery, but they are also more likely to be readmitted for all causes (Jain et al., 2018). A 2016 study by Sing and colleagues of 174 patients undergoing total joint arthroplasty at a single institution found that surgical patients with OUD had a higher unadjusted rate of 90-day readmission (9% vs. 5%, p-value=0.389), but this difference was not statistically significant (Sing, Barry, Cheah, Vail, & Hansen, 2016). Given that no studies have found that hospital characteristics explain differences in readmission between surgical patients with and without OUD, it is plausible that nursing resources may account for variation in readmission across hospitals.

Risk Adjustment

Risk adjustment allows for meaningful comparisons to be made between different groups (Iezzoni, 2013). While risk adjustment is not necessary in a perfectly randomized study, cross-sectional studies of existing data require risk adjustment to account for the observable differences among the comparison groups (Iezzoni, 2013). In this study of postsurgical outcomes for patients with OUD, patient and hospital characteristics were controlled for through risk adjustment since they influence the measurement of outcomes (Silber, Williams, Krakauer, & Schwartz, 1992). The following section discusses common patient and hospital characterizes used in the literature. No prior studies have examined the relationship between nursing resources and postsurgical outcomes among patients with OUD while accounting for patient and hospital characteristics, so risk adjustment for this study was guided by previous research on hospitalized surgical patient outcomes, as well as the National Quality Forum technical report entitled “Risk Adjustment for Socioeconomic Status or Other Sociodemographic

Factors Forum's" (National Quality Forum, 2014). It was also informed by literature on surgical patients with OUD.

Patient Characteristics

Age. There is an association between age and postsurgical outcomes, with older age being associated with poorer outcomes (Hu, Gonsahn, & Nerenz, 2014; National Quality Forum, 2014; Pugely, Callaghan, Martin, Cram, & Gao, 2013). These findings are logical given that physiologic changes accompany age and given that the probability of disease increase with age (National Quality Forum, 2014). Age is frequently used in risk adjustment approaches and should continue to be utilized given conceptual and empirical relationships between age and outcomes (National Quality Forum, 2014). Furthermore, research suggests that surgical patients with OUD are younger than surgical patients without OUD (Dewan et al., 2019; Gupta et al., 2018; Jain et al., 2018; Menendez, Ring, et al., 2015). Therefore, patient age was controlled for in the analysis of the specific aim.

Sex. Studies examining postsurgical outcomes consistently adjust for patient sex (Aiken et al., 2011; Kutney-Lee & Aiken, 2008; National Quality Forum, 2014). While some studies do not find an association between sex and postsurgical outcomes (Schairer, Vail, & Bozic, 2014), most studies find that being male puts you at higher risk for poor postsurgical outcomes (Hu et al., 2014; Pugely et al., 2013; Tsai, Joynt, Orav, Gawande, & Jha, 2013; Zmistowski, Karam, Durinka, Casper, & Parvizi, 2013). Additionally, surgical patients with

OUD are more likely to be male compared to surgical patients without OUD (Dewan et al., 2019; Gupta et al., 2018; Menendez, Ring, et al., 2015). Patient sex was controlled for in adjusted analyses of the specific aim.

Comorbidities. Regardless of how comorbidities are defined, studies consistently find that having more comorbidities puts patients at higher risk for poor outcomes including mortality and readmission (Härstedt, Rogmark, Sutton, Melander, & Fedorowski, 2015; Kork et al., 2015; Stimson et al., 2010; Voskuijl, Hageman, & Ring, 2014). Dewan et al. found that a larger proportion of surgical patients with OUD have five or fewer Elixhauser comorbidities (79% v. 72%) (Dewan et al., 2019). Another study of surgical patients with OUD also employed Elixhauser comorbidities (excluding drug abuse) and found that these patients have higher prevalence of acquired immunodeficiency syndrome, psychoses, alcohol abuse, depression, chronic lung disease, and liver disease compared to surgical patients without OUD (Gupta et al., 2018). Patient comorbidities were defined by Elixhauser' s comorbidity measures (Elixhauser et al., 1998) excluding drug abuse (Gupta et al., 2018). The presence of each comorbidity was controlled for in the analysis of the specific aim.

Diagnosis Related Group (DRG). Postsurgical outcomes vary based on DRGs. Different readmission risks exist across surgical procedures (Basques, Miller, Golinvaux, Bohl, & Grauer, 2015; Mnatzaganian, Ryan, Norman, Davidson, & Hiller, 2012; Pugely et al., 2013; Zmistowski, Restrepo, et al., 2013). This variation in outcomes by surgery type is also present for patients with OUD

(Dewan et al., 2019; Gupta et al., 2018; Weick et al., 2018). DRG was controlled for in the analysis of the specific aim.

Race/ethnicity. Race/ethnicity is known to impact postsurgical outcomes (Brooks Carthon et al., 2012; Schoenfeld et al., 2017). While one study found that White patients are at higher odds of readmission compared to Black patients (Mahomed et al., 2003), most studies find that Black patients are at higher odds of readmission compared to White patients (Hu et al., 2014; Jencks, Williams, & Coleman, 2009; Zmistowski, Restrepo, et al., 2013). While it has been reported that the opioid crisis predominately affects White Americans (Om, 2018), two studies have found that, compared to surgical patients without OUD, a higher proportion of surgical patients with OUD are Black (Dewan et al., 2019; Menendez, Ring, et al., 2015). Therefore, race/ethnicity was controlled for in the analysis of the specific aim.

Insurance status. Insurance status accounts for variation in postsurgical outcomes, with Medicaid patients having higher rates of postsurgical inpatient mortality (64%) compared to privately insured patients (56%) (Connolly et al., 2018). Medicaid patients, compared to those who are privately insured, also are at higher odds of 30-and 90-day readmission after adjusting for other relevant characteristics (52% and 53% higher odds, respectively) (Connolly et al., 2018). Additionally, surgical patients with OUD are more likely to be covered by Medicaid than those without OUD (37% vs. 5%), which likely influences outcomes (Dewan et al., 2019). Conversely, surgical patients with OUD are less likely to be privately insured compared to patients without OUD (20% vs. 35%) (Dewan et al., 2019). Given that insurance status impacts patient outcomes, and that it is different for surgical patients with OUD, it was included as a control in the analysis of the specific aim.

Discharge disposition. Where patients are discharged post-hospitalization is associated with postsurgical outcomes. One study found that patients discharged home with health services had a significantly lower 30-day readmission rate compared to those discharged to inpatient rehab facilities (Ramos et al., 2014). Other studies have also found that patients discharged to skilled nursing facilities have higher odds of readmission (Keswani et al., 2016; Schairer et al., 2014). Compared to surgical patients without OUD, those with OUD are less often discharged routinely (45% vs. 48%) (Dewan et al., 2019) and, in adjusted models, have a nearly three times higher odds of being discharged AMA (OR 2.9, *p*-value <0.001) (Menendez, van Dijk, & Ring, 2015). Discharge disposition was controlled for in the analysis of the specific aim.

Socioeconomic status. Socioeconomic status is a predictor of patient outcomes including readmission and postsurgical mortality (N. J. Birkmeyer, Gu, Baser, Morris, & Birkmeyer, 2008; Weissman, Stern, & Epstein, 1994). It has been defined as a measure of an individual's income, education, and employment status (Green, 1970). Income is frequently used as a measure of socioeconomic status and evidence supports a relationship between lower income and higher odds of postsurgical readmission (Mahomed et al., 2003;

Weissman et al., 1994). Patient income, however, is not usually in administrative data making a patient-level socioeconomic measure difficult to obtain. Studies have used other measures, including the receipt of supplemental security income or Medicaid status, as proxies for socioeconomic disadvantage (Jencks et al., 2009; Schechter, Shelton, Margolis, & FitzSimmons, 2001). According to the National Quality Forum (NQF), Medicaid eligibility is a valid indicator of low-income status (National Quality Forum, 2014). Geo-coding has also been used to generate area-based measures of income that enable the linking of a patient's address with Census data (Brooks Carthon et al., 2012; Roux et al., 2001). Studies have also used employment and education as proxies for socioeconomic status, yet information on such measures if difficult to obtain from administrative data (National Quality Forum, 2014). One study found that patients working in unskilled occupations were more likely to be readmitted, a finding that makes sense since employment status is positively corelated with income (Weissman et al., 1994). Compared to surgical patients without OUD, surgical patients with OUD are more often insured by Medicaid (37% v. 5%) and in the lowest quartile of median household income (31% v. 17%). Socioeconomic status was not controlled for in the analysis of the specific aim given that insurance status, including Medicaid, was controlled for.

Hospital Characteristics

Bed size. Bed size is frequently controlled for in studies comparing outcomes across hospitals (Aiken et al., 2011; Aiken et al., 2003; Kutney-Lee &

Aiken, 2008; M. D. McHugh et al., 2016). Hospitals with more beds are theorized to have greater patient volume, allowing them to perform surgical procedures more often. The more experience providers having performing procedures, the better the health outcomes for their patients. Larger hospitals, however, are also more likely to treat sicker patients, which may lead to poorer unadjusted outcomes for larger hospitals. The relationship between patient volume and outcomes is mixed, even among the same group of researchers. In 2011, Joynt and colleagues found that smaller hospitals had higher readmission rates (Joynt, Orav, & Jha, 2011), while in 2013 Joynt and Jha found that larger hospitals were more likely to be penalized under the HRRP penalties (Joynt & Jha, 2013). Compared to surgical patients without OUD, surgical patients with OUD are more often cared for in hospitals with a large bed size, though this difference is not statistically significant (Dewan et al., 2019). Given the precedent to control for bed size in other studies and the unclear relationship between hospital bed size and outcomes, it was controlled for in the analysis of the specific aim.

Teaching status. Hospital teaching status is defined by the ratio of medical residents and fellows providing medical care per hospital beds. Despite the frequent use of teaching status as a control of in studies of outcomes across hospitals (Aiken et al., 2011; Aiken et al., 2003; Kutney-Lee & Aiken, 2008; M. D. McHugh et al., 2016), little evidence documents the relationship between a hospital’s teaching status and surgical patient outcomes. Some evidence suggests that teaching status is associated with higher rates of readmission and that high teaching status hospitals are more likely to be penalized under the HRRP (Joynt & Jha, 2013; Press et al., 2013). Teaching hospitals are often located close to medical schools and in urban settings. Given the large size of many teaching hospitals, medical trainees, residents, and fellows generally get a wide range of experience across specialties in such hospitals. The increased risk of poor outcomes among patients cared for in teaching hospitals may be the result of the increased patient acuity at teaching hospitals. Compared to surgical patients without OUD, surgical patients with OUD are more often cared for in teaching hospitals (Dewan et al., 2019). Hospital teaching status was controlled for in the analysis of the specific aim.

Technology status. Hospital technology status is defined by a hospital's ability to perform open-heart surgery and/or major organ transplants. Generally, high technology hospitals are large, urban, and major teaching status, attracting a case mix of patients that are sicker and more clinically complex. Most literature shows that high technology is associated with better outcomes, so many studies that examine variation in outcomes across hospitals control for it (Aiken et al., 2003; Aiken et al., 2002; Brooks Carthon et al., 2012; Brooks Carthon, Lasater, Sloane, & Kutney-Lee, 2015; Lasater & McHugh, 2016; Silber et al., 2016). Hospital technology status was controlled for in the analysis of the specific aim.

Geographic location. As mentioned, urban hospitals are more often large with major teaching and high technology status; they are therefore more likely to have a sicker and more clinically complex case mix. On the other hand, rural hospitals are more likely to be small with non-teaching and low technology status, and often transfer higher acuity patients to hospitals with more resources. Compared to surgical patients without OUD, surgical patients with OUD are more often cared for in urban hospitals (Dewan et al., 2019). Hospital geographic location was therefore controlled for in the analysis of the specific aim.

Caseload volume. The effect of surgeon and hospital volume on postsurgical outcomes, including readmission and mortality, is generally supported, with some mixed findings. A 2004 study by Katz and colleagues found that while hospitals with higher surgeon and hospital volume may protect patients against perioperative adverse events, patients cared for in such hospitals do not have significantly lower odds of mortality (Katz et al., 2004). A study in Finnish hospitals reported that lower volume trusts had lower readmission rates (Mäkelä et al., 2011). A 2011 systematic review and meta-analysis of the volume–outcome relationship in pancreatic surgery found a consistent association between high hospital volume and lower postoperative mortality rates (Gooiker et al., 2011). A 2016 systematic review supported a positive relationship between surgeon volume and outcomes for patients undergoing colorectal cancer, bariatric surgery, and breast cancer procedures (Morche, Mathes, & Pieper, 2016). Particularly important for this study, Wiltse Nicely and colleagues found an interaction effect between nurse staffing and patient volume such that volume produced better outcomes only in hospitals with good staffing (Wiltse Nicely, Sloane, & Aiken, 2013). In summary, while research generally supports a positive surgeon volume-outcome relationship, much of the research is procedure specific and may not be applicable for all general, orthopedic, and vascular surgical patients. Compared to surgical patients without OUD, surgical patients with OUD are more often cared for in hospitals with a low cardiac surgery volume (Dewan et al., 2019). Hospital caseload volume was not examined in the analysis of the specific aim.

Ownership type. Limited research documents an association between hospital ownership type and patient outcomes. A study by Jensen and colleagues documents that private hospitals outperform public hospitals with regard to mortality and readmission outcomes (Jensen, Webster, & Witt, 2009). Another study found that non-profit hospitals had better readmission rates compared to government owned hospitals (Joynt & Jha, 2011). Compared to surgical patients without OUD, surgical patients with OUD are more often cared for in government or non-profit hospitals rather than private hospitals (Dewan et al., 2019). Hospital ownership was not controlled for in analysis of the specific aim given that other included controls account for variation in outcomes across ownership types.

Socioeconomic status profile. In addition to patient socioeconomic status, the hospital's socioeconomic status profile may account for variation in postsurgical outcomes. The Institute of Medicine defined safety-net hospitals as having both 1) a legal mandate or mission to offer services for patients regardless of their ability to pay and 2) a substantial share of their patient mix is uninsured, Medicaid, and other vulnerable patients (Altman & Lewin, 2000). For research purposes, safety-net hospitals have been identified in a variety of ways. CMS provides additional payments to hospitals serving a substantial percentage of individuals insured through Medicaid, called disproportionate share hospitals (DSHs). Blegen and colleagues identified DSHs as safety-net hospitals and found that patients in safety-net hospitals were more likely to have poorer outcomes, including higher rates of mortality, even after accounting for nurse staffing ratios (Blegen, Goode, Spetz, Vaughn, & Park, 2011). Findings from this study suggest that controlling for patient and nursing characteristics may not fully account for postsurgical outcomes and that hospital socioeconomic status may put patients at higher risk of poor outcomes. Safety-net hospitals have also been classified based on the amount of uncompensated care provided or other hospital characteristics such as being a public or teaching hospital (M. D. McHugh et al., 2012). Werner and colleagues defined safety-net status as the percentage of patients insured by Medicaid because that measure is available for all US hospitals and Medicaid is increasingly recognized as the main source to finance health care for low-income populations (Weil, 2003; Werner, Goldman, & Dudley, 2008). Because the definition of safety-net varies across the literature, and there are mixed findings about the impact of safety-net status on patient outcomes (M. McHugh, Kang, & Hasnain-Wynia, 2009), it was not controlled for in the analysis.

Nursing Characteristics

Nurse education. Substantial evidence reveals that patients cared for in hospitals with better nursing resources have better outcomes. Receiving care in hospitals with higher proportions of nurses educated at the BSN level is associated with better postsurgical outcomes including shorter lengths of stay (Cho, Park, Choi, Lee, & Kim, 2018), lower mortality (Aiken et al., 2011; Aiken et al., 2003; Aiken et al., 2014; Kutney-Lee, Sloane, & Aiken, 2013), and fewer readmissions (Yakusheva, Lindrooth, & Weiss, 2014). Further evidence reveals relationships between hospital-level nurse educational preparation and postsurgical outcomes among vulnerable populations. A study by Kutney-Lee et al. documented that an increased proportion of nurses educated at the BSN level is associated with shorter lengths of stays for surgical patients with serious mental illness (Kutney-Lee & Aiken, 2008). Similarly, White and colleagues, found that individuals with Alzheimer's disease and related dementias have disproportionately lower odds of mortality when cared for in hospitals with a more educated nursing workforce (White et al., 2018). Surgical patients with OUD are likely comparably sensitive to the educational composition of the nursing workforce. Nurse education was used as a control in the analysis of the specific aim in which either nurse staffing or the nurse work environment was the independent variable.

Nurse staffing. Another nursing resource, nurse staffing, is also associated with numerous postsurgical outcomes across patient populations. Like nurse education, nurse staffing influences length of stay (Cho et al., 2018), mortality (Aiken et al., 2011; Aiken et al., 2014; Brooks Carthon et al., 2012; Estabrooks, Midodzi, Cummings, Ricker, & Giovannetti, 2005; Needleman, Buerhaus, Mattke, Stewart, & Zelevinsky, 2002), and readmission (Lasater & McHugh, 2016; Ma, McHugh, & Aiken, 2015) among surgical patients. Nurse staffing is also related to other outcomes including failure to rescue (Aiken et al., 2002), patient safety (Lake, Shang, Klaus, & Dunton, 2010), and survival from in-hospital cardiac arrest (M. D. McHugh et al., 2016). Furthermore, better nurse staffing levels has a disproportionally positive effect on the prevention of death among patients with serious mental illness compared to those without it (Kutney-Lee & Aiken, 2008), highlighting potential implications of better nurse staffing levels for another vulnerable population: surgical patients with OUD. Nurses caring for surgical patients with OUD perform patient assessments aimed at preventing postoperative adverse events including respiratory arrest and infection (Barelli, Morelli Sbarra, Sbaraglia, Zappia, & Rossi, 2019; Dewan et al., 2019; Kim et al., 2016; Menendez, Ring, et al., 2015; Sayal, Bateman, Menendez, Eikermann, & Ladha, 2018; Stromer, Michaeli, & Sandner-Kiesling, 2013). When nurses have too many patients to care for, their time for performing assessments and facilitating appropriate interventions is compromised. Because care for surgical patients with OUD is time intensive and nuanced, these patients likely benefit from better nurse staffing levels. Nurse staffing was controlled for in the analysis of the specific aim when it was not the predictor variable.

Nurse work environment. The nurse work environment has been defined as the “organizational characteristics of a work setting that facilitate or constrain professional nursing practice” (Lake, 2002) (p. 178). The Practice Environment Scale of the Nursing Work Index (PES-NWI) is a common survey instrument used to measure the nurse work environment and has construct validity (Lake, 2002). Measurement of the nurse work environment through the PES-NWI has revealed a consistent relationship between better work environments and improved patient outcomes. Patients cared for in hospitals with good work environments—signified by greater autonomy, excellent collaborative relationships with other members of the healthcare team, and exceptional communication with colleagues—have reduced mortality (Aiken et al., 2011; Aiken et al., 2003; Aiken et al., 2008; Kendall-Gallagher, Aiken, Sloane, & Cimiotti, 2011; Silber et al., 2016) and lower odds of readmissions (Lasater & McHugh, 2016; M. D. McHugh et al., 2016). Patients cared for in such settings also have increased patient satisfaction (Kutney-Lee et al., 2009; Stimpfel, Sloane, McHugh, & Aiken, 2016) and better odds of survival after cardiac arrest (M. D. McHugh et al., 2016). Good work environments empower nurses to facilitate care, make pain management recommendations, and report abnormal findings from patient assessments, which likely facilitates better outcomes for surgical patients with OUD. The nurse work environment was controlled for in the analysis of the specific aim when it was not the predictor variable.

Summary

While the effects of nursing resources on outcomes are well understood among surgical patients, little is known about their effects on surgical patients with OUD. This study represents the first examination of how nursing resources are associated with length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission for surgical patients with OUD. While some studies have found covariates like race and socio-economic status to be related to outcomes, these studies were not able to examine nursing resources which already account for many of these covariates. Controlling for such covariates in this study, therefore, might constitute over-controlling. Findings from this study have implications for other vulnerable patient populations undergoing surgery.

Significance

Social

The societal burden of sub-optimal recovery for surgical patients with OUD is significant. Patients who are hospitalized suffer from lost work or school hours, productivity, and wages (Smith, 2010). Hospitalized patients may experience a loss of identify or sense of self given their inability to engage in activities that they enjoy. Recovery for surgical patients with OUD necessitates adequate pain management, or else unmanaged acute pain may progress to chronic pain (Casey, Greenberg, Nicassio, Harpin, & Hubbard, 2008), and potentially opioid use disorder. Given that surgical patients with OUD are often hospitalized for longer periods of time, nurses are instrumental in coordinating care among the team to meet the patient’s needs. They provide frequent patient assessment, pain management coordination, and key patient education to facilitate optimal outcomes for these patients (French et al., 2020). The outcomes of interest for this study also indirectly capture sequelae of OUD like being able to work and long-term wellbeing.

Financial

In addition to having a human toll on patients, poor outcomes are a financial toll for hospitals (Bisognano & Boutwell, 2009). Depending on the type of surgery, the average cost of each readmission after surgery is estimated to be $16,000-18,000 and each additional day of a postsurgical hospital stay costs $1,649 (Blumberg et al., 2018; Goel et al., 2018; Kent et al., 2011). CMS is estimated to spend almost $17 billion annually on avoidable readmissions (Jencks et al., 2009). As such, the potential for savings by reducing readmissions is great. Given the cost of readmissions for hospitals, interventions aimed at reducing readmissions are a national priority for hospitals and policymakers.

Political

Hospitals caring for higher proportions of surgical patients with OUD may face disproportionate reimbursement penalties for readmission due to the higher rates of readmission compared to surgical patients without OUD (M. D. McHugh, Brooks Carthon, & Kang, 2010). With the intention of improving quality and containing costs, CMS instituted the Hospital Readmissions Reduction Program (HRRP) in 2012 (McIlvennan, Eapen, & Allen, 2015). The HRRP financially penalizes hospitals for having higher than expected 30-day readmission rates for select conditions, including following hip and knee surgery (Goel et al., 2018). In 2017, 80% of hospitals were penalized with HRRP fines totaling $528 million (Goel et al., 2018). Though HRRP only applies to Medicare patients, private insurance payers have adopted similar payment policies and it has brought awareness to excess costs associated with readmissions and motivated hospitals to address this problem (Independence Blue Cross, 2018; McIlvennan et al., 2015). This study addresses modifiable nursing predictors of 7, 30, 60, and 90-day readmission for patients following surgery. Understanding the contribution of nursing to readmissions will guide hospital administrators and policymakers to appropriately invest in nursing resources.

The increased burden of hospitals caring for surgical patients with OUD has prompted two landmark guidelines from NAM, but these reports fail to account for the contribution of nursing resources of outcomes for patients with OUD (National Academies of Sciences Engineering and Medicine, 2019, 2020). The section dedicated to acute care settings in NAM's 2019 report *Medications for Opioid Use Disorder Save Lives* highlights the missed opportunities to engage patients in longer-term opioid treatment during hospitalization. Nurses working in settings with bolstered nursing resources are likely well equipped to facilitate connection to opioid treatment for patients, which has implications for patient outcomes. The 2020 NAM report *Framing Opioid Prescribing Guidelines for Acute Pain* calls for providers to tailor clinical practice guidelines when managing acute pain among patients with OUD, highlighting the needs for individualized care for patients with OUD. This report acknowledges that nurses are important for meeting the care needs of patients with OUD but that nurses frequently lack the time to provide tailored care for these patients. If nurses were responsible for fewer patients, they would likely have the time to provide such care. While these NAM reports provide clinical guidance for the management of hospitalized patients with OUD, they do not address how the organizational context of nursing can facilitate adequate care for hospitalized patients with OUD. This work can inform future high-impact reports seeking to improve hospital care delivery for patients with OUD.

Summary

In Chapter 2, the adapted QHOM was introduced and described. A review of the literature detailed relationships between nursing resources and surgical patient outcomes, as well as outcomes for surgical patients with OUD. Significance of the study was revealed via a discussion of social, financial, and political implications of the study findings. Finally, covariates for this study were outlined. Chapter 3 will describe the methods of the study, the parent study, the datasets, the sample, and the analytic plan.

Chapter 3: METHODS

Introduction

Chapter 3 details the methodological approach for this study. The overall objective is to examine mechanisms for improving outcomes for surgical patients with OUD. This chapter details the research design, the procedure for identifying the sample, and the plan for measuring the variables. It also outlines the analytic plan for the specific aim and sensitivity analysis. Human subject protections are addressed.

Overview

This is a study of hospitals and the outcomes of the patients in them; specifically, whether differences across hospitals in nursing resources are associated outcomes for surgical patients with OUD. This cross-sectional analysis uses three secondary data sources: 1) a nurse survey (RN4CAST-US), 2) an annual hospital administrative survey (AHA Annual Survey of Hospitals), and 3) patient discharge summaries. The nurse survey provides demographic information on nurses and measures of education, staffing, and the work environment at hospitals where nurses work. The hospital administrative survey provides information on hospital characteristics including bed size, teaching status, technology status, and state. The patient data includes patient demographic information, diagnoses and procedures during each hospitalization, and measures of outcomes.

Data Sources

This study determined whether hospital nursing resources (i.e., education, staffing, and work environment) were more strongly associated with postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) for patients with compared to without OUD (Aim 1). Data from the RN4CAST-US survey, AHA Annual Survey of Hospitals, and patient discharge summaries were linked by a common hospital identifier to produce the analytic dataset.

RN4CAST

The RN4CAST-US is a survey of registered nurses (RNs) in the US that provides RN demographic information, as well as measures of nursing resources and care quality in hospitals where survey respondents work (R01NR014855, L. Aiken, PI) (Lasater et al., 2019). The survey was conducted by a modified Dillman approach (Dillman, Smyth, & Christian, 2014). It was sent via postal or electronic mail to a 30% random sample of licensed RNs (about 231,000 RNs) in four states (California, Florida, New Jersey, and Pennsylvania) between 2015 and 2016. These four states are geographically diverse and represent a large proportion of annual hospitalizations in the US. Home mailing and personal email addresses were identified through state boards of nursing licensure lists. Respondents had the option of responding to the survey via mail or online. Survey respondents were asked to identify the name of the hospital where they were employed and to provide information about education, staffing, and the work environment at that hospital. The name of individual hospitals where nurses worked was needed to create hospital-level measures of nursing resources that can be linked to hospital and patient data.

The response rate of the RN4CAST-US survey was 26%. To address potential concerns about a nonresponse bias at the nurse level, a second random sample of 1,400 non-respondents was conducted. Intensive recruiting methods—including financial incentives, phone calls, and certified mail—were employed to incentivize participation in the survey resulting in a response rate of 87% (Lasater et al., 2019). Analyses of the subsample responses revealed no statistically significant differences in nurse-level evaluations of staffing or the work environment. Non-respondents in Florida were significantly more likely to have a BSN compared to respondents of the original survey (Lasater et al., 2019). The analytic sample included 28,792 RNs.

AHA Annual Survey of Hospitals

The AHA is a national organization that represents and serves all types of hospitals, healthcare networks, and their patients and communities (American Hospital Association, 2020). The AHA Annual Survey is a voluntary survey of 6,300 hospitals and 400 healthcare systems. The survey has data on hospital structural characteristics, utilization, personnel, revenue, expenses, and more (American Hospital Association, 2020). For this study, 2015 and 2016 AHA Annual Survey data provided measures of hospital structural characteristics including bed size, teaching status, technology status, and state. These variables were used to describe the hospital sample and as controls in analyses.

Patient Discharge Summaries

Patient data from 2015 and 2016 were derived from annual inpatient discharge summaries from the California Office of Statewide Health Planning and Development, the Agency for Health Care Administration for Florida, the New Jersey Department of Health and Senior Services, and the Pennsylvania Health Care Cost Containment Council. These state agencies provided de-identified discharge claims data. Patient diagnostic codes for identifying OUD, surgical procedure, and comorbidities, as well as demographic characteristics, including sex, race, ethnicity, and insurance status, were obtained from these data sources. These data sources were used to generate the outcomes of interest for this study: length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission.

Samples

Hospitals

Hospitals were included in the sample if they had at least 10 nurse survey respondents based on previous research (Aiken et al., 2003; Aiken et al., 2002; Lasater & McHugh, 2016; M. D. McHugh & Ma, 2013), at least 20 surgical patient discharges to assure hospitals have enough patient volume to warrant examination (Lorch, Zhang, Rosenbaum, Evan-Shoshan, & Silber, 2004), and at least five OUD patients to ensure hospitals have experience treating OUD patients (Kelly, Reilly, Quiñones, Desai, & Rosenheck, 2018). Nonfederal, acute care hospitals (excluding psychiatric hospitals) were included. Federal Veterans

Health Administration hospitals were excluded given that they have inherently different patients. The final analytic sample included 448 hospitals. Hospitals had 61 nurse survey respondents on average (median 48), ranging from 10 to 204 nurses per hospital.

Patients

Patients were included in the study sample if they were admitted to a study hospital in the fourth quarter of 2015 or any quarter of 2016. These quarters of data were selected because they overlap with International Classification of Diseases, Tenth Revision (ICD-10) coding. Research documents that coding for OUD increased during the transition from ICD-9 to ICD-10 coding, suggesting that the newer ICD-10 classification system may capture OUD stays that were missed by the ICD-9 data (Heslin et al., 2017). Therefore, years of data that use ICD-9 coding are excluded from this study. Included patients were 18 to 99 years old and had a general, orthopedic, or vascular surgical condition. These procedures were selected because they allow for well-validated risk adjustment and because almost all acute hospital perform them (Aiken et al., 2003; Aiken et al., 2008; Aiken et al., 2002; Brooks Carthon et al., 2012; Kutney-Lee et al., 2013; M. D. McHugh & Ma, 2013; Silber et al., 2000). Only the first admission (i.e., the index admission) was kept for each patient. The analytic sample comprised 919,601 patients. Figure 3.1 describes how many hospitals and patients met the inclusion criteria.

Figure 3.1. Included Patients and Hospitals

1. Index admission for patients in a nonfederal, acute care hospital in the four states in the fourth quarter of 2015 or 2016 with at least 10 direct care nurse survey respondents
998,355 patients, 550 hospitals

↓

2. In a hospital with at least 20 surgical patients
988,350 in 549 hospitals

↓

3. In a hospital with at least 5 surgical patients with OUD
919,601 in 448 hospitals

Study Variables and Measurement

The study sought to determine the effect of nursing resources on the outcomes of surgical patients with OUD. Nurses, hospitals, and patients were the units of observation. The unit of analysis was patients nested within hospitals. A description of variables for the study is found in Table 3.1. A summary of select study variables follows.

Table 3.1. ***Study Variables***

Category	Title	Description	Variable Type	Level	Database
Explanatory Variables	Education	Percentage of nurses with a BSN or higher	Continuous	Hospital	RN4CAST-US
	Staffing	Average number of patients per nurse	Continuous	Hospital	RN4CAST-US
	Work environment	Good, mixed, or poor based on hospital score relative to the median	Categorical	Hospital	RN4CAST-US

Outcome Variables	Length of stay	Total number of days patient spent in the hospital	Continuous	Patient	Patient Discharge Data
	In-hospital 30-day mortality	Indicator of death in the hospital within 30 days of the index admission	Dichotomous	Patient	Patient Discharge Data
	7, 30, 60, and 90-day readmission	Indicator of readmission within 7, 30, 60, and 90 days of discharge from index hospitalization	Dichotomous	Patient	Patient Discharge Data
Hospital Covariates	Bed size	0=≤100 beds 1=101-250 beds 2=≥251 beds	Categorical	Hospital	AHA Annual Survey of Hospitals
	Teaching status	0=Non-teaching 1=Minor teaching 2=Major teaching	Categorical	Hospital	AHA Annual Survey of Hospitals
	Technology status	0=Low-tech 1=High-tech	Dichotomous	Hospital	AHA Annual Survey of Hospitals
	Geographic location	0=Rural 1=Urban	Dichotomous	Hospital	AHA Annual Survey of Hospitals
Patient Covariates	OUD	Indicator of OUD diagnosis	Dichotomous	Patient	Patient Discharge Data
	Age	Age in years	Continuous	Patient	Patient Discharge Data
	Sex	0=Female 1=Male	Dichotomous	Patient	Patient Discharge Data
	Elixhauser Comorbidities	Dummy for each Elixhauser	Dichotomous	Patient	Patient Discharge Data

		comorbidity (except drug abuse)			
	Diagnosis Related Group (DRG)	Dummy for each DRG	Dichotomous	Patient	Patient Discharge Data
	Discharge Disposition	0=Routine 1=Home health care 2=Skilled nursing facility 3=Another type of facility 4=Against medical advice 5=Intermediate care 6=Died in the hospital 7=Other	Categorical	Patient	Patient Discharge Data
	Race	0=White 1=Black 2=Asian / Pacific Islander 3=Native American 4=Other	Categorical	Patient	Patient Discharge Data
	Ethnicity	0=Not Hispanic 1=Hispanic	Dichotomous	Patient	Patient Discharge Data
	Insurance status	0=Medicare 1=Medicaid 2=Private 3=Self pay 4=No charge 5=Other	Categorical	Patient	Patient Discharge Data

Explanatory Variables

Nurse Education. The RN4CAST survey asked nurses to report their highest nursing degree which was used to derive a measure of nurse education. The hospital-level average of nurses with a BSN or higher was represented as a continuous variable. A measure of nurse education was generated such that each unit increase will equate to a 10% increase in the hospital-proportion of nurses educated at the BSN level of higher.

Nurse Staffing. The measure of nurse staffing was the average patient-to-nurse ratio at the hospital-level. The RN4CAST survey includes nurse-reports of the number of patients cared for on the last shift as well as the number of nurses. The continuous staffing variable was derived from the hospital-level average of patients per nurse. Direct survey measures of staffing have been shown to be more predictive of patient outcomes than other sources (Aiken et al., 2003; Aiken et al., 2008; Aiken et al., 2002; Harless & Mark, 2010). For statistical interpretation, a one-unit increase in nurse staffing indicates an additional patient per nurse, on average, per hospital.

Nurse Work Environment. The nurse work environment is the organizational work characteristics that facilitate or constrain nursing practice (Lake, 2002). The nurse work environment was derived from the Practice Environment Scale of the Nursing Work Index-Revised (PES-NWI), a validated, 31-item measure included in the RN4CAST nurse survey (Lake, 2002; Lake et al., 2019). Nurses rate the degree to which an array of organizational characteristics are present in their current job on a Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree) (Lake, 2002). The PES-NWI has five subscales—Nurse Participation in Organization Affairs, Nursing Foundations for Quality of Care, Nurse Manager Ability, Leadership, and Support of Nurses, Staffing and Resource Adequacy, and Collegial Nurse-Physician Relations—that were each aggregated to the hospital-level. The internal consistency coefficients for the five subscales range from Cronbach's α of 0.71 to 0.84 (Lake, 2002). Hospitals were then categorized as "good" (above the median on 4 or 5 subscales), "mixed" (above the median on 2 or 3 subscales), or "poor" (above the median on only 1 or no subscales). This approach for measuring the nurse work environment has good predictive validity (Aiken et al., 2008; M. D. McHugh & Ma, 2013).

Outcome Variables

Length of Stay. Length of stay was calculated based on the number of days a patient spends in the hospital during their index hospitalization from patient discharge data. A continuous variable was generated to represent length of stay. Patients who died in the hospital or were discharged AMA were excluded from analyses of length of stay, as including those patients would mispresent the average lengths of stay for hospitals. Given that length of stay is generally right-skewed and does not include zero (i.e., patients must stay at least 1 day), this variable was analyzed using ZTNB in regression analyses (UCLA, n.d.).

Mortality. Mortality was measured based on whether patients died in the hospital within 30 days of admission during their index hospitalization. This measure was derived from patient discharge data. A dichotomous variable was created to indicate 30-day inpatient mortality as done previously (Aiken et al., 2011).

Readmission. Readmission was defined as readmission to the hospital for any cause within 7, 30, 60, or 90 days of discharge from the index hospitalization based on patient discharge data. As done previously, admission for the same condition beyond 30 days post discharge was considered another index admission; patients readmitted within 30 days were excluded to avoid double counting an admission as both an index admission and readmission (M. D. McHugh & Ma, 2013). Only patients who were discharged alive were included in readmission analyses (Lasater & McHugh, 2016). Readmission for 7, 30, 60, and 90 days were each captured via a dichotomous variable.

Hospital Covariates

Bed Size. The AHA Annual Survey was used to generate a categorical measure of bed size: small (≤100 beds), medium (101-250 beds), and large (≥251 beds). Small hospitals were the reference group.

Teaching Status. Teaching status was derived from the AHA Annual Survey and defined by the number of medical residents and fellows per hospital beds. The variable had three categories: non-teaching (no medical residents), minor teaching (1:4 or smaller trainee to bed ratio), and major teaching (higher than 1:4 trainee to bed ratio). Non-teaching hospitals were the reference group.

Technology Status. A dichotomous measure of hospital technology status was generated from the AHA Annual Survey. Hospitals were designated as high technology if they have facilities for open-heart surgery, major organ transplants, or both. Low technology hospitals (i.e., those hospitals that do not qualify as high technology hospitals) were the reference group.

Geographic location. A dichotomous measure or urban status was generated from the AHA Annual Survey. Hospitals were designed as urban (“1”) if they are designated as metropolitan and rural (“0”) if they are designated as metropolitical based on Core-Based Statistical Areas (United States Census Bureau, 2016).

Patient Covariates

OUD. Patients with OUD were identified using ICD codes as done previously (Gupta et al., 2018), though this study required cross-walking ICD codes from ICD version 9 to version 10. While OUD has been coded using ICD-9 codes (Gupta et al., 2018; Menendez, Ring, et al., 2015), ICD-10 codes have been infrequently utilized. For the purposes of the analysis, the OUD variable was dichotomized (presence vs. absence of OUD). Informed by current literature and clinical understanding, OUD was defined as having opioid abuse or dependence that is not in remission (Gupta et al., 2018; Menendez, Ring, et al., 2015; Owens et al., 2020; Weiss, Heslin, Stocks, & Owens, 2020). Table 3.2 details the specific ICD-10 codes used. We will descriptively analyze surgical

Table 3.2. ***ICD-10 Diagnosis Codes Used to Defined Opioid use Disorder (OUD)***

Opioid abuse/dependence	F11.10 F11.121 F11.122 F11.14 F11.151 F11.159 F11.181 F11.182 F11.188 F11.19 F11.20 F11.21 F11. F11.221 F11.222 F11.229 F11.23 F11.24 F11.250 F11.251 F11.259 F11.281 F11.282 F11.288 F11.29

patients with OUD.

Age. Age was derived from the patient discharge data and classified as a continuous variable ranging from 18 to 99.

Sex. Sex was derived from the patient discharge data and classified as a dichotomous variable: a value of “1” was assigned to male patients and a value of “0” was assigned to female patients.

Elixhauser Comorbidities. Elixhauser comorbidities are comorbidities (e.g., congestive heart failure, valvular disease, hypertension) derived from ICD diagnosis codes (Li, Evans, Faris, Dean, & Quan, 2008). In this study, 28 Elixhauser comorbidities (drug abuse was excluded) were used to adjust for comorbidities as done previously in similar studies of surgical patients (Aiken et al., 2002; Wiltse Nicely et al., 2013). For regression analyses, each Elixhauser comorbidity was dichotomous variable derived from the patient discharge data. For a descriptive analysis, drug abuse was included. A total descriptive comorbidity score was generated by summing the number of comorbidities for each patient (possible range: 0 to 29).

DRG. Given that variation in outcomes can result from the clinical conditions of patients (Gani et al., 2015), a dichotomous variable representing each DRG was derived from the patient discharge data. For regression analyses, each DRG was dichotomous variable derived from the patient discharge data and accounted for the presence or absence of various patient diagnoses.

Discharge Disposition. Discharge disposition was derived from the patient discharge data and represented by a categorical variable: a value of “0” was assigned to patients discharged routinely, “1” to home health care, “2” to a skilled nursing facility, “3” to another type of facility (e.g., cancer hospitals excluded from Medicare Prospective Payment System) (Medicare Learning Network, 2008), “4” for AMA, “5” for intermediate care (e.g., a nursing facility that cares for less acute patients than a skilled nursing facility) (Melis, Rikkert, Parker, & van Eijken, 2004), “6” for died in the hospital, and “7” for other (i.e., anything not captured in the other codes).

Race. Race was derived from the patient discharge data and classified as a categorical variable: a value of “0” was assigned to White patients, “1” to Black patients, “2” to Asian / Pacific Islander patients, “3” to Native American patients, and “4” to patients who identify as another race.

Ethnicity. Ethnicity was derived from the patient discharge data and classified as a dichotomous variable: a value of “1” was assigned to Hispanic patients and a value of “0” was assigned to non-Hispanic patients.

Insurance Status. Patient socioeconomic status was derived from the patient discharge data and classified as a categorical variable: “0” represented Medicare, “1” Medicaid, “2” private insurance, “3” self-pay, “4” no charge, and “5” other.

Preliminary Analyses

The feasibility of this study is supported by a statistical power analysis. The primary power analysis will focus on the moderating effect of nurse education on the relationship between having OUD and 30-day readmission for surgical patients. Diggle's method of using estimation formulas to derive sample-size for hierarchical data was employed (Diggle et al., 2002). Based on the inclusion criteria, the analytic sample includes 448 hospitals with 224 hospitals having lower than the median proportion of nurses with at least a BSN (median = 58.2%) and 217 having below the mean proportion (mean = 57.5%). There are 919,601 total surgical patients, resulting in an average of 2,053 patients per hospital, and 11,610 patients with OUD, with an average of 26 OUD patients per hospital. Hospitals have a range of 5 to 546 OUD patients, with 29 hospitals having the minimum of 5 OUD patients. Further information on the distribution of patients across hospitals can be found in Appendices A.1 and A.2. Prior literature examining 30-day readmission among surgical patients reports an overall readmission rate of 8.8%, which is the estimated readmission rate for this analysis (Gupta et al., 2018). Based on prior research conducted using this administrative data, the rho (intraclass correlation) estimate is set at 0.100, which yields the ability to detect an odds ratio (OR) for readmission as low as 1.023. Table 3.3 displays the rise of odds ratios as rho estimates increase from 0.100 to the more conservative 0.300. The power analysis was completed with PASS 16 and employed Tests for Two Proportions in a Repeated Measures Design. All other analyses conducted in this study were considered exploratory and evaluated at the p<0.05 level

Table 3.3. ***Power Analysis Results with varying Rho Estimates***

Rho	Odds Ratio
0.100	1.023
0.200	1.026
0.300	1.029

Data Analysis

The following section details the analytic procedure for this study. It reviews the construction of the final analytic data set, the analysis plan to address the study's specific aim, and sensitivity analyses. Statistical analyses were performed using STATA (Version 15.1, College Station, TX, USA). All tests were 2-sided, and a *p*-value <0.05 was considered statistically significant.

Construction of the Analytic Dataset

Data from the nurse survey were aggregated to the hospital level and merged with the AHA data via a one-to-one merge using a unique hospital identifier at the hospital level. The merged nurse and hospital survey data were then merged with the patient-level state administrative patient discharge data. The resulting dataset included hospital-level measures of nursing resources, hospital characteristics, a patient-level variable indicating the presence or absence of OUD, patient characteristics, and outcomes. Patterns and quantities of missing data were assessed, and appropriate management strategies were considered. The construction of the analytic dataset is displayed in Figure 3.2.

Figure 3.2. ***Construction of the Analytic Dataset***

RN4CAST-US	AHA Annual Survey	Patient Discharge Data
• **Hospital ID** • Nurse Education • Nurse Staffing • Nurse Work Environment	• **Hospital ID** • Bed size • Technology status • Teaching status • Geographic location	• **Hospital ID** • Opioid use disorder • Age • Sex • Comorbidities • Diagnosis Related Group • Discharge disposition • Race/ethnicity • Insurance status

Analysis Plan

Descriptive statistics. We descriptively analyzed differences in patient characteristics, hospital characteristics, nursing resources, and outcomes among surgical patients with and without OUD in the sample. For example, using ANOVAs, chi-squared tests and t-tests, we evaluated how demographics and comorbidities differed for surgical patients with compared to without OUD. We also described the most common comorbidities. We examined hospital characteristics by the distribution of all patients and patients with and without OUD. We examined whether patients with OUD are generally seen in all hospitals or whether they cluster in certain types of hospitals (e.g., better/worse staffed, urban/rural, high technology).

For categorical variables and binary outcomes, frequencies and percentages were employed. For continuous variables, means, standard deviations, and ranges were used to describe the data. T-tests were used to test for statistical significance for continuous variables while chi-square tests were used for categorical and binary variables.

Specific Aim 1. Aim 1 determined whether variations in nursing resources (i.e., education, staffing, and work environment) were associated with postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) for patients with and without OUD. Zero truncated negative binomial (ZTNB) regression was used for length of stay, as such a method is appropriate when a zero value cannot occur or there is concern for over-dispersion (UCLA, n.d.). Multiple logistic regression was used for in-hospital 30-day mortality and 7, 30, 60, and 90-day readmission. These regressions modeled associations and accounted for clustering of individual patients within hospitals. Bivariate models of each nursing resource on each outcome were conducted separately. No covariates were included in this analysis to provide a baseline understanding of the likelihood of the outcome in relation to a sole predictor variable (i.e., nurse education, staffing, or work environment). These unadjusted models estimated the independent effects of each of the primary predictor variables on the outcomes without controlling for the other primary predictor variable. Unadjusted models that included interactions between each nursing resource and having OUD were also estimated.

Sequential multivariate models incorporating patient, hospital, and nursing characteristics were utilized. Building the models sequentially enabled identification of the extent to which each level of analysis impacts each outcome. In some models, the effects of nursing resources were modeled jointly so that the effect of primary predictor variables (i.e., one of the three nursing resources) on the outcome controlled for the patient and hospital covariates in addition to adjusting for the effects of each other.

A final model introducing an interaction term was used to test the significance of the hypothesized effect of each nursing resource on outcomes for surgical patients with OUD. This approach is informative because it also provided the effect of each nursing resource on outcomes for surgical patients with vs. without OUD, thus allowing for relative comparisons of the effects of nursing resources for different populations. Evaluating interactions allowed for the determination of whether the effects of nursing resources differed or were conditional for patients with OUD, compared to the overall sample and those without OUD. For example, a significant direct effect of patients-per-nurse staffing (theoretical odds ratios of 1.10) as well as a significant interaction between staffing and OUD status of the patient (theoretical odds ratio of 1.15) would suggest that while staffing is important for surgical patients without OUD, the effect is more pronounced among surgical patients with OUD. Each continuous nursing resource variable was centered to facilitate interpretation of interactions.

1. $Y = \beta_0 + \beta_1 M + \beta_2 P + \beta_3 H + \beta_4 N + \beta_5 I + \varepsilon$ (Eq.1).
    a. *Y* is either the continuous outcome (length of stay) or the logit transformation of the binary (in-hospital 30-day mortality or 7, 30, 60, or 90-day readmission).
    b. β_0 is the intercept term in the regression
    c. *M* is the main independent variable of having OUD
    d. *P* is patient characteristics (age, sex, each Elixhauser comorbidity (except drug abuse), DRG, race/ethnicity, insurance status)
    e. *H* is hospital characteristics (bed size, teaching status, technology status, urban/rural status)
    f. *N* is nursing resources (education, staffing, work environment)
    g. I represents a dummy variable for the interaction between each nursing resource variable and having OUD
    h. ε is the residual

Sensitivity Analyses

Sensitivity analyses were performed to evaluate the effect of other potentially influential factors on postsurgical outcomes for patients with OUD. They examined the effect of various patient (e.g., transferred in status) and hospital (e.g., state) characteristics. Given the high rate of discharge AMA among surgical patients with OUD and the increased risk of readmission among patients discharged AMA (Garland et al., 2013; Olufajo et al., 2016; Simon et al., 2019), the adjusted models were also conducted excluding patients discharged AMA.

Limitations

A limitation of this study is that it cannot assess causation, though research has documented that cross-sectional associations between nursing resources and patient outcomes closely approximate longitudinal panel findings (Sloane et al., 2018). Additionally, the definition of OUD is not consistent across the literature and has been infrequently reported using ICD-10 codes. This study was among the first studies to examine OUD using ICD-10 codes. The study does not capture whether a patient was on opioids or medication for OUD prior to or during hospitalization, medications that are known to impact outcomes (Barocas et al., 2021; Mark & Parish, 2019). It also does not capture more granular aspects of clinical care delivery that impact postsurgical outcomes for patients with OUD like pain and withdrawal management or addiction medicine consultation (Desai et al., 2018; Marks et al., 2019; Moreno et al., 2019).

Furthermore, the impacts of nursing resources may be larger than this study is able to detect. Using Elixhauser comorbidities for risk adjustment may lessen the impact of nursing resources on outcomes. Lastly, the use of patient discharge abstracts for this study—data that exist primarily for billing and administrative purposes—may lack information that coders deems not likely to affect reimbursement, even though such information could be relevant for this study. Therefore, the lack of detail may impact risk adjustment and potentially underestimate postsurgical adverse outcomes. Given that this limitation biases results towards the null, it need not be addressed because doing so would only lead to stronger evidence about the contribution of nursing resources on postsurgical outcomes for patients with OUD.

Protection of Human Subjects

This study is a cross-sectional, secondary data analysis employing nurse survey, hospital, and patient data from four states: California, Florida, New Jersey, and Pennsylvania. Aggregated and de-identified data from RN4CAST-US were used to measure nurse education, staffing, and the work environment. Administrative data including from the AHA Annual Survey and state discharge abstracts from the four states were used. Only data from the fourth quarter of 2015 and all quarters of 2016 were used. The RN4CAST-US nurse survey was conducted as part of the approved parent study, *Panel Study of Effects of Changes in Nursing on Patient Outcomes* (IRB protocol 819470; LH Aiken, PI). The protocol was renewed on December 17, 2018 in compliance with University of Pennsylvania’s policies.

CHAPTER 4: RESULTS

Introduction

This chapter presents the findings from this study. We begin by describing the characteristics of hospitals and patients in the sample. The hypothesis of the study was that better nursing resources would be associated with lower likelihood of adverse postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) for all surgical patients and particularly for surgical patients with compared to without OUD.

Sample Characteristics

Patient Characteristics

Table 4.1 presents descriptive characteristics of the patient sample. The final analytic sampled included 919,601 surgical patients, of whom 11,610 (1.3%) had OUD. On average, patients in the sample were 63 years old (SD 16), with patients with OUD averaging 54 years old (SD 15) compared to 64 years old (SD 16) for patients without OUD (*p*-value <0.001). Less than half (45.5%) of the overall sample was male; over half (50.7%) of surgical patients with OUD were male compared to 45.5% of surgical patients without OUD (*p*-value <0.001). While one in 10 (10.7%) patients overall were insured by Medicaid, 28.3% of surgical patients with OUD and 10.5% of surgical patients without OUD had such insurance (*p*-value <0.001). In the overall sample, most patients (79.7%) were White (83.7% and 79.7% for surgical patients with and without patients OUD, respectively; *p*-value <0.001), 9.8% were Black (9.7% and 9.8%; *p*-value = 0.695), 3.2% were Asian American or Pacific Islander (3.2% vs. 0.8%; *p*-value <0.001), 0.2% were Native American (0.4% and 0.2%; *p*-value <0.001), and 7.1% were another race (5.5% and 7.1%; *p*-value <0.001). Nearly one in seven (13.4%) patients were Hispanic, compared to 11.2% of surgical patients with OUD and 13.4% of surgical patients without OUD (*p*-value <0.001).

Most of the overall sample (51.7%) comprised orthopedic surgery patients, followed by general (35.6%) and vascular (12.7%) surgery patients. Compared to those without OUD, surgical patients with OUD were more often undergoing orthopedic (54.7% vs. 52.7%, *p*-value <0.001) and general (37.9% vs. 35.5%, *p*-value <0.001) surgery, and less often undergoing vascular surgery (7.4% vs. 12.8%, *p*-value <0.001). Regarding discharge disposition, compared to surgical patients without OUD, those with OUD were less often discharged routinely (43.1% vs. 47.9%, *p*-value <0.001) and more often discharged AMA (3.9% vs. 0.5%, *p*-value <0.001).

Comorbidities derived from Elixhauser's comorbidity index are shown in Table 4.1. Of note, while over half (58.8%) of the surgical patients without OUD had hypertension, less than half (49.2%) of the surgical patient with OUD subsample did (*p*-value <0.001). All surgical patients with OUD had drug abuse as a comorbidity, while the prevalence of drug abuse among surgical patients without OUD is only 1.2% (*p*-value <0.001). Additionally, while 3.4% of surgical patients without OUD had alcohol abuse, over one in ten surgical patients with

OUD had that comorbidity (p-value <0.001). Compared to surgical patients without OUD, a greater proportion of surgical patients with OUD had psychoses (9.2% vs. 2.4%, p-value <0.001) and depression (25% vs. 11.5%, p-value <0.001) as comorbidities.

Regarding outcomes, while the average length of stay for surgical patients without OUD was 5.1 days, surgical patients with OUD had an average length of stay of 8.1 days (p-value <0.001). Surgical patients with OUD less often suffered 30-day inpatient mortality (0.7%) compared to patients in the overall sample (0.9%) (p-value = 0.008). Surgical patients with OUD, however, experienced higher rates of readmissions than patients in the overall sample at 7 (5.7% vs. 3.9%), 30 (15.8% vs. 9.9%), 60 (22.6% vs. 13.8%), and 90 (27.5% vs. 16.8%) days (all readmission p-values <0.001). Further information on the distribution of outcomes across hospitals is displayed in Appendices B.1 through B.6.

<u>Table 4.1</u>. *Patient Characteristics in Overall Sample and by Opioid Use Disorder (OUD) Status*

n (%)	All patients (n= 919,601)	Patients with OUD (n=11,610)	Patients without OUD (n=907,991)	*p*-value*
Demographics				
Age (years), mean (SD)	63.3 (16.3)	53.6 (15.2)	63.4 (16.3)	<0.001
Age group (years)				
18-44	121,422 (13.2)	3,194 (27.5)	118,228 (13)	<0.001
45-54	123,991 (13.5)	2,481 (21.4)	121,510 (13.4)	<0.001
55-64	204,034 (22.2)	3,180 (27.4)	200,854 (22.1)	<0.001
65-74	230,034 (25.1)	1,829 (15.6)	228,549 (25.2)	<0.001
75-84	160,228 (17.4)	711 (6.1)	159,517 (17.6)	<0.001
85-99	79,548 (8.7)	215 (1.9)	79,333 (8.7)	<0.001
Male	418,592 (45.5)	5,880 (50.7)	412,712 (45.5)	<0.001
Transferred in	26,160 (2.8)	404 (3.5)	25,756 (2.8)	<0.001
Race				
White	772,583 (79.7)	9,606 (83.7)	712,977 (79.7)	<0.001
Black	88,744 (9.8)	1,108 (9.7)	87,636 (9.8)	0.695
Asian American/Pacific Islander	28,517 (3.2)	90 (0.8)	28,427 (3.2)	<0.001
Native American	1,959 (0.2)	44 (0.4)	1,915 (0.2)	<0.001
Other	64,494 (7.1)	626 (5.5)	63,868 (7.1)	<0.001
Hispanic ethnicity	121,123 (13.4)	1,279 (11.2)	119,844 (13.4)	<0.001
Insurance Status				
Medicare	488,165 (53.8)	4,914 (43.1)	483,251 (53.9)	<0.001
Medicaid	97,416 (10.7)	3,234 (28.3)	94,182 (10.5)	<0.001
Private	271,181 (29.9)	2,215 (19.4)	268,966 (30)	<0.001
Self-pay	20,012 (2.2)	546 (4.8)	19,466 (2.2)	<0.001
No charge	3,865 (0.4)	131 (1.2)	3,734 (0.4)	<0.001
Other	27,651 (3)	370 (3.2)	27,281 (3)	0.253
Discharge Disposition				
Routine	439,965 (47.8)	5,004 (43.1)	434,861 (47.9)	<0.001
Home health care	225,522 (24.5)	2,806 (24.2)	222,716 (24.5)	0.371
Skilled nursing facility	177,847 (19.3)	2,331 (20.1)	175,516 (19.3)	0.043
Another type of facility	56,023 (6.1)	793 (6.8)	55,230 (6.1)	0.001
Against medical advice	4,649 (0.5)	454 (3.9)	4,195 (0.5)	<0.001

Intermediate care	1,617 (0.2)	41 (0.4)	1,576 (0.2)	<0.001
Died in the hospital	8,616 (0.9)	86 (0.7)	8,530 (0.9)	<0.001
Other	212 (0.02)	11 (0.1)	201 (0.02)	0.085
Surgical Group				
General Surgery	326,924 (35.6)	4,404 (37.9)	322,520 (35.5)	<0.001
Orthopedic Surgery	475,612 (51.7)	6,345 (54.7)	469,267 (51.7)	<0.001
Vascular Surgery	117,065 (12.7)	861 (7.4)	116,204 (12.8)	<0.001
Elixhauser Comorbidities				
Total number, mean (SD)	2.4 (1.9)	3.9 (2)	2.4 (1.9)	<0.001
Congestive heart failure	48,452 (5.3)	672 (5.8)	47,780 (5.3)	0.012
Valvular disease	37,773 (4.1)	332 (2.9)	37,441 (4.1)	<0.001
Pulmonary circulation disorders	4,609 (0.5)	91 (0.8)	4,518 (0.5)	<0.001
Peripheral vascular disorders	64,079 (7)	770 (6.6)	63,309 (7)	0.153
Hypertension	539,790 (58.7)	5,710 (49.2)	534,080 (58.8)	<0.001
Paralysis	18,585 (2)	369 (3.2)	18,216 (2)	<0.001
Other neurological disorders	57,570 (6.3)	1,069 (9.2)	56,501 (6.2)	<0.001
Chronic pulmonary disease	151,089 (16.4)	2,826 (24.3)	148,263 (16.3)	<0.001
Diabetes, uncomplicated	135,269 (14.7)	1,041 (9)	134,228 (14.8)	<0.001
Diabetes, complicated	88,531 (9.6)	1,315 (11.3)	87,216 (9.6)	<0.001
Hypothyroidism	125,079 (13.6)	1,389 (12)	123,690 (13.6)	<0.001
Renal failure	98,484 (10.7)	1,011 (8.7)	97,473 (10.7)	<0.001
Liver disease	37,201 (4.1)	1,305 (11.2)	35,896 (4)	<0.001
Peptic ulcer disease	8,774 (1)	158 (1.4)	8,616 (1)	<0.001
AIDS	1,830 (0.2)	91 (0.8)	1,739 (0.2)	<0.001
Lymphoma	4,584 (0.5)	62 (0.5)	4,522 (0.5)	0.584
Metastatic cancer	25,811 (2.8)	236 (2)	25,575 (2.8)	<0.001
Solid tumor without metastasis	14,623 (1.6)	144 (1.3)	14,479 (1.6)	0.002
Rheumatoid arthritis/collagen vascular disorders	30,837 (3.4)	649 (5.6)	30,188 (3.3)	<0.001
Obesity	160,841 (17.5)	2,018 (17.4)	158,823 (17.5)	0.756
Weight loss	36,460 (4)	965 (8.3)	35,495 (3.9)	<0.001
Chronic blood-loss anemia	11,050 (1.2)	167 (1.4)	10,883 (1.2)	0.018
Deficiency anemias	140,049 (15.2)	2,449 (21.1)	137,600 (15.2)	<0.001
Alcohol abuse	32,000 (3.5)	1,221 (10.5)	30,779 (3.4)	<0.001
Drug abuse	22,660 (2.5)	11,610 (100)	11,050 (1.2)	<0.001
Psychoses	22,999 (2.5)	1,066 (9.2)	21,933 (2.4)	<0.001

Depression	105,335 (11.5)	2,906 (25)	102,429 (11.3)	<0.001
Coagulopathy	39,397 (4.3)	736 (6.3)	38,661 (4.3)	<0.001
Fluid and electrolyte disorders	163,554 (17.8)	2,984 (25.7)	160,570 (17.7)	<0.001
Outcomes				
Length of stay	5.1 (5.8)	8.1 (11.3)	5.1 (5.7)	<0.001
In-hospital 30-day mortality	8,107 (0.9)	76 (0.7)	8,031 (0.9)	0.008
7-day readmission	34,749 (3.9)	653 (5.7)	34,096 (3.8)	<0.001
30-day readmission	85,291 (9.9)	1,727 (15.8)	83,564 (9.8)	<0.001
60-day readmission	114,062 (13.8)	2,338 (22.6)	111,724 (13.7)	<0.001
90-day readmission	130,635 (16.8)	2,663 (27.5)	127,972 (16.6)	<0.001

Note: *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. *p-value <0.05; **p-value <0.01; ***p-value <0.001.

Hospital Characteristics

Table 4.2 presents descriptive statistics of the overall hospital sample (n=448). About three-fifths of hospitals in the sample were large (i.e., >250 beds) (58.3%) and high technology (60.5%). Most (59%) were teaching hospitals, with 47.5% having minor and 11.5% having major teaching status. Hospitals were distributed across all four states, with 39.7% of hospitals in California, 30.4% in Florida, 19.2% in Pennsylvania, and 10.7% in New Jersey. Nearly all (96.9%) hospitals were in urban areas. The average number of patients with OUD per hospital was 25.9 (SD 35).

Regarding nursing resources hospitals' nursing workforces were mostly (mean 57.5%, SD 14.5%) comprised of BSN-prepared nurses. The average number of patients-per-nurse at the hospital level was 4.3 (SD 0.9). By definition, 25% of hospitals had poor work environments, 50% had mixed, and 25% had good.

Table 4.2. ***Sample Hospital Characteristics***

n (%)	All hospitals (n=448)
Bed size	
Small (≤100)	19 (4.2)
Medium (101-250)	168 (37.5)
Large (>250)	261 (58.3)
Teaching status	
Non-teaching	179 (41.1)
Minor Teaching	207 (47.5)
Major Teaching	50 (11.5)
Technology Status	
High	266 (60.5)
State	
California	178 (39.7)
Florida	136 (30.4)
Pennsylvania	86 (19.2)
New Jersey	48 (10.7)
Urban	
	434 (96.9)
% nursing with a BSN or higher, mean (SD)	
	57.5 (14.5)
Patients per nurse, mean (SD)	
	4.3 (0.9)
Nurse Work Environment	
Poor	112 (25)
Mixed	224 (50)
Good	112 (25)
Average Number of Patients with OUD, mean (SD)	
	25.9 (35)

Abbreviations: n = number; SD = standard deviation. **Note**: Work environment was measured by the PES-NWI excluding the staffing and resource adequacy subscale. Poor are were hospitals in the bottom 25%, mixed work environments are the middle 50%, and good work environments are the top 25% of hospitals.

Hospital Characteristics in Overall Patient Sample and by OUD Status

Table 4.3 shows the distribution of all surgical patients across hospitals with varying characteristics. Also displayed is the distribution of surgical patients with and without OUD across hospitals. Some differences exist between where surgical patients with and without OUD received care. Most patients with (74.7%) and without (75.7%) OUD were cared for in large hospitals (*p*-value <0.001). While 58.1% of patients with OUD received care in teaching hospitals, over three-fifths (62.2%) of patients without OUD received care in such settings (*p*-value <0.001). Most patients with (73.1%) and without (74.1%) OUD were cared for in high technology hospitals (*p*-value = 0.019) in urban settings (98.3% and 98.8% of patients with and without OUD, respectively; *p*-value <0.001). On average, the hospital-level percentage of nurses with a BSN was not statistically different for patients with (60.2%, SD 13.8%) vs. without (60.1%, SD 14.1) OUD (*p*-value = 0.4597). Compared to patients without OUD, patients with OUD were cared for in hospitals with slightly fewer patients per nurse on average (4.2 [SD 0.8] vs. 4.3 [SD 0.8]; *p*-value <0.001). While 32.6% of patients with OUD were cared for in hospitals with good nurse work environments, 31.1% of surgical patients without OUD were cared for in such environments (*p*-value <0.001).

Table 4.3. ***Hospital Characteristics in Overall Sample and by OUD Status***

n (%)	All patients (n= 919,601)	Patients with OUD (n=11,610)	Patients without OUD (n=907,991)	*p*-value*
Bed size				<0.001
Small (≤100)	15,043 (1.6)	303 (2.6)	14,740 (1.6)	
Medium (101-250)	108,933 (22.7)	2,633 (22.7)	206,300 (22.7)	
Large (>250)	695,625 (75.6)	8,674 (74.7)	686,951 (75.7)	
Teaching status				<0.001
Non-teaching	342,438 (37.8)	4,805 (42)	337,633 (37.8)	
Minor Teaching	402,077 (44.4)	4,290 (37.5)	397,787 (44.5)	
Major Teaching	160,433 (17.7)	2,356 (20.6)	158,077 (17.7)	
Technology Status				0.019
High	672,510 (74)	8,403 (73.1)	664,107 (74.1)	
State				<0.001
California	325,659 (35.4)	4,994 (43)	320,665 (35.3)	
Florida	303,227 (33)	4,040 (34.8)	299,187 (33)	
New Jersey	101,742 (11.1)	893 (7.7)	100,849 (11.1)	
Pennsylvania	188,973 (20.6)	1,683 (14.5)	187,290 (20.6)	
Urban				<0.001
Yes	908,514 (98.8)	11,410 (98.3)	897,104 (98.8)	
% nursing with a BSN or higher				0.4597
Mean (SD)	60.1 (14.1)	60.2 (13.8)	60.1 (14.1)	
Patients per nurse				<0.001
Mean (SD)	4.3 (0.8)	4.2 (0.8)	4.3 (0.8)	
Nurse Work Environment				<0.001
Poor	175,908 (19.1)	1,945 (16.8)	173,963 (19.2)	
Mixed	457,268 (49.7)	5,878 (50.6)	451,390 (49.7)	
Good	286,425 (31.2)	3,787 (32.6)	282,638 (31.1)	

Abbreviations: n = number; SD = standard deviation. **Note**: Work environment was measured by the PES-NWI excluding the staffing and resource adequacy subscale. Poor are were hospitals in the bottom 25%, mixed work environments are the middle 50%, and good work environments are the top 25% of hospitals. *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. **p*-value <0.05; ***p*-value <0.01; ****p*-value <0.001.

Specific Aim Results

Table 4.4 presents the analysis for Aim 1. For binary outcomes, logistic regression models were utilized to generate ORs. For the continuous outcome of length of stay, ZTNB was used to generate the incidence rate ratio (IRR). The first model determined the unadjusted relationship between variables (e.g., OUD, nurse education, nurse staffing, and the nurse work environment) and outcomes (i.e., length of stay, 30-day in-hospital 30-day mortality, and 7-, 30-, 60-, and 90-day readmission). Subsequent models stepped in interactions between OUD and each nursing resource, as well as direct effects of patient and hospital characteristics. Each subsequent model included the variables in the prior model.

Specific Aim 1. To determine whether variations in nursing resources (i.e., education, staffing, and work environment) were associated with disparities in postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) between patients with and without OUD.

Hypothesis 1: We hypothesized that better nursing resources would be associated with lower likelihood of adverse postsurgical outcomes among all patients and that these effects would be more pronounced for patients with compared to without OUD.

<u>Table 4.4</u>. ***7, 30, 60, and 90-day Readmission, In-hospital 30-day Mortality, and Length of Stay, Adjusting for Clusters of Patient, Hospital, and Nursing Characteristics***

	Model 1	Model 2	Model 3	Model 4
	7-day readmission			
	OR (95% CI)			
OUD	1.53*** (1.40-1.67)	-	-	-
Education	0.98 (0.95-1.01)	-	0.95*** (0.92-0.97)	0.95** (0.93-0.98)
Staffing	0.98 (0.95-1.01)	-	1.02 (0.99-1.04)	1.00 (0.98-1.03)
WE	0.96 (0.93-0.99)	-	0.96** (0.93-0.98)	0.97* (0.94-0.99)
OUD x Education	-	0.90 (0.81-1.01)	0.89* (0.79-0.99)	0.89* (0.79-0.99)
OUD x Staffing	-	1.14* (1.02-1.26)	1.13* (1.01-1.26)	1.13* (1.01-1.26)
OUD x WE	-	1.13 (0.99-1.28)	1.09 (0.96-1.24)	1.09 (0.95-1.23)
	30-day readmission			
	OR (95% CI)			
OUD	1.73*** (1.62-1.85)	-	-	-
Education	0.99 (0.96-1.02)	-	0.94*** (0.92-0.96)	0.95*** (0.93-0.97)
Staffing	0.98 (0.96-1.01)	-	1.03* (1.00-1.05)	1.01 (0.99-1.04)
WE	0.97 (0.94-1.00)	-	0.96** (0.94-0.99)	0.97* (0.95-1.00)
OUD x Education	-	0.90** (0.83-0.97)	0.88** (0.81-0.95)	0.88** (0.81-0.95)
OUD x Staffing	-	1.09* (1.01-1.18)	1.09* (1.01-1.18)	1.09* (1.01-1.18)
OUD x WE	-	1.06 (0.97-1.17)	1.04 (0.95-1.15)	1.04 (0.95-1.15)
	60-day readmission			
	OR (95% CI)			
OUD	1.83*** (1.72-1.95)	-	-	-
Education	0.98 (0.95-1.01)	-	0.94*** (0.92-0.96)	0.95*** (0.92-0.97)
Staffing	0.99 (0.96-1.02)	-	1.03** (1.01-1.06)	1.02 (1.00-1.04)
WE	0.97 (0.94-1.00)	-	0.96** (0.94-0.99)	0.98 (0.95-1.00)
OUD x Education	**-**	0.93* (0.86-1.00)	0.91* (0.84-0.98)	0.91* (0.84-0.98)
OUD x Staffing	**-**	1.05 (0.98-1.12)	1.05 (0.99-1.13)	1.05 (0.99-1.13)
OUD x WE	**-**	1.04 (0.95-1.13)	1.01 (0.93-1.10)	1.01 (0.93-1.10)
	90-day readmission			
	OR (95% CI)			
OUD	1.90*** (1.79-2.01)	-	-	-
Education	0.99 (0.96-1.02)	-	0.94*** (0.92-0.96)	0.95*** (0.92-0.97)

Staffing	0.99 (0.96-1.02)	-	1.03** (1.01-1.06)	1.02 (1.00-1.04)
WE	0.98 (0.95-1.01)	-	0.97* (0.94-0.99)	0.98 (0.95-1.01)
OUD x Education	**-**	0.92* (0.87-0.99)	0.90** (0.84-0.96)	0.90** (0.84-0.96)
OUD x Staffing	**-**	1.04 (0.98-1.11)	1.06 (0.99-1.13)	1.06 (0.99-1.13)
OUD x WE	**-**	1.08 (1.00-1.16)	1.05 (0.98-1.14)	1.05 (0.97-1.14)
	30-day in-hospital mortality			
	OR (95% CI)			
OUD	0.74* (0.59-0.93)	-	-	-
Education	0.99 (0.94-1.05)	-	0.95 (0.89-1.00)	0.97 (0.91-1.03)
Staffing	0.97 (0.93-1.01)	-	1.04 (0.99-1.09)	1.02 (0.97-1.07)
WE	0.90*** (0.86-0.95)	-	0.88*** (0.83-0.92)	0.88*** (0.84-0.93)
OUD x Education	-	1.03 (0.72-1.48)	1.00 (0.70-1.42)	1.01 (0.71-1.44)
OUD x Staffing	-	0.94 (0.69-1.29)	0.97 (0.69-1.35)	0.98 (0.70-1.37)
OUD x WE	-	0.91 (0.65-1.26)	0.87 (0.62-1.22)	0.87 (0.62-1.21)
	Length of Stay			
	IRR (95% CI)			
OUD	1.69*** (1.63-1.76)	-	-	-
Education	1.03* (1.01-1.06)	-	0.98** (0.96-0.99)	0.98* (0.97-1.00)
Staffing	0.97* (0.95-0.99)	-	1.01 (1.00-1.02)	1.01 (0.99-1.02)
WE	0.99 (0.97-1.02)	-	0.98** (0.96-0.99)	0.98* (0.97-1.00)
OUD x Education	-	1.04 (0.99-1.09)	1.01 (0.97-1.05)	1.01 (0.97-1.05)
OUD x Staffing	-	1.01 (0.96-1.06)	1.01 (0.98-1.05)	1.01 (0.98-1.05)
OUD x WE	-	1.01 (0.95-1.07)	0.99 (0.95-1.03)	0.99 (0.96-1.03)

Models: 1 = Unadjusted; 2 = Unadjusted Interaction of OUD and Education, Staffing and Work Environment (separately); 3 = Adjusted for Hospital and Patient Characteristics (jointly); 4 = Model 3 + Education, Staffing, and Work Environment. Each model accounts for clustering of patients within the 448 hospitals.

Number of patients. Models predicting readmission exclude patients who died in the hospital. Models predicting length of stay exclude patents who died in the hospital or were discharged AMA. Sample sizes vary due to missing data. 7-day readmission = 903,585 (Models 1 & 2); 847,278 (Models 3 & 4). 30-day readmission = 866,088 (Models 1 & 2); 812,552 (Models 3 & 4). 60-day readmission = 824,030 (Models 1 & 2); 773,587 (Models 3 & 4). 90-day readmission = 778,864 (Models 1 & 2); 731,583 (Models 3 & 4). Length of stay = 914,952 (Models 1 & 2); 857,808 (Models 3 & 4). In-hospital 30-day mortality = 919,601 (Models 1 & 2); 776,185 (Models 3 & 4).

Abbreviations: n = number; SD = standard deviation; WE = work environment; CI = confidence interval; OR = odds ratio; IRR = incidence rate ratio. **Notes**: Hospital characteristics include bed size, teaching status, technology status, and urban status. Patient characteristics include age, sex, each Elixhauser comorbidity (except drug abuse), each Medicare Severity Diagnosis Related Groups (MS-DRGs), race, ethnicity, insurance status, and discharge disposition. Specific contributions not shown due to space. Nurse education represents a 10% increase in the percentage of nurses with a baccalaureate degree in a hospital. Staffing represents an additional patient per nurse. Work environment is categorized as poor, mixed, and good. The odds ratio reflects the change in work environment from poor to good. Work environment was created from PES-NWI and excludes the staffing and resource adequacy subscale. *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. *p-value <0.05; **p-value <0.01; ***p-value <0.001.

Model 1 Results

For the analysis of the aim, we first tested the unadjusted relationship between variables of interest (e.g., OUD, nurse education, nurse staffing, and the nurse work environment) and outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7-, 30-, 60-, and 90-day readmission) in Model 1. We hypothesized that having OUD would be associated with longer lengths of stay and higher odds of mortality and readmission at all time points. We also hypothesized that each nursing resource would be positively associated with patient outcomes. We found significant unadjusted associations between having OUD and longer lengths of stay, as well as having OUD and lower odds of in-hospital 30-day mortality and readmission at 7, 30, 60, and 90 days. The associations between having OUD and outcomes held when adjusting for patient and hospital characteristics (Appendix C). We also found significant relationships between better nurse education and longer lengths of stay, as well as better nurse staffing and shorter lengths of stay and better work environments and lower odds of in-hospital 30-day mortality. In the unadjusted, bivariate Model 1, none of the nursing resources were significantly associated with readmission at any time point.

Model 2 Results

We next examined the interaction effect of OUD with each nursing resource not controlling for any other characteristics in Model 2. We hypothesized that improvements in each nursing resource would be associated with improvements in postsurgical outcomes for patients with OUD. We found that each additional patient per nurse was associated with increased odds of 7- (OR 1.14, *p*-value = 0.018) and 30-day (OR 1.09, *p*-value = 0.027) readmission and that each 10% increase in the proportion of BSN-educated nurses was associated with lower odds of 60- (OR 0.93, *p*-value = 0.039) and 90- (OR 0.92, *p*-value = 0.018) day readmission for surgical patients with OUD.

Model 3 Results

Model 3 displays direct effect and interaction findings after jointly adjusting for hospital and patient characteristics, while not adjusting for the other two nursing resources. We hypothesized that improvements in each nursing resource would be associated with better postsurgical outcomes for all patients, with even more profound effects for patients with compared to without OUD.

Nurse Education. In Model 3, we found that each 10% increase in the proportion of BSN-educated nurses was associated with shorter lengths of stay (IRR 0.98, *p*-value 0.003). Each 10% increase was also associated with lower odds of readmission at 7 (OR 0.95, *p*-value <0.001), 30 OR 0.94, *p*-value <0.001), 60 (OR 0.94, *p*-value <0.001), and 90 (OR 0.94, *p*-value <0.001) days for all surgical patients, and this effect of BSN on readmission was especially strong for surgical patients with OUD. Interacting nurse education and OUD yielded significant findings for 7- (OR 0.89, *p*-value = 0.035), 30- (OR 0.88, *p*-value = 0.001), 60- (OR 0.91, *p*-value = 0.012), and 90- (OR 0.90, *p*-value = 0.003) day readmission. After multiplying the OR of the direct effect of nurse education by the OR of the interaction, we found that each 10% increase in the proportion of BSN-educated nurses was associated with even lower odds of readmission for surgical patients with compared to without OUD (i.e., 15% lower odds for 7-day readmission; 17% for 30-day readmission; 14% for 60-day readmission; and 15% for 90-day readmission). These findings suggest that being cared for in hospitals with higher proportions of baccalaureate educated nurses is associated with reduced odds of readmissions for surgical patients generally, and that this relationship is even stronger for patients with OUD.

Nurse Staffing. Similar results were found for the relationship between nurse staffing and readmission in Model 3. We found that each additional patient-per-nurse was associated with significantly higher odds of readmission at 30 (OR 1.03, *p*-value = 0.016), 60 (OR 1.03, *p*-value = 0.005), and 90 (OR 1.03, *p*-value = 0.006) days for all surgical patients, but that this effect of nurse staffing on readmission was disproportionately strong for surgical patients with OUD at 7 and 30 days. Interacting nurse staffing and OUD yielded significant findings for 7- (OR 1.13, *p*-value = 0.031) and 30- (OR 1.09, *p*-value = 0.024) day readmission. After multiplying the OR of the direct effect of nurse staffing by the OR of the interaction, we found that each additional patient-per-nurse was associated with even higher odds of readmission for surgical patients with OUD (i.e., 15% higher odds for 7-day readmission and 12% for 30-day readmission) than for surgical patients without OUD. These findings suggest that being cared for in hospitals with more patients-per-nurse is associated with higher odds of readmissions for surgical patients at 30, 60, and 90 days, and that this readmission effect is also present for surgical patients with OUD at 7 and 30 days.

Nurse Work Environment. Also in Model 3, we found that with each categorical increase in the quality of the work environment (i.e., poor to mixed or mixed to good), patients experienced shorter length of stays (IRR 0.98, *p*-value = 0.004), and lower odds of in-hospital 30-day mortality (OR 0.88, *p*-value <0.001), 7-day readmission (OR 0.96, *p*-value = 0.002), 30-day readmission (OR 0.96, *p*-value = 0.002), 60-day readmission (OR 0.96, *p*-value = 0.007), and 90-day readmission (OR 0.97, *p*-value = 0.015). The work environment did not have an impact on outcomes for patients with OUD.

Model 4 Results

The most robustly adjusted model was introduced in Model 4. Model 4 was the same as Model 3 but additionally controlled for the two nursing resources that were not part of the interaction term. The margin plots showing the predicted probabilities of outcomes for the significant interactions in Model 4 are displayed in Figures 4.1 through 4.6.

Figure 4.1: Predicted probability of 7-day readmission for surgical patients with and without OUD at varying percentages of BSN nurses

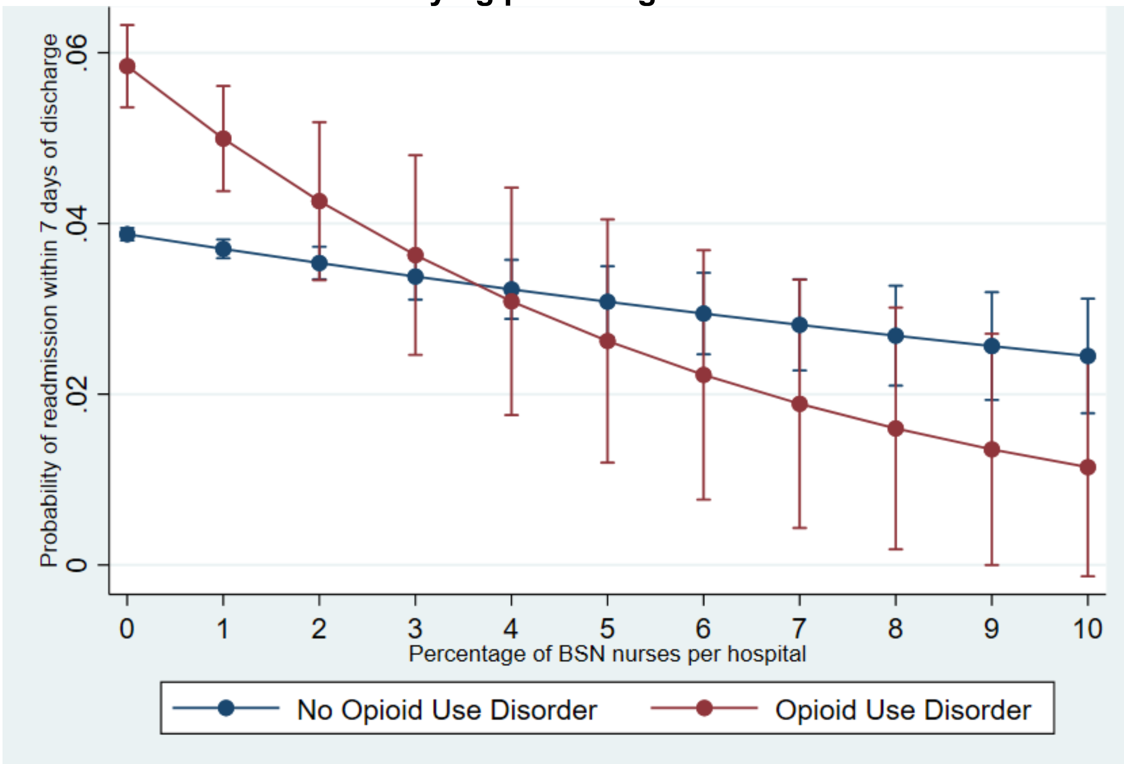
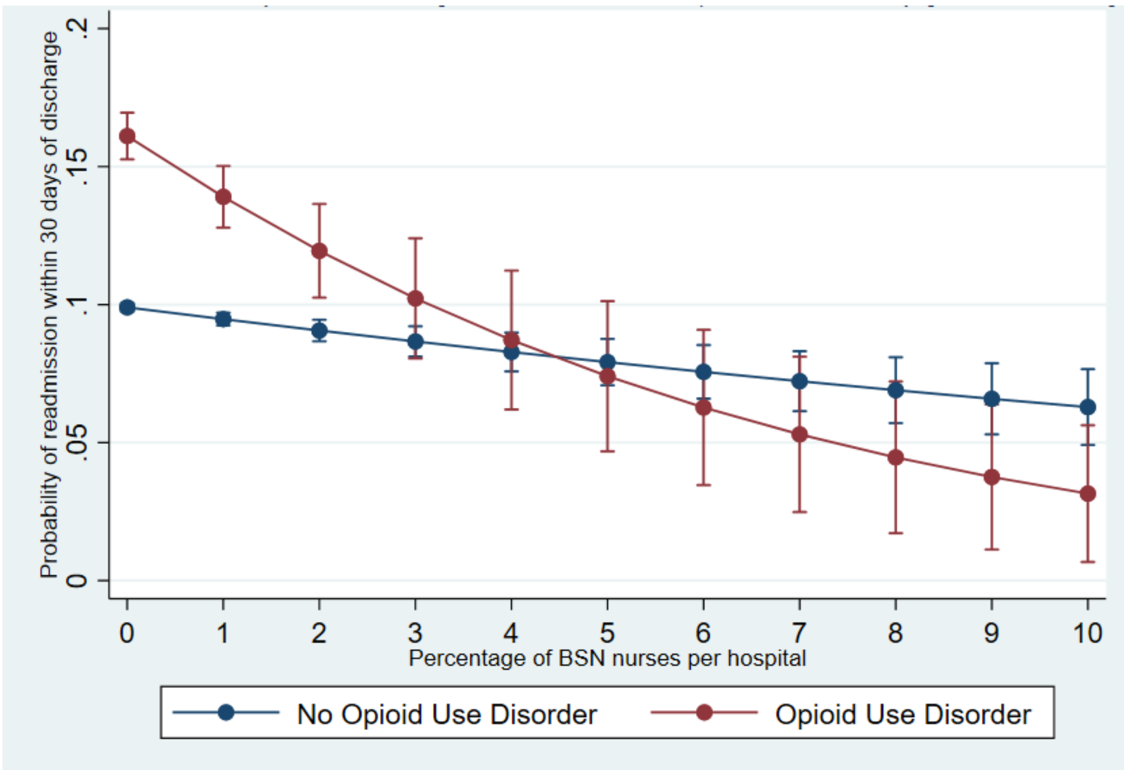


Figure 4.2: Predicted probability of 30-day readmission for surgical patients with and without OUD at varying percentages of BSN nurses:



Probability of readmission within 30 days of discharge
0
.05
.1
.15
.2
0
1
2
3
4
5
6
7
8
9
10
Percentage of BSN nurses per hospital
No Opioid Use Disorder
Opioid Use Disorder

Figure 4.3: Predicted probability of 60-day readmission for surgical patients with and without OUD at varying percentages of BSN nurses:

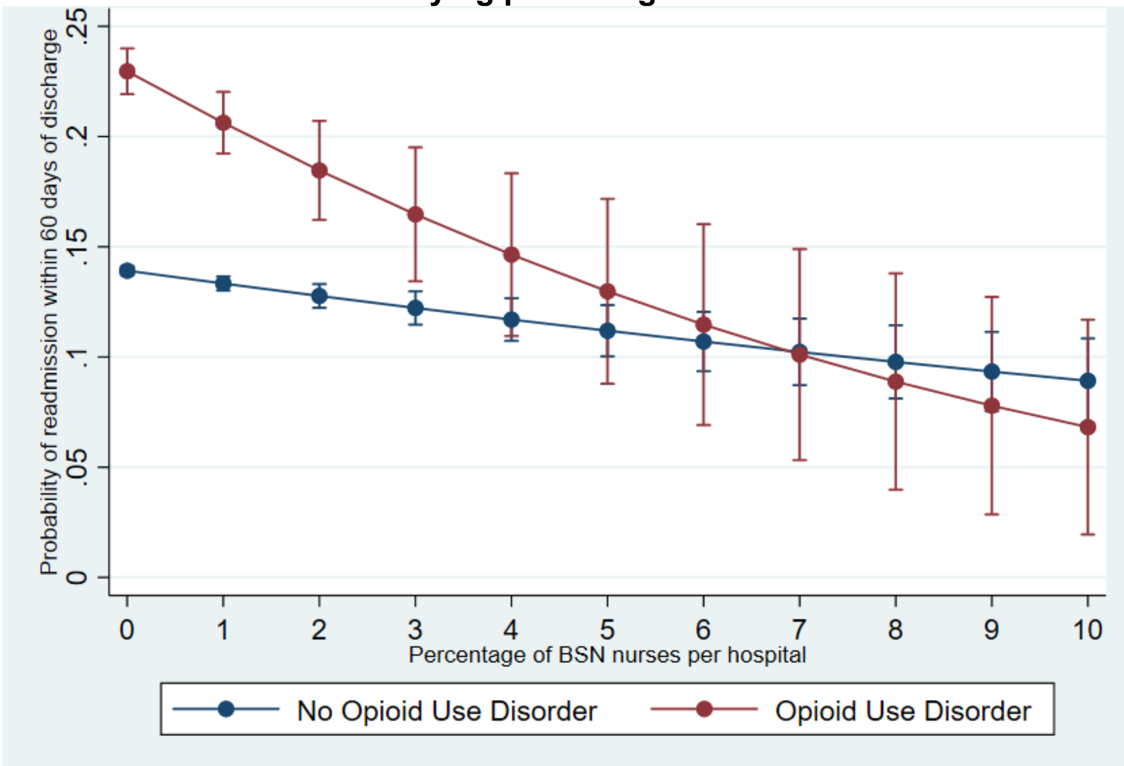


Figure 4.4: Predicted probability of 90-day readmission for surgical patients with and without OUD at varying percentages of BSN nurses:

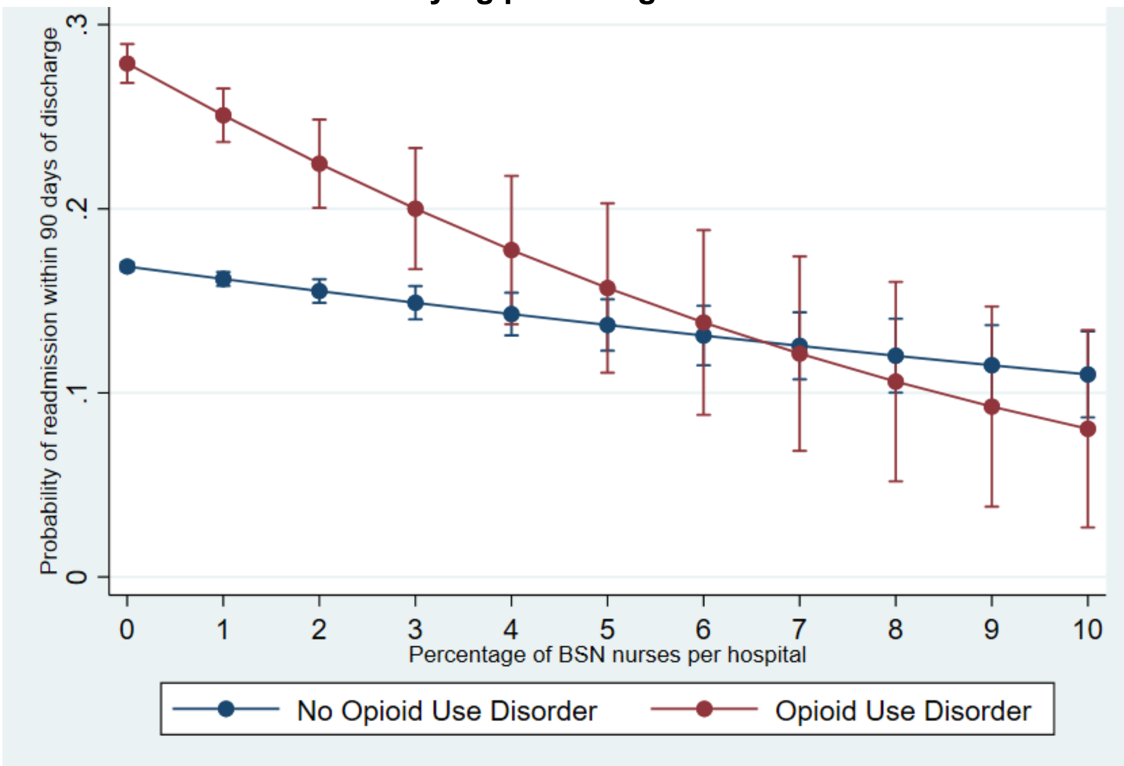


Figure 4.5: Predicted probability of 7-day readmission for surgical patients with and without OUD at varying patient-to-nurse staffing levels:

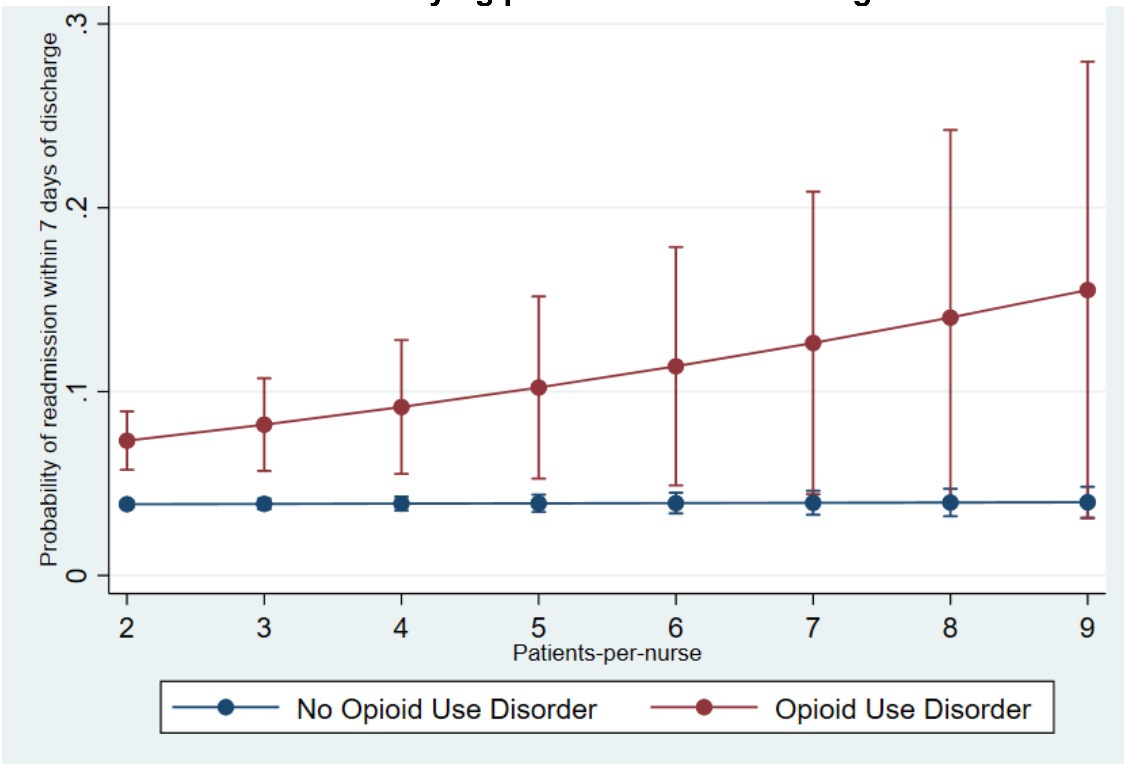
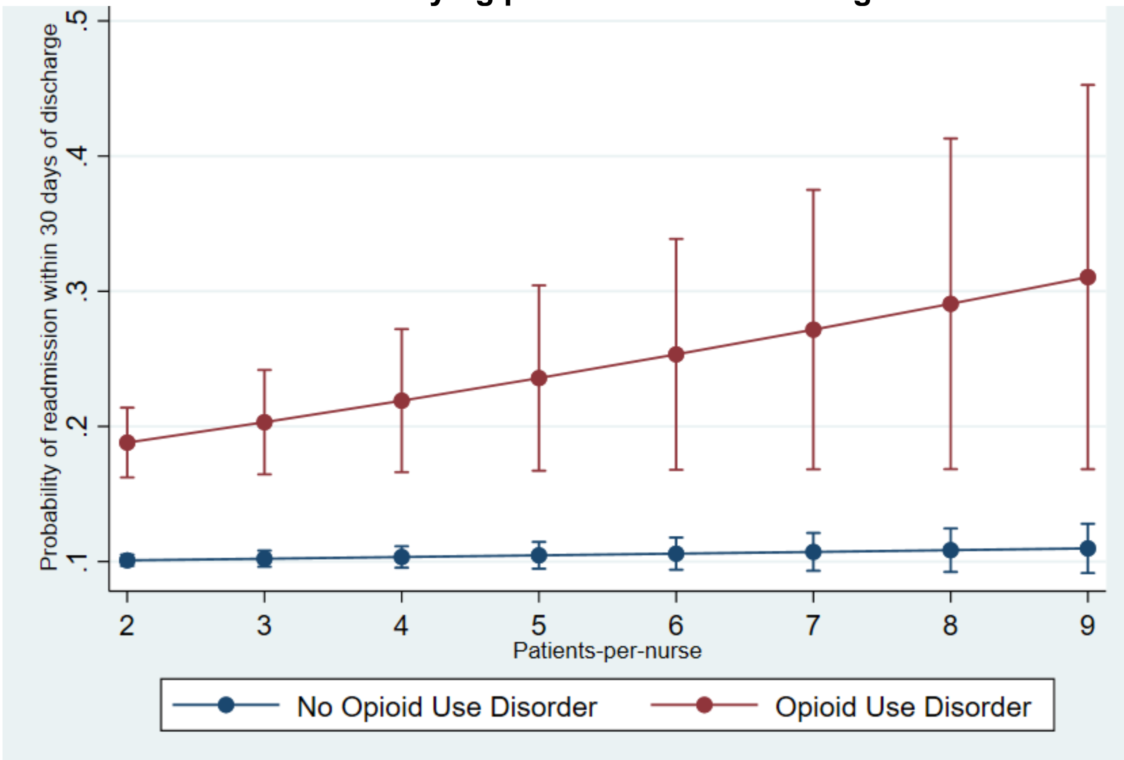


Figure 4.6: Predicted probability of 30-day readmission for surgical patients with and without OUD at varying patient-to-nurse staffing levels:



Nurse Education. Like in Model 3, we found that each 10% increase in the proportion of BSN-educated nurses was associated with shorter lengths of stay for all surgical patients. We also found lower odds of readmission at 7, 30, 60, and 90 days for all surgical patients with each 10% increase, and that this effect on readmission was stronger for surgical patients with OUD. In Model 4, interacting nurse education and OUD again yielded significant findings for 7-, 30-, 60-, and 90-day readmission. After multiplying the OR of the direct effect of nurse education by the OR of the interaction, we found that each 10% increase in the proportion of BSN-educated nurses was associated with even lower odds of readmission for surgical patients with OUD (i.e., 15% lower odds for 7-day readmission; 16% for 30-day readmission; 14% for 60-day readmission; and 14% for 90-day readmission) than for surgical patients without OUD. These findings suggest that being cared for in hospitals with higher proportions of baccalaureate educated nurses is associated with reduced odds of readmissions for surgical patients, including those with OUD.

Nurse Staffing. We again examined the relationship between nurse staffing and readmission in Model 4. While there was a significant direct effect of nurse staffing on 30-, 60-, and 90-day readmission for all patients in Model 3, these relationships were no longer significant in Model 4 once adjusting for nurse education and the work environment. We continued to find, however, that the effect of nurse staffing on readmission was present for surgical patients with OUD at 7 and 30 days. Interacting nurse staffing and OUD yielded significant findings for 7- (OR 1.13, *p*-value = 0.032) and 30- (OR 1.09, *p*-value = 0.025) day readmission. After multiplying the OR of the direct effect of nurse staffing by the OR of the interaction, we found that each additional patient-per-nurse was associated with higher odds of readmission for surgical patients with OUD (i.e., 13% higher odds for 7-day readmission and 10% for 30-day readmission). These findings suggest that being cared for in hospitals with more patients-per-nurse is associated with higher odds of readmissions surgical patients with OUD at 7 and 30 days.

Nurse Work Environment. In Model 4, the impact of the work environment on length of stay, in-hospital 30-day mortality, and 7- and 30-day readmission was similar to that in Model 3. There was no longer a significant direct effect of the work environment on 60 or 90-day readmission, however. Like in Model 3, the work environment was not associated with outcomes for patients with OUD.

CHAPTER 5: DISCUSSION

Introduction

The opioid and overdose crisis is an epidemic that has profound implications for healthcare delivery (G. H. Jones, Bruera, et al., 2018; Sharfstein & Olsen, 2019). Prior research documents that having OUD increases the risk of poor outcomes like readmission for hospitalized patients, including those undergoing surgery (Dewan et al., 2019; Gupta et al., 2018; Menendez, Ring, et al., 2015). These findings may be partially explained by where patients with OUD receive care, specifically if they are cared for in hospitals with poorer nursing resources.

We found that being cared for in hospitals with lower proportions of baccalaureate educated nurses and more patients per nurse accounts for some of the disparity in readmission risk between surgical patients with and without OUD. Figures 4.1 through 4.4 showing the predicted probabilities of 7-, 30-, 60-, and 90-day readmission at varying percentages of BSN nurses reveal how surgical patients with OUD have lower predicted odds of readmission than those without OUD when cared for in hospitals where BSN nurses account for at least 40% (7-day readmission), 45% (30-day readmission), 70% (60-day readmission), and 68% (90-day readmission) of the nursing workforce. Figures 4.5 and 4.6 reveal how each additional patient per nurse further perpetuates the disparity between outcomes for surgical patients with and without OUD. The implications of these findings are clear: hospital administrators and policymakers must ensure that patients are receiving care in settings that best support optimal outcomes for all patients, and especially those already at risk of poorer outcomes like those with OUD. Being readmitted threatens all patients' quality of life. For patients with OUD, being readmitted means being at higher risk of unmanaged pain or withdrawal during hospitalization, a life-threatening overdose post discharge, and lost income that may be vital to life stability (Barocas et al., 2021; Casey et al., 2008; Donroe et al., 2016; Segel, Shi, Moran, & Scanlon, 2019; Small, 2001). For other vulnerable populations like those with complex chronic diseases, being re-hospitalized can lead the loss of autonomy, diminished participation in meaningful activities, mental health challenges, and threats to financial stability (Kuluski et al., 2014).

For surgical patients with OUD to receive optimal care, hospitals must prioritize having a strong educational composition of the nursing workforce as well as manageable workloads for nurses. Seminal reports like "To Err is Human" and "Crossing the Quality Chasm" highlight the importance of systems in determining patient care quality and safety (A. Baker, 2001; Donaldson, Corrigan, & Kohn, 2000), thus revealing how hospitals can mitigate disparities that exist across populations. While literature repeatedly details the relationship between having OUD and poor patient outcomes (Dewan et al., 2019; Gupta et al., 2018; Menendez, Ring, et al., 2015; Wilson et al., 2019), little attention has been given to the role of system factors in this relationship, and particularly nursing resources.

Building on what is known about the relationship between bolstered nursing resources and improved postsurgical patient outcomes, our study filled a gap by considering the relationship between nursing resources (i.e., education, staffing, and the work environment) and patient outcomes known to be worse for surgical patients with compared to without OUD (i.e., length of stay, mortality, and readmission) (Aim 1). By considering nursing resources known to be associated with postsurgical outcomes for all patients as well as vulnerable patient subgroups (Aiken et al., 2003; Aiken et al., 2008; Kutney-Lee & Aiken, 2008; Lasater & McHugh, 2016; White et al., 2018), we are able to propose a solution that can mitigate the disparity in outcomes among hospitalized surgical patients with OUD: improve the education composition of the nursing workforce and improve nurse staffing levels. We know what needs to be done. What we need is the will from hospital administrators and policymakers to act on this empirical evidence.

Discussion of Principal Findings

The goal of this study was to determine whether variations in nursing resources (i.e., education, staffing, and work environment) were associated with disparities in postsurgical outcomes (i.e., length of stay, in-hospital 30-day mortality, and 7, 30, 60, and 90-day readmission) between patients with and without OUD (Aim 1). We hypothesized that better nursing resources would be associated with lower likelihood of adverse postsurgical outcomes among all patients and that these effects would be more pronounced for patients with compared to without OUD. Consistent with prior literature, we found that having OUD is associated with adverse outcomes and that, in the most robustly adjusted models, nursing resources (i.e., education and the work environment) were associated with better outcomes for all patients. We also identified a relationship between better nurse education (higher proportions of BSN nurses) and staffing (fewer patients per nurse) and lower odds of readmission that was particularly pronounced for surgical patients with OUD. Associations between the nurse work environment and outcomes were not detected for surgical patients with OUD.

In Model 4, a 10% increase in the proportion of nurses educated at the BSN level was associated with a 14-17% lower odds of readmission at 7, 30, 60, and 90 days for surgical patients with OUD, compared to only 5% lower odds for all surgical patients. For surgical patients with OUD, each additional patient per nurse was associated with 13% and 9% higher odds of 7- and 30-day readmission, respectively. The staffing effect for patients with OUD is stronger for 7- than 30-day readmission, and does not exist for 60- and 90-day readmission, suggesting that better nurse staffing may allow nurses to provide care that is key to success in the first days following discharge like thorough discharge teaching.

As hypothesized, all patients cared for in hospitals with higher proportions of nurses educated at the BSN level have better outcomes (i.e., lower rates of readmission and shorter lengths of stay), but surgical patients with OUD particularity benefited from receiving care in hospitals with more BSN nurses with respect to readmission. The strong associations between nurse education and nurse staffing with the odds of readmission suggest that readmissions for surgical patients with OUD can further be reduced by promoting better nurse education and staffing in hospitals. Evidence suggests that these approaches are also key to improving outcomes for all surgical patients (Aiken et al., 2003; Aiken et al., 2002; Aiken et al., 2014). Receiving care in hospitals where BSN educational preparation is valued and there are enough nurses to provide high quality patient care could have profound impacts on postsurgical readmissions for patients with OUD. While improving nurse education and staffing can serve as a targeted approach for hospital administrators seeking to reduce readmission risk for surgical patients with OUD, this approach is also general and thus may positively impact all patients.

Some findings warrant comment. For example, in the unadjusted Model 1, each 10% increase in the proportion of nurses educated at the BSN level was associated with a longer length of stay (IRR = 1.03, *p*-value = 0.018). This finding is no longer significant in models that adjust for patient and hospital characteristics, suggesting that those factors impact length of stay. Additionally, our findings in Model 4 are not consistent with evidence that documents the association between nurse staffing and postsurgical outcomes (Aiken et al., 2002; Kutney-Lee & Aiken, 2008; Lasater & McHugh, 2016). We did find a significant relationship between nurse staffing and 30-, 60-, and 90-day readmission in Model 3 that adjusts for patient and hospital characteristics but not nurse education and the work environment. The lack some significant nurse staffing findings in adjusted models may have to do with the interrelated nature of nurse staffing and the work environment (Aiken et al., 2011). As such, we found that a change in the nurse work environment from poor to mixed or mixed to good was associated with a 12% decreased odds of mortality and a decreased length of stay (IRR 0.98, *p*-value = 0.028) for all patients, findings consistent with literature showing the importance of good work environments for patient outcomes (Aiken et al., 2011; Brom et al., 2021). The work environment was not differentially associated with outcomes for surgical patients with OUD, though future work with more granular detail about the care surgical patients with OUD received (e.g., medication for OUD, addiction medicine consult) should examine this question.

The finding that the effect of nursing staffing on 30-, 60-, and 90-day readmission for all surgical patients observed in Model 3 (all ORs = 1.03) was no longer significant in Model 4 that additionally controlled for nurse education and the work environment suggests that these two organizational features may partially account for the relationship between nurse staffing and readmission. In the adjusted models that examined the relationships between nursing staffing and odds of readmission for all patients, both nurse education (OR = 0.95, *p*-value <0.001) and the work environment (OR = 0.97, *p*-value 0.042) were found to significantly impact 30-day readmission. For all surgical patients, only nurse education was significantly associated 60- and 90-day readmission (ORs = 0.95, *p*-values <0.001) in adjusted models controlling for nurse resources, as well as patient and hospital characteristics. Taken in conjunction with evidence documenting that better nurse staffing most improves patient outcomes in hospitals with good work environments, our findings suggest that simultaneously addressing multiple nursing resources can reduce the risk of readmission for surgical patients (Aiken et al., 2011).

Important to note are the distinct characteristics of surgical patients with OUD. Consistent with existing literature, we found that patients with OUD are disproportionally insured by Medicaid compared to those without OUD (28.3% vs. 10.5%, *p*-value <0.001) (Dewan et al., 2019; Orgera & Tolbert, 2019). This finding may have implications for accessing specialty care, like for OUD treatment (Orgera & Tolbert, 2019). We also found that a greater proportion of patients with OUD were White (83.7% vs 79.7%, p-value <0.001) and a slightly smaller proportion were Black (9.7% vs. 9.8%, p-value = 0.695). Depending on the sample, the literature varies with respect to the racial composition of hospitalized patients with OUD, but it is clear that opioid-related deaths have risen more steeply among Blacks in recent years revealing the changing demographics of who is impacted by the opioid and overdose crisis (Scholl et al., 2019).

Also of note is that mental health conditions like psychoses (9.2% vs. 2.4%, *p*-value <0.001) and depression (25% vs. 11.5%, *p*-value <0.001) were more common among surgical patients with than without OUD, confirming what is known about the increased prevalence of mental health conditions among those with OUD (Heslin, Elixhauser, & Steiner, 2006; Rubenstein, Grace, Croci, & Ward, 2018). This finding is particularly salient given that better nurse education and staffing mitigates poor postsurgical outcomes among patients with comorbid serious mental illness (Kutney-Lee & Aiken, 2008). For patients with mental health conditions, high quality nursing care may be even more important than for the general population, as such care can facilitate identification and treatment of these conditions. Additionally, compared to surgical patients without OUD, alcohol abuse was more common among those with OUD (10.5% vs. 3.4%, *p*-value <0.001). As the literature documents, we found that surgical patients with OUD were more often discharged AMA than those without OUD (3.9% vs. 0.5%, *p*-value <0.001) (Simon et al., 2019). Given the relatively large percentage of surgical patients with OUD who were discharged AMA, the characteristics of the 4,649 patients discharged AMA can be found in Appendix D.

Whether patients with OUD are over- or under-represented in certain hospitals must be considered. Therefore, we examined the characteristics of hospitals based on the average number of patients with OUD cared for. Appendix E details these findings. In general, hospitals in the 4^{th} (i.e., highest number of patients with OUD) compared to 1^{st} (i.e., lowest number of patients with OUD) quartile were more often large, high technology, in California or Florida, and less often minor or major teaching hospitals. Regarding nursing resources, hospitals in the 4^{th} compared to the 1^{st} quartile had on average more nurses educated at the BSN level, fewer patients per nurse, and better nurse work environments. These findings confirmed the importance of controlling for many hospital characteristics, as well as nursing resources, in adjusted models, though we were not able to capture differences in community-based OUD resources that may impact post-discharge care. We did not control for state in the main analysis given that it is unclear what such a control would actually be measuring given that there should not be inherent differences in hospital care by state. When we controlled for state in a sensitivity analysis, the effect of nurse education on readmission for the overall sample was no longer significant suggesting BSN education and state may be corelated.

Given the high rate of discharge AMA for patients with OUD and the known association between being discharged AMA and readmission (Garland et al., 2013; Olufajo et al., 2016; Simon et al., 2019), we performed a sensitivity analyses in which we excluded patients discharged AMA. We found that the effect of nurse education on postsurgical readmission for patients with OUD remained at 30, 60, and 90 days. The association of nurse staffing on postsurgical readmissions was no longer present, suggesting that the impact of nurse staffing is particularly strong for surgical patients with OUD who are discharged AMA. Future work should explore this area further. These findings also help to inform how to target clinical and policy interventions in hospitals where the greatest number of surgical patients with OUD receive care.

Limitations

The limitations of this study deserve comment. First, given the cross-sectional nature of our data, we are unable to make causal inferences. A recent analysis of panel data using data from 2006 and 2016, however, found that cross-sectional associations of nursing resources with patient outcomes were sustained over time (Sloane et al., 2018). The associations found between nursing resources (i.e., education and staffing) and postsurgical readmission risk for patients with OUD would likely remain over time, but future work should consider this longitudinal relationship.

Second, in-hospital 30-day mortality is not an optimal mortality measure given that it does not capture deaths that occur following discharge. This measure may be biased by hospitals' discharge patterns, inappropriately suggesting lower rates for hospitals who transfer patients earlier on in their hospital stay or prematurely discharge patients to reduce their length of stay. Given that we did not find a relationship between nursing resources and in-hospital 30-day mortality for surgical patients with OUD, this limitation does not notably impact our study findings. On the contrary, our findings may not be capturing an association between nursing resources and mortality for this population that may in fact exist. Future research should include more robust mortality measures.

As is conventional in health services research, we examined outcomes that are time-constrained and accessible in administrative data like readmission and mortality. Given the time limited nature of the outcomes, we were not able to capture prolonged challenges for patients with OUD following discharge, like the ability to work or engage with loved ones. We were unable to directly measure more granular features of hospital care, like pain or withdrawal management, the prescription of medication for OUD, or receiving a consultation from addiction medicine. These features are known to impact the risk of readmission for hospitalized patients with OUD (Desai et al., 2018; Marks et al., 2019; Moreno et al., 2019). The approach taken in this study, however, has profound advantages like allowing for the evaluation of the association between objective patient outcomes that have implications for hospitals and nursing resources for surgical patients with OUD — a question previously unexplored. We also performed sensitivity analyses controlling for additional patient and hospital characteristics. We found that the adjusted results remained when we controlled for whether patients were transferred in from another hospital.

A limitation of this work is how OUD was defined. While OUD has been studied using administrative data, its definition using ICD codes is inconsistent across the literature (Gupta et al., 2018; Menendez, Ring, et al., 2015; Owens et al., 2020; Weiss et al., 2020). For example, an April 2020 Statistical Brief #256 published by the Healthcare Cost and Utilization Project (HCUP) identified OUD using ICD-10 codes for opioid abuse/dependence, opioid use, opioid poisoning, opioid-related adverse effects, and long-term use of opiates (Weiss et al., 2020). Statistical Brief #258 published by HCUP in May 2020 defined opioid-related inpatient stays using slightly different ICD-10 codes, excluding opioid dependence, in remission, and long-term (current) use of opiate analgesic (Owens et al., 2020). These HCUP definitions of OUD, however, are broad and capture conditions like long-term use of opiates which is not synonymous with a use disorder. Much of the published literature focuses on opioid abuse and dependence, though these conditions have been defined using ICD-9 codes (Gupta et al., 2018; Menendez, Ring, et al., 2015). Informed by current literature and clinical understanding, for this study, OUD was defined as having opioid abuse or dependence that is not in remission (Gupta et al., 2018; Menendez, Ring, et al., 2015; Owens et al., 2020; Weiss et al., 2020), thus allowing for comparisons with published literature about outcomes including readmission and mortality for surgical patients with OUD (Gupta et al., 2018; Menendez, Ring, et al., 2015).

Additionally, OUD is inconsistently identified and charted by clinicians during a hospital stay, resulting in inconsistent ICD coding of OUD (Heslin et al., 2017). For example, clinicians and medical coders at hospitals where identifying and addressing OUD is a priority (Englander et al., 2019; Marks et al., 2019; Priest, Lovejoy, Englander, Shull, & McCarty, 2020; Wakeman, Metlay, Chang, Herman, & Rigotti, 2017) may more often document OUD than those at hospitals less focused on addressing OUD-specific needs. Clearer guidelines for the coding of OUD are necessary to ensure the accurate assessment and treatment of those with OUD (Lagisetty et al., 2021). Such guidelines would also ensure that patients with chronic pain or long-term opiate use are appropriately differentiated from those with OUD so that they may receive evidence-based care for their condition (Hser et al., 2017; Young et al., 2020).

Implications

Our work provides an actionable solution for hospital administrators and policymakers seeking to mitigate disparities in outcomes between surgical patients with and without OUD: bolster nursing education and nurse staffing. The needs of patients with OUD have long been ignored in hospital settings, resulting in poorer outcomes. The unique contribution of this study is the evaluation of system factors that, in conjunction with clinical and quality improvement efforts to improve care for patients with OUD, can be employed to improve the outcomes of all surgical patients and particularly those with OUD.

In the most robustly adjusted models, nurse education was found to impact the odds of readmission for surgical patients with OUD at 7, 30, 60, and 90 days, and nurse staffing was found to impact odds of readmission at 7 and 30 days. The prolonged impact of BSN education on readmission is a relatively novel finding and should inform future research questions about the relationship between nurse education and readmission. Also worthy of consideration in future work is the relationship between other nursing resources and 7-day readmission, as recent evidence documented the relationship between better work environments and 7-day readmission (Brom et al., 2021). Interesting to note is that the nurse staffing effect for surgical patients with OUD was stronger for 7- than 30-day readmission. This finding indicates that adequate nurse staffing levels facilitate smoother transitions from hospital to home—an effect that is most apparent within the first week following discharge.

When considering findings from this study, important to consider is what a better educated nursing workforce is capturing. For example, does something in the BSN curriculum prepare a nursing workforce that is better equipped to provide high quality patient care, or do hospitals who preferentially hire BSN nurses have other supports in place that facilitate better care? While the answer to this question remains opaque, it is important to consider this question and the implications of preferentially hiring BSN nurses on the nursing profession. Associates or diploma nursing programs may eliminate barriers (e.g., cost, time) to BSN programs, and care must be taken to ensure that preferentially hiring BSN nurses does not prevent people historically and currently underrepresented in nursing, like people of color and people from economically disadvantaged backgrounds, from being part of the profession of nursing (Williams, Bourgault, Valenti, Howie, & Mathur, 2018). When preferentially hiring BSN nurses, hospitals should also partner with BSN programs, including Baccalaureate Completion Programs (Clark, 2004), to ensure accessibly and support the education of a diverse nursing workforce (Porat-Dahlerbruch, 2021).

The process by which improved nurse staffing may reduce postsurgical readmission risk for patients with OUD also warrants further exploration. More time spent with patients may mean that nurses are better able to meet their OUD-specific needs. For example, unmanaged pain or withdrawal may cause patients with OUD to leave the hospital AMA, thus increasing their risk of readmission (Choi et al., 2011; Garland et al., 2013; Simon et al., 2019). If nurses have the time to identify and address pain and withdrawal with an interdisciplinary team, patients will be more likely to have a routine discharge and less likely to be readmitted (Choi et al., 2011; French et al., 2020; Simon et al., 2019). Additionally, better nurse staffing is associated with less missed nursing care, including care that is directly relevant for patients with OUD like pain management and discharge preparation (French et al., 2020; Lake et al., 2020). Better nurse staffing has direct implications for clinicians working with all patients, and especially patients with OUD.

Improving nurse education and staffing are actionable, evidence-based mechanisms for addressing outcome disparities among patients with OUD, but hospital-based interventions aimed at improving the outcomes of these patients should also be employed. Given the strong evidence base for initiating medication for OUD such as buprenorphine, methadone, and naltrexone during hospitalization, hospital-based interventions aimed at such initiation have proliferated in recent years (Englander et al., 2019; Marks et al., 2019; Priest et al., 2020; Wakeman et al., 2017). Addiction Medicine Consultation models also are gaining traction in hospital settings and often feature additional services like managing in-hospital withdrawal, providing psychosocial addiction treatment, and facilitating linkage to post-discharge care (Marks et al., 2019; Wakeman et al., 2017). Additionally, given the well-documented stigma of healthcare providers towards people who use drugs and its impact on care delivery and outcomes, stigma reduction campaigns should also be championed by hospitals (Biancarelli et al., 2019; Muncan, Walters, Ezell, & Ompad, 2020; Paquette, Syvertsen, & Pollini, 2018; Van Boekel, Brouwers, Van Weeghel, & Garretsen, 2013). Hospital interventions addressing OUD-specific needs have the potential to synergize with system-level interventions known to have a disproportionally positive impact on outcomes of surgical patients with OUD (i.e., improving nurse education and staffing), thus presenting opportunities for hospital administrators to operationalize findings from this study along with other empirical evidence.

Alongside these clinical and system-level interventions, federal policy reform is also needed to address the ongoing needs of hospitalized patients amidst the opioid and overdose crisis. Notably, policy is needed to increase the availability of substance use services which would allow for more people to access treatment for OUD prior to hospitalization for a medical or surgical condition and would also better facilitate post discharge connection to OUD treatment following hospitalization. Specific policy action that could increase access to needed services includes relaxing federal regulations on methadone, creating aligned incentives for payors and providers to offer effective OUD treatment, and ensuring that the Biden administration's decision to eliminate the X-waiver, a waiver previously needed to prescribe buprenorphine, is meaningfully implemented and acted upon by providers now eligible to prescribe this life-saving medication. The elimination of this hurdle also means that the nurse practitioner and physician assistant workforce that was disproportionately burdened by X wavier requirements now has even greater potential to be a key lever for expanding equitable access to evidence-based OUD treatment. Secondly, ensuring access to and coverage of effective pain management for all people, including those with OUD, is urgently needed. Profound racial disparities in pain treatment must also be addressed (Meghani, Byun, & Gallagher, 2012; Ringwalt, Roberts, Gugelmann, & Skinner, 2015). Federal policies to ensure the equitable distribution of funds from pharmaceutical settlements and to promote harm reduction strategies, like increasing access to naloxone and safe injection supplies through mailing, are also needed.

Also important to consider is the current policy context related to OUD. Given that OUD can stem from the misuse of prescription opioids, 33 states have implemented limits for new opioid prescriptions (Lowenstein et al., 2019; National Conference of State Legislatures, 2017). Florida, New Jersey, and Pennsylvania have all passed such legislation, while California has not (National Conference of State Legislatures, 2017). In Florida, legislation that was implemented in 2018 mandates that first-time opioid prescriptions cannot exceed 3 days for acute pain (Hincapie-Castillo, Goodin, Possinger, Usmani, & Vouri, 2020). New Jersey similarly implemented legislation in 2017 that limits new opioid prescriptions for acute pain to 5 days (Lowenstein et al., 2019). Pennsylvania's legislation enacted in 2017 limits the duration of new opioid prescriptions to 7 days for patients receiving care in emergency departments, urgent care, or in observation status in a hospital, but opioid prescriptions for acute pain are not directly limited (Pennsylvania Department of Health, 2017).

Additionally, many states—including Florida and Pennsylvania—currently mandate the use of Prescription Drug Monitoring Programs (PDMP) systems that track controlled substance prescriptions. Similar legislation will be enacted in California in 2022 and has been proposed in Florida (DrFirst, 2020).

Pennsylvania's PDMP system was introduced in August 2016, which may have contributed to the decrease in prescription opioid-related deaths in the fourth quarter of 2016 (Mirigian, Hendrick, Pringle, & Zemaitis, 2018). Florida's PDMP was implemented in September 2011 as part as comprehensive opioid legislation and was associated a modest decrease in opioid prescribing and use (Rutkow et al., 2015). These policy efforts reveal the multifaceted approach to addressing the ongoing opioid and overdose crisis, some of which span the time period of this study. As such, it is essential to interpret findings from this study in the context of what is known about national and state legislation.

Efforts aimed at reducing disparities in access to and the treatment of people with OUD are tantamount. While the opioid epidemic has historically been associated with White, middle-class suburban and rural communities, opioid-related deaths have risen more steeply among Blacks in recent years, and this trend has only been exacerbated by the COVID-19 pandemic (Khatri et al., 2021; Scholl et al., 2019). Furthermore, Black individuals have less access to evidence-based OUD treatment presenting access challenges (James & Jordan, 2018; Wu, Zhu, & Swartz, 2016). The ongoing lack of attention to the impact of the opioid and overdose crisis in communities of color perpetuates the long history of racism in the United States and is consistent with a history of criminalizing Black individuals with OUD instead of providing evidence-based care (James & Jordan, 2018). Intentionally and thoughtfully increasing access to treatment and evidence-based harm reduction efforts of racialized and minoritized groups is one way to address the long-ignored health needs of Black people amidst the opioid and overdose crisis. Also important to note is that this study was made possible by interest in OUD from the research community and prominent funders; we must be careful to ensure that our findings actively mitigate racial disparities that exist.

Directions for Future Research

This cross-sectional study about the relationships between nursing resources and postsurgical outcomes for patients with OUD serves as a foundation for future work that should consider this relationship over time to support causality. While this study focused on surgical patients given well established risk adjustment for this population, future studies should examine the relationship between nursing resources and outcomes for other groups of hospitalized patients with OUD, particularly those with commonly co-occurring medical conditions with OUD like endocarditis or osteomyelitis (Barocas et al., 2021; Marks et al., 2019; Weiss et al., 2020). Future work should also examine how nursing resources may be associated with other common adverse outcomes for hospitalized patients with OUD, like discharge AMA. Considering the interaction between insurance type and discharge disposition is also important, given that having Medicaid and being discharged AMA are common among patients with OUD (Dewan et al., 2019; Simon et al., 2019).

While prior research has documented the positive impact of nurse staffing on surgical patient outcomes, we did not find such a relationship in the most robustly adjusted models (Aiken et al., 2003; Aiken et al., 2002; Brooks Carthon et al., 2012; Lasater & McHugh, 2016). We did, however, find a significant effect of nurse staffing on 30-, 60-, and 90-day readmission for all patients in Model 3 when not controlling for nurse education and the work environment. We also found that better nurse staffing was associated with lower odds of 7- and 30-day readmission for surgical patients with OUD, signaling the importance of bolstered nurse staffing for patients with historically unmet needs. Given these findings and that research documents that better nurse staffing has the greatest impact on outcomes in hospitals with good work environments (Aiken et al., 2011), future research should consider the relationship between nurse staffing and other nursing resources on surgical patient outcomes.

Our findings provide strong empirical evidence about the importance of nurse education for postsurgical outcomes for patients with OUD, but future work should consider the impact of other factors known to influence outcomes for hospitalized patients with OUD, like the use of medication for OUD, pain and withdrawal management, and addiction medicine consultation (Desai et al., 2018; Marks et al., 2019; Moreno et al., 2019). Receiving care in hospitals with strong nursing resources that also provide evidence-based care for OUD will likely optimize outcomes for hospitalized patients with OUD, yet this question has yet to be explored.

While this study reveals the impact of nursing resources on outcomes for patients with OUD, future work is needed to understand the additional impact of CDC prescribing guidelines, state opioid prescribing limits, and PDMP programs on hospitalized patient with OUD outcomes while accounting for nursing resources. Additionally, applying implementation science principles to expand the use of evidence-based approaches to caring for hospitalized patients with OUD is a promising strategy. To improve outcomes and leverage existing empirical evidence, future work is needed to develop, and ultimately implement, a toolkit of implementation strategies targeted at hospitalized patients with OUD.

Exploring the impact of nursing resources on racial disparities in outcomes among hospitalized patients with OUD is of great importance. As mentioned, the lack of attention to the impact of the opioid and overdose crisis on people of color is a profound threat to the provision of equitable hospital care. Future work is needed to understand the contribution of nursing resources on outcomes of minoritized surgical patients with OUD.

Summary

Despite recommendations from the “Future of Nursing” report over a decade ago calling for an increase in the proportion of BSN nurses to 80% by 2020 (Institute of Medicine, 2010) and decades of evidence suggesting the importance of having fewer patients per nurse (Aiken et al., 2002; Aiken et al., 2014; Lasater et al., 2021), variation in the educational composition of the nursing workforce and nurse staffing remain. This study confirms what is known about the elevated risk of poor outcomes for surgical patients with OUD and offers an evidence-based solution to mitigate readmission disparities between surgical patients with and without OUD.

We found that in hospitals with greater proportions of BSN nurses, surgical patients with OUD have lower odds of readmission at 7, 30, 60 and 90 days and that in hospitals with more patients per nurse, these patients have higher odds of 7- and 30-day readmission compared to the overall surgical population. These findings suggest that postsurgical outcomes for patients with OUD are greatly influenced by nursing resources at the hospital where they receive care, even after accounting for the impact of patient characteristics like insurance status and hospital characteristics like bed size. In order for hospitals in the United States to address the ongoing needs of patients impacted by the opioid and overdose crisis, they must invest in nursing resources like nurse education and staffing.

APPENDIX A

Figure A.1: DISTRIBUTION OF PATIENTS ACROSS HOSPITALS

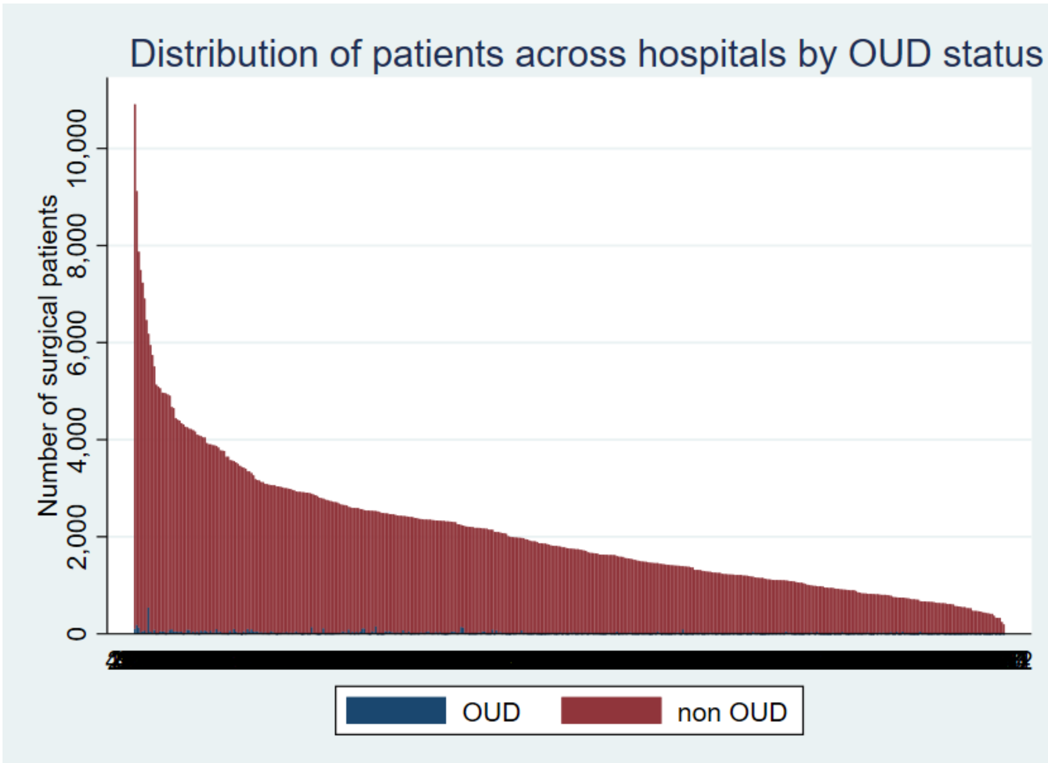
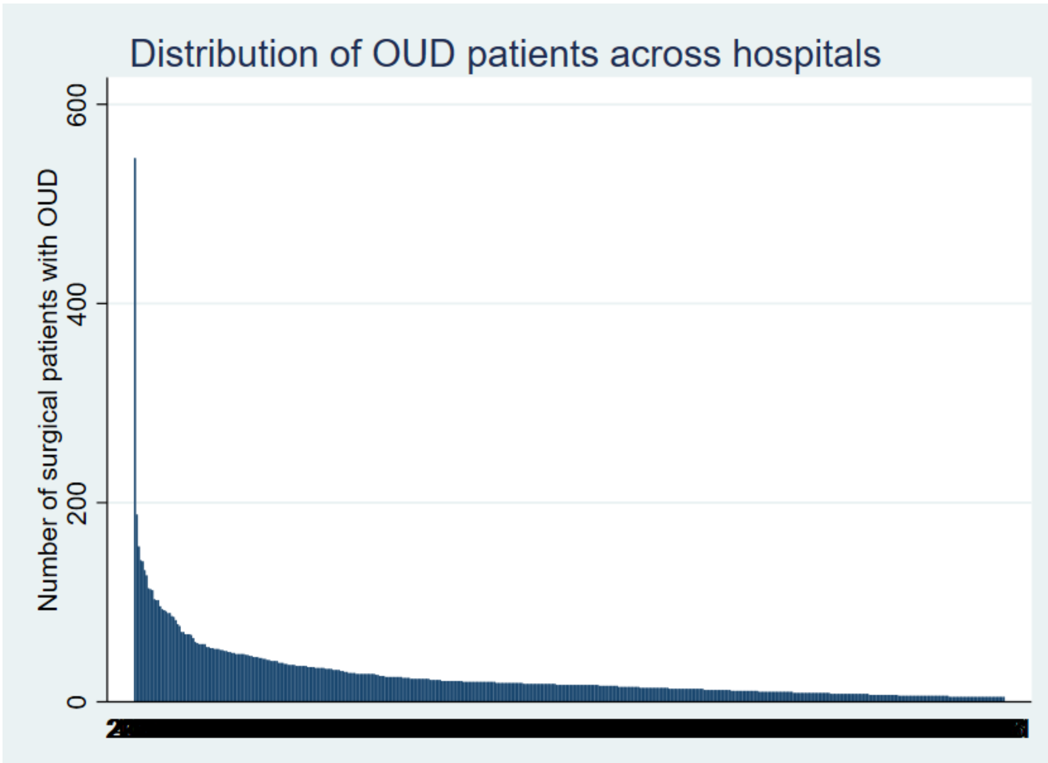


Figure A.2: DISTRIBUTION OF SURGICAL PATIENTS WITH OUD ACROSS HOSPITALS



APPENDIX B: DISTRIBUTION OF OUTCOMES ACROSS HOSPITALS

Figure B.1: 7-day readmission

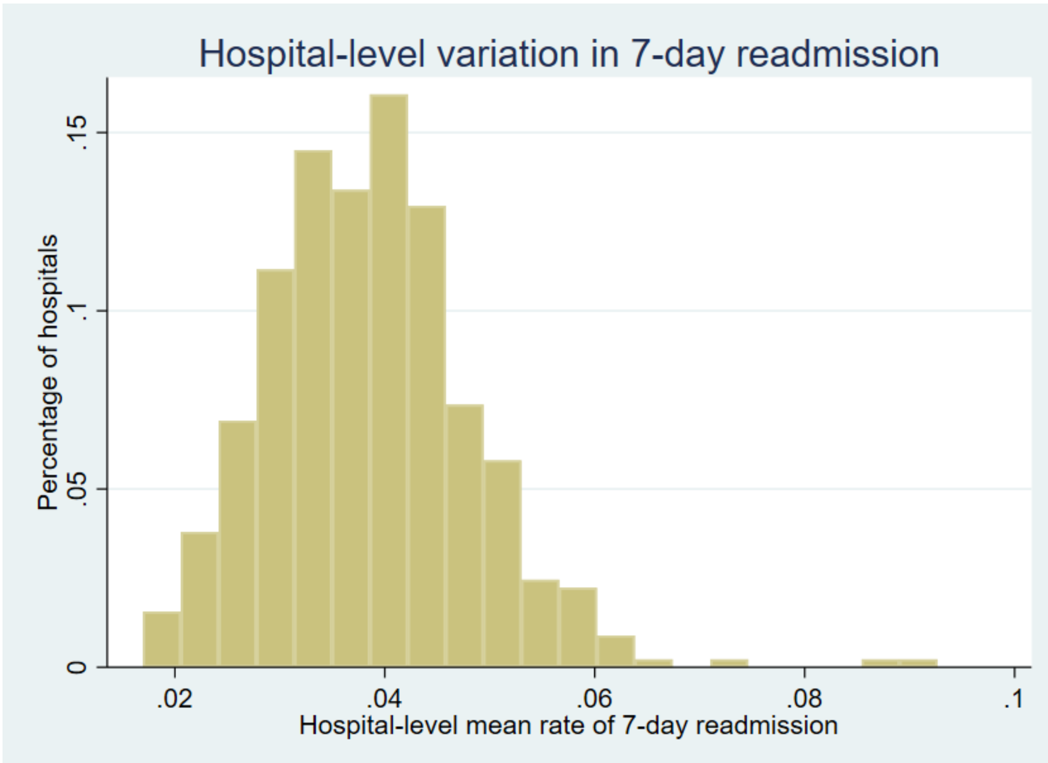


Figure B.2: 30-day readmission

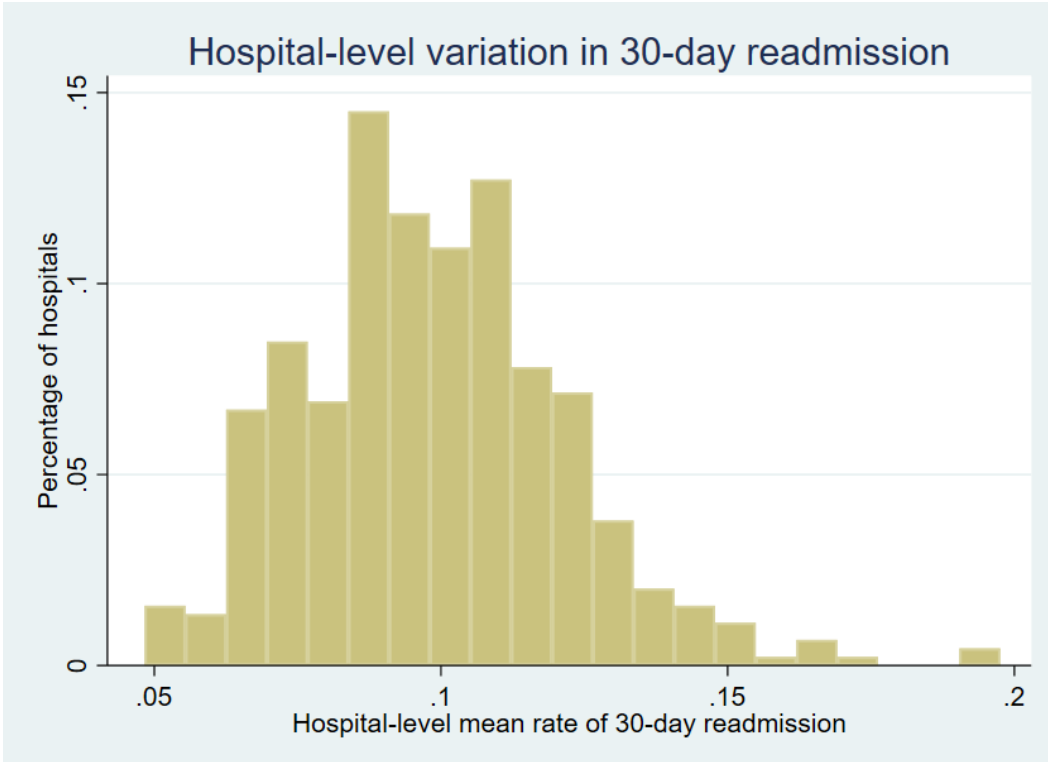


Figure B.3: 60-day readmission

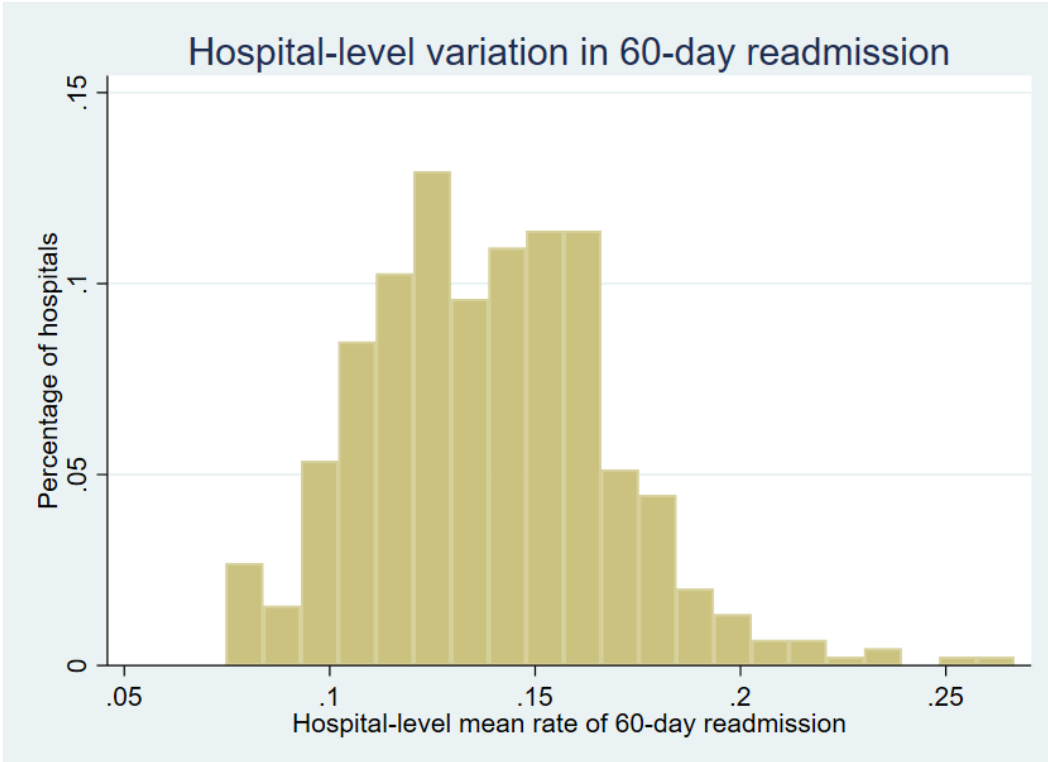


Figure B.4: 90-day readmission

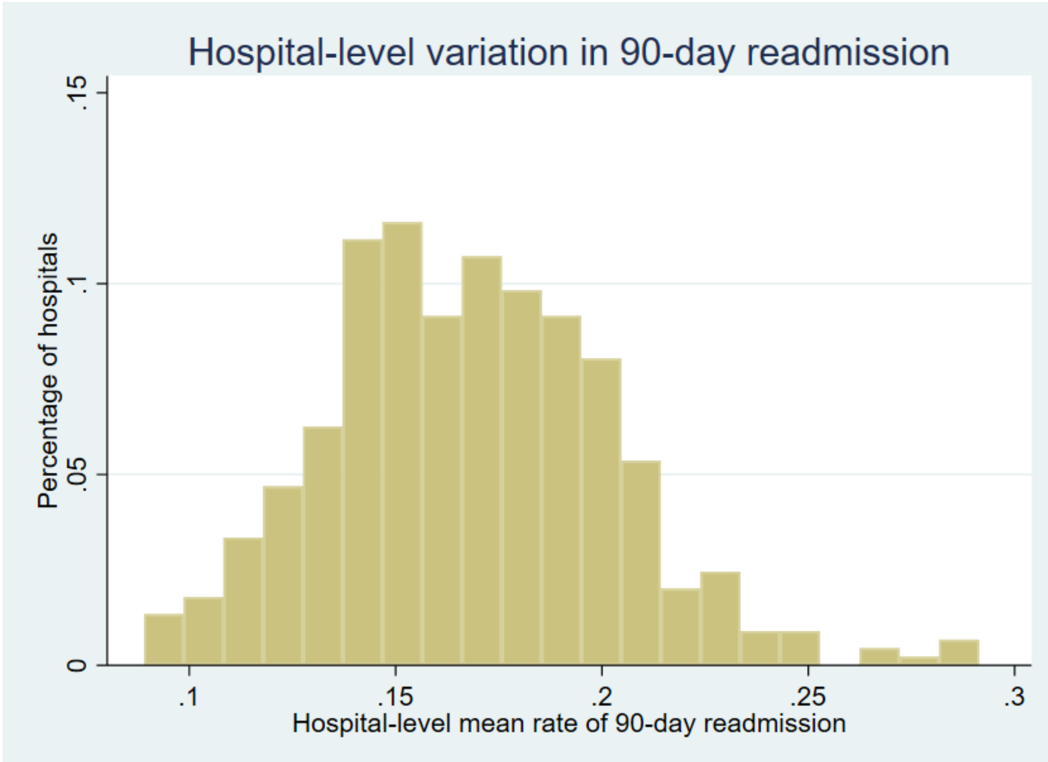


Figure B.5: In-hospital 30-day mortality

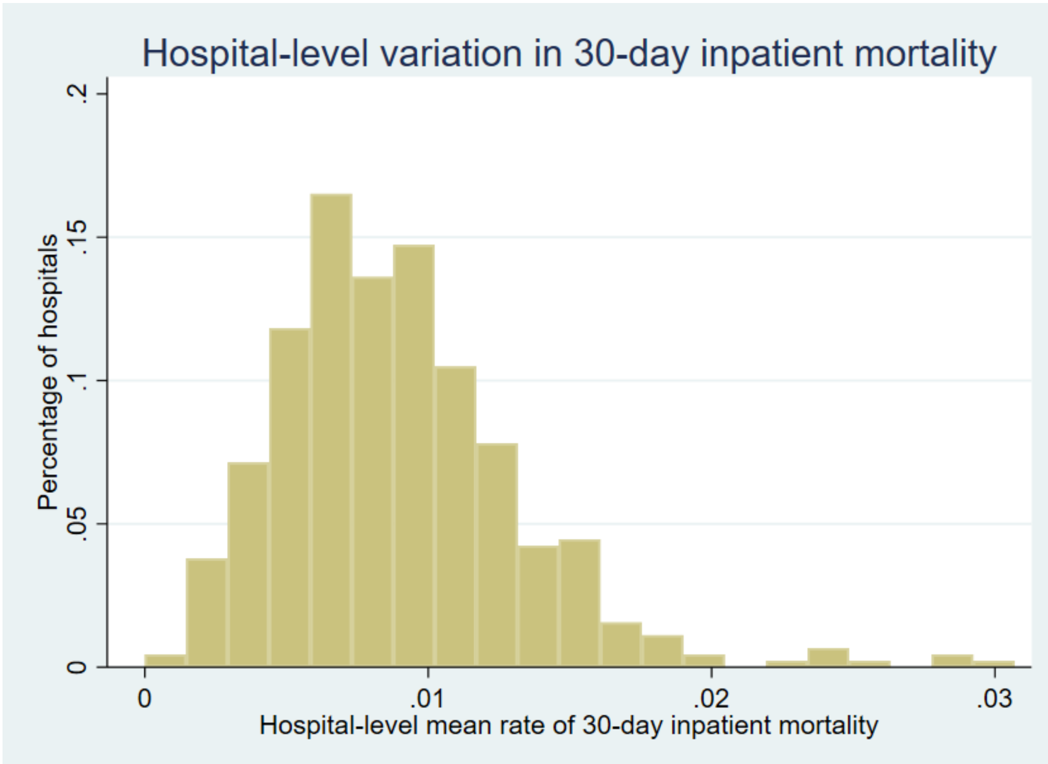
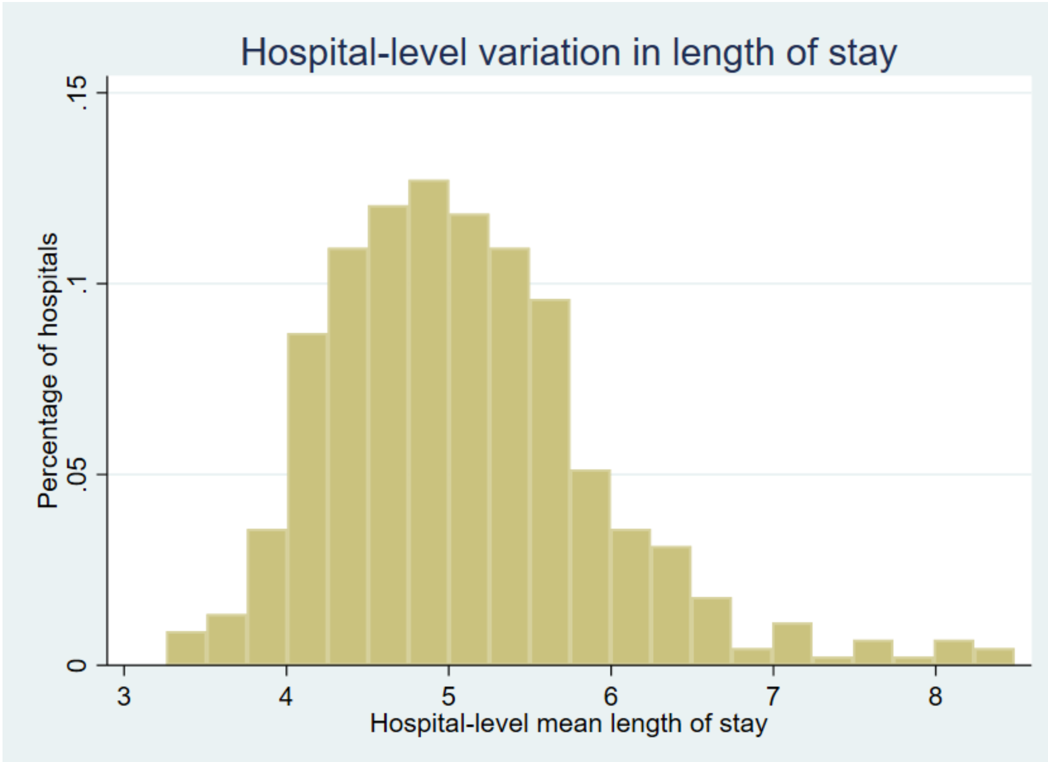


Figure B.6: Length of stay



APPENDIX C

Table C.1. EFFECT OF HAVING OPIOID USE DISORDER ON PATIENT OUTCOMES ADJUSTING FOR PATIENT AND HOSPITAL CHARACTERISTICS

Patient Outcomes	Unadjusted	Adjusted for Patient & Hospital Characteristics
	IRR (95% CI)	**IRR (95% CI)**
Length of stay	1.69*** (1.63-1.76)	1.23*** (1.20-1.26)
	OR (95% CI)	**OR (95% CI)**
In-hospital 30-day mortality	0.74* (0.59-0.93)	0.82 (0.64-1.03)
7-day readmission	1.53*** (1.40-1.67)	1.26*** (1.15-1.38)
30-day readmission	1.73*** (1.62-1.85)	1.35*** (1.26-1.45)
60-day readmission	1.83*** (1.72-1.95)	1.40*** (1.31-1.49)
90-day readmission	1.90*** (1.79-2.01)	1.44*** (1.36-1.52)

Abbreviations: CI = confidence interval; OR= odds ratio; IRR = incidence rate ratio. **Notes**: Hospital characteristics include bed size, teaching status, technology status, and urban status. Patient characteristics include age, sex, each Elixhauser comorbidity (except drug abuse), each Medicare Severity Diagnosis Related Groups (MS-DRGs), race, ethnicity, insurance status, and discharge disposition. Specific contributions not shown due to space. *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. *p-value <0.05; **p-value <0.01; ***p-value <0.001.

APPENDIX D

Table D.1. CHARACTERISTICS OF PATIENTS DISCHARGED AGAINST MEDICAL ADVICE IN OVERALL SAMPLE AND BY OUD STATUS

n (%)	All patients (n= 4,649)	Patients with OUD (n=454)	Patients without OUD (n=4,195)	*p*-value*
Demographics				
Age (years), mean (SD)	58.7 (18.4)	41.8 (13.1)	60.5 (18)	<0.001
Age group (years)				
18-44	1,060 (22.8)	268 (59)	792 (18.9)	<0.001
45-54	813 (17.5)	94 (20.7)	719 (17.1)	0.057
55-64	971 (20.9)	73 (16.1)	898 (21.4)	0.008
65-74	771 (16.6)	14 (3.1)	757 (18.1)	<0.001
75-84	609 (13.1)	3 (0.7)	606 (14.5)	<0.001
85-99	425 (9.1)	2 (0.4)	423 (10.1)	<0.001
Male	2,765 (59.5)	281 (61.9)	2,484 (59.2)	<0.001
Transferred in	121 (2.6)	9 (2)	112 (2.7)	0.382
Medicaid insured				
Race				
White	3,456 (75)	358 (79.4)	3,098 (74.5)	0.020
Black	646 (14)	57 (12.6)	589 (14.2)	0.385
Asian/Pacific Islander	136 (3)	1 (0.2)	135 (3.3)	<0.001
Native American	19 (0.4)	3 (0.7)	16 (0.4)	0.375
Other	354 (7.7)	32 (7.1)	322 (7.7)	0.632
Hispanic ethnicity	889 (19.4)	63 (14)	826 (20)	0.003
Insurance Status				
Medicare	2,186 (47.6)	74 (16.7)	2,112 (50.8)	<0.001
Medicaid	1,365 (29.7)	236 (53.8)	1,129 (27.2)	<0.001
Private	544 (11.8)	43 (9.8)	501 (12.1)	0.120
Self-pay	325 (7.1)	70 (16)	255 (6.1)	<0.001
No charge	60 (1.3)	10 (2.3)	50 (1.2)	0.070
Other	115 (2.5)	6 (1.4)	109 (2.6)	0.096
Surgical Group				
General Surgery	1,709 (36.8)	243 (53.5)	1,466 (35)	<0.001

Orthopedic Surgery	2,248 (48.4)	183 (40.3)	2,065 (49.2)	<0.001
Vascular Surgery	692 (14.9)	28 (6.2)	664 (15.8)	<0.001
Elixhauser Comorbidities				
Total number, mean (SD)	2.9 (1.9)	3.1 (1.7)	2.9 (2)	0.057
Congestive heart failure	277 (6)	11 (2.4)	266 (6.3)	0.001
Valvular disease	141 (3)	14 (3.1)	127 (3)	0.947
Pulmonary circulation disorders	23 (0.5)	3 (0.7)	20 (0.5)	0.595
Peripheral vascular disorders	388 (8.4)	15 (3.3)	373 (8.9)	<0.001
Hypertension	2,554 (54.9)	127 (28)	2,427 (57.9)	<0.001
Paralysis	108 (2.3)	5 (1.1)	103 (2.5)	0.069
Other neurological disorders	396 (8.5)	34 (7.5)	362 (8.6)	0.408
Chronic pulmonary disease	868 (18.7)	70 (15.4)	798 (19)	0.061
Diabetes, uncomplicated	582 (12.5)	16 (3.5)	566 (13.5)	<0.001
Diabetes, complicated	699 (15)	38 (8.4)	661 (15.8)	<0.001
Hypothyroidism	406 (8.7)	10 (2.2)	396 (9.4)	<0.001
Renal failure	649 (14)	17 (3.8)	632 (15.1)	<0.001
Liver disease	368 (7.9)	69 (15.2)	299 (7.1)	<0.001
Peptic ulcer disease	57 (1.2)	4 (0.9)	53 (1.3)	0.482
AIDS	38 (0.8)	7 (1.5)	31 (0.7)	0.071
Lymphoma	15 (0.3)	0 (0)	15 ().4)	0.202
Metastatic cancer	79 (1.7)	0 (0)	79 (1.9)	0.003
Solid tumor without metastasis	64 (1.4)	3 (0.7)	61 (1.5)	0.168
Rheumatoid arthritis/collagen vascular disorders	120 (2.6)	6 (1.3)	114 (2.7)	0.075
Obesity	595 (12.8)	19 (4.2)	576 (13.7)	<0.001
Weight loss	239 (5.1)	23 (5.1)	216 (5.2)	0.939
Chronic blood-loss anemia	72 (1.6)	6 (1.3)	66 (1.6)	0.680
Deficiency anemias	1,036 (22.3)	99 (21.8)	937 (22.3)	0.797
Alcohol abuse	526 (11.3)	67 (14.8)	459 (10.9)	0.015
Psychoses	373 (8)	76 (16.7)	297 (7.1)	<0.001
Depression	515 (11.1)	76 (16.7)	439 (10.5)	<0.001
Coagulopathy	275 (5.9)	14 (3.1)	261 (6.2)	0.007
Fluid and electrolyte disorders	1,133 (24.4)	110 (24.2)	1,023 (24.4)	0.941
Outcomes				
Length of stay	6.3 (7.8)	8.4 (10.8)	6 (7.4)	<0.001

In-hospital 30-day mortality	0 (0)	0 (0)	0 (0)	-
7-day readmission	522 (11.4)	75 (16.7)	447 (10.8)	<0.001
30-day readmission	948 (21.7)	112 (26.3)	836 (21.2)	0.015
60-day readmission	1,123 (27.2)	124 (31.3)	999 (26.8)	0.053
90-day readmission	1,182 (30.8)	123 (33.4)	1,059 (30.5)	0.247

Note: *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. *p-value <0.05; **p-value <0.01; ***p-value <0.001.

APPENDIX E

Table E.1. CHARACTERISTICS OF HOSPITALS BY QUARTILE OF AVERAGE NUMBER OF PATIENTS WITH OUD

n (%)	All hospitals (n=448)	1st quartile (n= 127)	2nd quartile (n= 104)	3rd quartile (n= 107)	4th quartile (n= 110)	*p*-value*
Average Number of Patients with OUD, mean (SD)						<0.001
	25.9 (35)	7.2 (1.8)	14.1 (2.1)	22 (3.4)	62.5 (55.6)	
Bed size						<0.001
Small (≤100)	19 (4.2)	8 (6.3)	4 (3.9)	4 (3.7)	3 (2.7)	
Medium (101-250)	168 (37.5)	82 (64.6)	43 (41.4)	26 (24.3)	17 (15.5)	
Large (>250)	261 (58.3)	37 (29.1)	57 (54.8)	77 (72)	90 (81.8)	
Teaching status						0.006
Non-teaching	179 (41.1)	48 (39.7)	40 (39.2)	42 (40.8)	49 (44.6)	
Minor Teaching	207 (47.5)	65 (53.7)	51 (50)	53 (51.5)	38 (34.6)	
Major Teaching	50 (11.5)	8 (6.6)	11 (10.8)	8 (7.8)	23 (20.9)	
Technology Status						<0.001
High	266 (60.5)	48 (39.3)	60 (57.7)	73 (69.5)	85 (78)	
State						0.015
California	178 (39.7)	40 (31.5)	40 (38.5)	42 (39.3)	56 (50.9)	
Florida	136 (30.4)	39 (30.7)	30 (28.9)	30 (28)	37 (33.6)	
New Jersey	48 (10.7)	13 (10.2)	14 (13.5)	15 (14)	6 (5.5)	
Pennsylvania	86 (19.2)	35 (27.6)	20 (19.2)	20 (18.7)	11 (10)	
Urban / Rural Status						0.002
Urban	434 (96.9)	117 (92.1)	104 (100)	106 (99.1)	107 (97.3)	
% nursing staffing with a BSN or higher, mean (SD)						0.0022
	57.5 (14.5)	53.7 (15.5)	57.2 (13.9)	59.5 (13.7)	60.1 (14.1)	
Patients per nurse, mean (SD)						<0.001
	4.3 (0.9)	4.7 (1.1)	4.4 (1)	4.1 (0.8)	4.1 (0.7)	
Nurse Work Environment						<0.001
Poor	112 (25%)	38 (29.9)	41 (39.4)	18 (16.8)	15 (13.6)	
Mixed	224 (50%)	68 (53.5)	50 (48.1)	60 (56.1)	46 (41.8)	
Good	112 (25%)	21 (16.5)	13 (12.5)	29 (27.1)	49 (44.6)	

Abbreviations: n = number; SD = standard deviation. **Notes**: Work environment was measured by the PES-NWI excluding the staffing and resource adequacy subscale. Poor are were hospitals in the bottom 25%, mixed work environments are the middle 50%, and good work environments are the top 25% of hospitals. 1^{st} quartile range 5-10 patients with OUD; 2^{nd} quartile range 11-17; 3^{rd} quartile range 18-29; 4^{th} quartile range 30-546. *P*-values were generated from χ^2 for categorical and ANOVA for continuous variables. **p*-value <0.05; ***p*-value <0.01; ****p*-value <0.001.

Bibliography

Aiken, L. H., Cimiotti, J. P., Sloane, D. M., Smith, H. L., Flynn, L., & Neff, D. F. (2011). Effects of nurse staffing and nurse education on patient deaths in hospitals with different nurse work environments. *Medical Care, 42*(10 Suppl), S10.

Aiken, L. H., Clarke, S. P., Cheung, R. B., Sloane, D. M., & Silber, J. H. (2003). Educational levels of hospital nurses and surgical patient mortality. *Jama, 290*(12), 1617-1623.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Lake, E. T., & Cheney, T. (2008). Effects of hospital care environment on patient mortality and nurse outcomes. *The Journal of nursing administration, 38*(5), 223.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. *Jama, 288*(16), 1987-1993.

Aiken, L. H., Sloane, D. M., Bruyneel, L., Van den Heede, K., Griffiths, P., Busse, R., . . . Lesaffre, E. (2014). Nurse staffing and education and hospital mortality in nine European countries: a retrospective observational study. *The lancet, 383*(9931), 1824-1830.

Allen, L. A., Tomic, K. E. S., Smith, D. M., Wilson, K. L., & Agodoa, I. (2012). Rates and predictors of 30-day readmission among commercially insured and Medicaid-enrolled patients hospitalized with systolic heart failure. *Circulation: Heart Failure, 5*(6), 672-679.

Altman, S., & Lewin, M. E. (2000). *America's health care safety net: intact but endangered* National Academies Press.

American Association of Nurse Anesthetists. (2018). Enhanced Recovery after Surgery.

American Hospital Association. (2020). Fast Facts on US Hospitals, 2020. *Chicago, IL: American Hospital Association*.

Armaghani, S. J., Lee, D. S., Bible, J. E., Shau, D. N., Kay, H., Zhang, C., . . . Devin, C. J. (2016). Increased preoperative narcotic use and its association with postoperative complications and length of hospital stay in patients undergoing spine surgery. *Journal of Spinal Disorders and Techniques, 29*(2), E93-E98.

Baker, A. (2001). *Crossing the quality chasm: a new health system for the 21st century* (Vol. 323)British Medical Journal Publishing Group.

Baker, D. W. (2017). History of The Joint Commission's pain standards: lessons for today's prescription opioid epidemic. *Jama, 317*(11), 1117-1118.

Barelli, R., Morelli Sbarra, G., Sbaraglia, F., Zappia, L., & Rossi, M. (2019). Prevention of post-operative hyperalgesia in a heroin-addicted patient on methadone maintenance. *Journal of Clinical Pharmacy and Therapeutics, 44*(3), 397-399. doi:10.1111/jcpt.12798

Barocas, J. A., Morgan, J. R., Wang, J., McLoone, D., Wurcel, A., & Stein, M. D. (2021). Outcomes associated with medications for opioid use disorder among persons hospitalized for infective endocarditis. *Clinical Infectious Diseases, 72*(3), 472-478.

Basques, B. A., Miller, C. P., Golinvaux, N. S., Bohl, D. D., & Grauer, J. N. (2015). Morbidity and readmission after open reduction and internal fixation of ankle fractures are associated with preoperative patient characteristics. *Clinical Orthopaedics and Related Research®, 473*(3), 1133-1139.

Bentzley, B. S., Barth, K. S., Back, S. E., & Book, S. W. (2015). Discontinuation of buprenorphine maintenance therapy: perspectives and outcomes. *Journal of substance abuse treatment, 52*, 48-57.

Biancarelli, D. L., Biello, K. B., Childs, E., Drainoni, M., Salhaney, P., Edeza, A., . . . Bazzi, A. R. (2019). Strategies used by people who inject drugs to avoid stigma in healthcare settings. *Drug and alcohol dependence, 198*, 80-86.

Birkmeyer, J. D., Siewers, A. E., Finlayson, E. V., Stukel, T. A., Lucas, F. L., Batista, I., . . . Wennberg, D. E. (2002). Hospital volume and surgical mortality in the United States. *New England Journal of Medicine, 346*(15), 1128-1137.

Birkmeyer, N. J., Gu, N., Baser, O., Morris, A. M., & Birkmeyer, J. D. (2008). Socioeconomic status and surgical mortality in the elderly. *Medical Care*, 893-899.

Bisognano, M., & Boutwell, A. (2009). Improving transitions to reduce readmissions. *Front Health Serv Manage, 25*(3), 3-10.

Blegen, M. A., Goode, C. J., Spetz, J., Vaughn, T., & Park, S. H. (2011). Nurse staffing effects on patient outcomes: safety-net and non-safety-net hospitals. *Medical Care*, 406-414.

Blumberg, T. J., Woelber, E., Bellabarba, C., Bransford, R., & Spina, N. (2018). Predictors of increased cost and length of stay in the treatment of postoperative spine surgical site infection. *The Spine Journal, 18*(2), 300-306.

Brom, H., Brooks Carthon, J. M., Sloane, D., McHugh, M. D., & Aiken, L. H. (2021). Better nurse work environments associated with fewer readmissions and shorter length of stay among adults with ischemic stroke: A cross-sectional analysis of United States hospitals. *Research in nursing & health*, 1-9.

Brooke, B. S., Stone, D. H., Cronenwett, J. L., Nolan, B., DeMartino, R. R., MacKenzie, T. A., . . . Goodney, P. P. (2014). Early primary care provider follow-up and readmission after high-risk surgery. *JAMA Surgery, 149*(8), 821-828.

Brooks Carthon, J. M., Kutney-Lee, A., Jarrin, O., Sloane, D., & Aiken, L. H. (2012). Nurse Staffing and Postsurgical Outcomes in Black Adults. *JAGS, 60*(6). doi:10.1111/j.1532-5415.2012.03990.x

Brooks Carthon, J. M., Lasater, K. B., Sloane, D. M., & Kutney-Lee, A. (2015). The quality of hospital work environments and missed nursing care is linked to heart failure readmissions: a cross-sectional study of US hospitals. *BMJ Qual Saf, 24*(4), 255-263.

Campbell, J. N. (1996). *APS 1995 presidential address.* Paper presented at the Pain Forum.

Casey, C. Y., Greenberg, M. A., Nicassio, P. M., Harpin, R. E., & Hubbard, D. (2008). Transition from acute to chronic pain and disability: a model including cognitive, affective, and trauma factors. *Pain, 134*(1-2), 69-79.

Centers for Disease Control and Prevention. (2013). *Prescription drug overdose data & statistics: guide to ICD-9-CM and ICD-10 codes related to poisoning and pain*. Retrieved from https://www.cdc.gov/drugoverdose/pdf/pdo_guide_to_icd-9-cm_and_icd-10_codes-a.pdf

Centers for Disease Control and Prevention. (2016). *CDC guideline for prescribing opioids for chronic pain—United States, 2016*. Retrieved from https://www.cdc.gov/mmwr/volumes/65/rr/rr6501e1.htm

Centers for Disease Control and Prevention. (2020). *Drug Overdoses in the United States*. Retrieved from https://www.cdc.gov/injury/features/prescription-drug-overdose/index.html

Centers for Medicare and Medicaid Services. (2018). Hospital Readmissions Reduction Program (HRRP).

Cho, E., Park, J., Choi, M., Lee, H. S., & Kim, E. Y. (2018). Associations of nurse staffing and education with the length of stay of surgical patients. *Journal of Nursing Scholarship, 50*(2), 210-218.

Choi, M., Kim, H., Qian, H., & Palepu, A. (2011). Readmission rates of patients discharged against medical advice: a matched cohort study. *PloS one, 6*(9), e24459.

Ciccarone, D. (2019). The triple wave epidemic: supply and demand drivers of the US opioid overdose crisis. *The International journal on drug policy, 71*, 183.

Clark, C. L. (2004). The professional socialization of graduating students in generic and two-plus-two baccalaureate completion nursing programs. *Journal of Nursing Education, 43*(8), 346-351.

Connolly, T. M., White, R. S., Sastow, D. L., Gaber-Baylis, L. K., Turnbull, Z. A., & Rong, L. Q. (2018). The disparities of coronary artery bypass grafting surgery outcomes by insurance status: a retrospective cohort study, 2007–2014. *World journal of surgery, 42*(10), 3240-3249.

Cron, D. C., Englesbe, M. J., Bolton, C. J., Joseph, M. T., Carrier, K. L., Moser, S. E., . . . Brummett, C. M. (2017). Preoperative opioid use is independently associated with increased costs and worse outcomes after major abdominal surgery. *Annals of surgery, 265*(4), 695-701.

D'Onofrio, G., O'Connor, P. G., Pantalon, M. V., Chawarski, M. C., Busch, S. H., Owens, P. H., . . . Fiellin, D. A. (2015). Emergency department–initiated buprenorphine/naloxone treatment for opioid dependence: a randomized clinical trial. *Jama, 313*(16), 1636-1644.

Desai, K., Carroll, I., Asch, S. M., Seto, T., McDonald, K. M., Curtin, C., & Hernandez-Boussard, T. (2018). Utilization and effectiveness of multimodal discharge analgesia for postoperative pain management. *Journal of Surgical Research, 228*, 160-169.

Dewan, K. C., Dewan, K. S., Idrees, J. J., Navale, S. M., Rosinski, B. F., Svensson, L. G., . . . Soltesz, E. G. (2019). Trends and Outcomes of Cardiovascular Surgery in Patients with Opioid Use Disorders. *JAMA Surgery, 154*(3), 232-240. doi:10.1001/jamasurg.2018.4608

Diggle, P., Diggle, P. J., Heagerty, P., Liang, K.-Y., Heagerty, P. J., & Zeger, S. (2002). *Analysis of longitudinal data* Oxford University Press.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: the tailored design method* John Wiley & Sons.

Donabedian, A. (1966). Evaluating the quality of medical care. *The Milbank memorial fund quarterly, 44*(3), 166-206.

Donabedian, A. (1988). The quality of care: how can it be assessed? *Jama, 260*(12), 1743-1748.

Donaldson, M. S., Corrigan, J. M., & Kohn, L. T. (2000). To err is human: building a safer health system.

Donroe, J. H., Holt, S. R., & Tetrault, J. M. (2016). Caring for patients with opioid use disorder in the hospital. *CMAJ, 188*(17-18), 1232-1239.

Dowell, D., Haegerich, T. M., & Chou, R. (2016). CDC guideline for prescribing opioids for chronic pain—United States, 2016. *Jama, 315*(15), 1624-1645.

DrFirst. (2020). *State Mandates Driving EPCS and PDMP Utilization*. Retrieved from https://drfirst.com/resources/regulatory-mandates/

Elixhauser, A., Steiner, C., Harris, D. R., & Coffey, R. M. (1998). Comorbidity measures for use with administrative data. *Medical Care*, 8-27.

Englander, H., Dobbertin, K., Lind, B. K., Nicolaidis, C., Graven, P., Dorfman, C., & Korthuis, P. T. (2019). Inpatient Addiction Medicine Consultation and Post-Hospital Substance Use Disorder Treatment Engagement: a

Propensity-Matched Analysis. *J Gen Intern Med, 34*(12), 2796-2803. doi:10.1007/s11606-019-05251-9

Epstein, R. H., & Dexter, F. (2017). Development and validation of a structured query language implementation of the Elixhauser comorbidity index. *Journal of the American Medical Informatics Association, 24*(4), 845-850.

Estabrooks, C. A., Midodzi, W. K., Cummings, G. G., Ricker, K. L., & Giovannetti, P. (2005). The impact of hospital nursing characteristics on 30-day mortality. *Nursing Research, 54*(2), 74-84.

Fingar, K. R., & Owens, P. L. (2021). Opioid-Related and Stimulant-Related Adult Inpatient Stays, 2012–2018: statistical brief# 271. *Rockville: Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*.

Finney, L. (2010). Nursing care for the patient with co-existing pain and substance misuse: meeting the patient's needs. *MEDSURG Nursing, 19*(1), 25-53.

French, R., McHugh, M. D., Lake, E. T., & Brooks Carthon, J. M. (2020). A Systematic Review of Care Needs for Surgical Patients with Chronic Opioid Use: Implications for Nursing. *MEDSURG Nursing*.

Gani, F., Lucas, D. J., Kim, Y., Schneider, E. B., & Pawlik, T. M. (2015). Understanding variation in 30-day surgical readmission in the era of accountable care: effect of the patient, surgeon, and surgical subspecialties. *JAMA Surgery, 150*(11), 1042-1049.

Garland, A., Ramsey, C. D., Fransoo, R., Olafson, K., Chateau, D., Yogendran, M., & Kraut, A. (2013). Rates of readmission and death associated with leaving hospital against medical advice: a population-based study. *CMAJ, 185*(14), 1207-1214. doi:10.1503/cmaj.130029

Glasgow, J. M., Vaughn-Sarrazin, M., & Kaboli, P. J. (2010). Leaving against medical advice (AMA): risk of 30-day mortality and hospital readmission. *Journal of general internal medicine, 25*(9), 926-929.

Goel, A. N., Yang, J. Y., Wang, M. B., Lee, J. T., St. John, M. A., & Long, J. L. (2018). *Predictors, costs, and causes of readmission after surgery for sinonasal cancer: a national perspective.* Paper presented at the International forum of allergy & rhinology.

Gooiker, G., Van Gijn, W., Wouters, M., Post, P., Van De Velde, C., & Tollenaar, R. (2011). Systematic review and meta-analysis of the volume–outcome relationship in pancreatic surgery. *British journal of surgery, 98*(4), 485-494.

Gounder, C. (2013). Who is responsible for the pain-pill epidemic. *The New Yorker, 8*.

Green, L. W. (1970). Manual for scoring socioeconomic status for research on health behavior. *Public Health Reports, 85*(9), 815.

Gulur, P., Williams, L., Chaudhary, S., Koury, K., & Jaff, M. (2014). Opioid tolerance—a predictor of increased length of stay and higher readmission rates. *Pain physician, 17*(4), E503-E507.

Gunther, M., & Alligood, M. R. (2002). A discipline-specific determination of high quality nursing care. *Journal of advanced nursing, 38*(4), 353-359.

Gupta, A., Nizamuddin, J., Elmofty, D., Nizamuddin, S. L., Tung, A., Minhaj, M., . . . Shahul, S. (2018). Opioid Abuse or Dependence Increases 30-day

Readmission Rates after Major Operating Room ProceduresA National Readmissions Database Study. *Anesthesiology: The Journal of the American Society of Anesthesiologists, 128*(5), 880-890.

Guy, G. P., Zhang, K., Bohm, M. K., Losby, J., Lewis, B., Young, R., . . . Dowell, D. (2017). Vital signs: changes in opioid prescribing in the United States, 2006–2015. *MMWR. Morbidity and mortality weekly report, 66*(26), 697.

Hah, J. M., Bateman, B. T., Ratliff, J., Curtin, C., & Sun, E. (2017). Chronic Opioid Use After Surgery: Implications for Perioperative Management in the Face of the Opioid Epidemic. *Anesthesia and analgesia, 125*(5), 1733-1740.

Harless, D. W., & Mark, B. A. (2010). Nurse staffing and quality of care with direct measurement of inpatient staffing. *Medical Care*, 659-663.

Härstedt, M., Rogmark, C., Sutton, R., Melander, O., & Fedorowski, A. (2015). Impact of comorbidity on 6-month hospital readmission and mortality after hip fracture surgery. *Injury, 46*(4), 713-718.

Hatipoğlu, U., Wells, B. J., Chagin, K., Joshi, D., Milinovich, A., & Rothberg, M. B. (2018). Predicting 30-day all-cause readmission risk for subjects admitted with pneumonia at the point of care. *Respiratory care, 63*(1), 43-49.

Herzig, S. J., Calcaterra, S. L., Mosher, H. J., Ronan, M. V., Van Groningen, N., Shek, L., . . . Nuckols, T. K. (2018). Safe Opioid Prescribing for Acute Non-Cancer Pain in Hospitalized Adults: A Systematic Review of Existing Guidelines. *Journal of hospital medicine, 13*(4), 256.

Heslin, K. C., Elixhauser, A., & Steiner, C. A. (2006). Hospitalizations involving mental and substance use disorders among adults, 2012: statistical brief# 191. *Healthcare Cost and Utilization Project (HCUP) statistical briefs. Rockville: Agency for Healthcare Research and Quality (US)*.

Heslin, K. C., Owens, P. L., Karaca, Z., Barrett, M. L., Moore, B. J., & Elixhauser, A. (2017). Trends in opioid-related inpatient stays shifted after the US transitioned to ICD-10-CM diagnosis coding in 2015. *Medical Care, 55*(11), 918-923.

Hincapie-Castillo, J. M., Goodin, A., Possinger, M.-C., Usmani, S. A., & Vouri, S. M. (2020). Changes in Opioid use after Florida’s restriction law for acute pain prescriptions. *JAMA network open, 3*(2), e200234-e200234.

Hoehn, R. S., Hanseman, D. J., Chang, A. L., Daly, M. C., Ertel, A. E., Abbott, D. E., . . . Paquette, I. M. (2017). Surgeon characteristics supersede hospital characteristics in mortality after urgent colectomy. *Journal of Gastrointestinal Surgery, 21*(1), 23-32.

Hser, Y.-I., Mooney, L. J., Saxon, A. J., Miotto, K., Bell, D. S., & Huang, D. (2017). Chronic pain among patients with opioid use disorder: results from electronic health records data. *Journal of substance abuse treatment, 77*, 26-30.

Hu, J., Gonsahn, M. D., & Nerenz, D. R. (2014). Socioeconomic status and readmissions: evidence from an urban teaching hospital. *Health Affairs, 33*(5), 778-785.

Iezzoni, L. (2013). Risk adjustment for health care outcomes. In: Chicago: Health Administration Press.

Independence Blue Cross. (2018). Preventable Hospital Readmissions Cut by More Than 25 Percent Under Innovative Contract Between University of Pennsylvania Health System and Independence Blue Cross.

Institute of Medicine. (2010). *The future of nursing: Leading change, advancing health* National Academies Press Washington, DC.

Jackman, C. (2019). Perioperative Pain Management for the Chronic Pain Patient With Long-Term Opioid Use. *Orthopedic nursing, 38*(2), 159-163. doi:10.1097/NOR.0000000000000526

Jain, N., Phillips, F. M., Weaver, T., & Khan, S. N. (2018). Preoperative chronic opioid therapy: A risk factor for complications, readmission, continued opioid use and increased costs after one- and two-level posterior lumbar fusion. *Spine, 43*(19), 1331-1338. doi:10.1097/BRS.0000000000002609

James, K., & Jordan, A. (2018). The opioid crisis in black communities. *The Journal of Law, Medicine & Ethics, 46*(2), 404-421.

Jencks, S. F., Williams, M. V., & Coleman, E. A. (2009). Rehospitalizations among patients in the Medicare fee-for-service program. *New England Journal of Medicine, 360*(14), 1418-1428.

Jensen, P. H., Webster, E., & Witt, J. (2009). Hospital type and patient outcomes: an empirical examination using AMI readmission and mortality records. *Health economics, 18*(12), 1440-1460.

Jones, G. H., Bruera, E., Abdi, S., & Kantarjian, H. M. (2018). The opioid epidemic in the United States—Overview, origins, and potential solutions. *Cancer, 124*(22), 4279-4286.

Jones, M. R., Viswanath, O., Peck, J., Kaye, A. D., Gill, J. S., & Simopoulos, T. T. (2018). A brief history of the opioid epidemic and strategies for pain medicine. *Pain and therapy, 7*(1), 13-21.

Joynt, K. E., & Jha, A. K. (2011). Who has higher readmission rates for heart failure, and why? Implications for efforts to improve care using financial incentives. *Circulation: Cardiovascular Quality and Outcomes, 4*(1), 53-59.

Joynt, K. E., & Jha, A. K. (2013). Characteristics of hospitals receiving penalties under the Hospital Readmissions Reduction Program. *Jama, 309*(4), 342-343.

Joynt, K. E., Orav, E. J., & Jha, A. K. (2011). The association between hospital volume and processes, outcomes, and costs of care for congestive heart failure. *Annals of internal medicine, 154*(2), 94-102.

Katella, K. (2015). Caring for the psyche while treating the body. Retrieved from https://medicine.yale.edu/news-article/8539/

Katz, J. N., Barrett, J., Mahomed, N. N., Baron, J. A., Wright, R. J., & Losina, E. (2004). Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. *JBJS, 86*(9), 1909-1916.

Keller, D., Tahilramani, R., Flores-Gonzalez, J., Ibarra, S., & Haas, E. (2016). Pilot study of a novel pain management strategy: evaluating the impact on patient outcomes. *Surgical Endoscopy, 30*(6), 2192-2198.

Kelly, M. M., Reilly, E., Quiñones, T., Desai, N., & Rosenheck, R. (2018). Long-acting intramuscular naltrexone for opioid use disorder: Utilization and association with multi-morbidity nationally in the Veterans Health Administration. *Drug and alcohol dependence, 183*, 111-117.

Kendall-Gallagher, D., Aiken, L. H., Sloane, D. M., & Cimiotti, J. P. (2011). Nurse specialty certification, inpatient mortality, and failure to rescue. *Journal of Nursing Scholarship, 43*(2), 188-194.

Kent, T. S., Sachs, T. E., Callery, M. P., & Vollmer Jr, C. M. (2011). Readmission after major pancreatic resection: a necessary evil? *Journal of the American College of Surgeons, 213*(4), 515-523.

Keswani, A., Tasi, M. C., Fields, A., Lovy, A. J., Moucha, C. S., & Bozic, K. J. (2016). Discharge destination after total joint arthroplasty: an analysis of postdischarge outcomes, placement risk factors, and recent trends. *The Journal of arthroplasty, 31*(6), 1155-1162.

Khatri, U. G., & Perrone, J. (2020). Opioid use disorder and COVID-19: crashing of the crises. *Journal of addiction medicine*.

Khatri, U. G., Pizzicato, L. N., Viner, K., Bobyock, E., Sun, M., Meisel, Z. F., & South, E. C. (2021). Racial/Ethnic Disparities in Unintentional Fatal and Nonfatal Emergency Medical Services–Attended Opioid Overdoses During the COVID-19 Pandemic in Philadelphia. *JAMA network open, 4*(1), e2034878-e2034878.

Kim, J. B., Ejiofor, J. I., Yammine, M., Ando, M., Camuso, J. M., Youngster, I., . . . Sundt, T. M. (2016). Surgical outcomes of infective endocarditis among intravenous drug users. *Journal of Thoracic and Cardiovascular Surgery, 152*(3), 832-841. doi:10.1016/j.jtcvs.2016.02.072

Kork, F., Balzer, F., Krannich, A., Weiss, B., Wernecke, K.-D., & Spies, C. (2015). Association of comorbidities with postoperative in-hospital mortality: a retrospective cohort study. *Medicine, 94*(8).

Kuluski, K., Bensimon, C. M., Alvaro, C., Lyons, R. F., Schaink, A. K., & Tobias, R. (2014). Life interrupted: the impact of complex chronic disease from the perspective of hospitalized patients. *Illness, Crisis & Loss, 22*(2), 127-144.

Kunaviktikul, W., Anders, R. L., Srisuphan, W., Chontawan, R., Nuntasupawat, R., & Pumarporn, O. (2001). Development of quality of nursing care in Thailand. *Journal of advanced nursing, 36*(6), 776-784.

Kutney-Lee, A., & Aiken, L. H. (2008). Effect of nurse staffing and education on the outcomes of surgical patients with comorbid serious mental illness. *Psychiatric Services, 59*(12), 1466-1469.

Kutney-Lee, A., McHugh, M. D., Sloane, D. M., Cimiotti, J. P., Flynn, L., Neff, D. F., & Aiken, L. H. (2009). Nursing: A Key To Patient Satisfaction: Patients' reports of satisfaction are higher in hospitals where nurses practice in better work environments or with more favorable patient-to-nurse ratios. *Health Affairs, 28*(Suppl3), w669-w677.

Kutney-Lee, A., Sloane, D. M., & Aiken, L. H. (2013). An increase in the number of nurses with baccalaureate degrees is linked to lower rates of postsurgery mortality. *Health Affairs, 32*(3), 579-586.

Kutney-Lee, A., Stimpfel, A. W., Sloane, D. M., Cimiotti, J. P., Quinn, L. W., & Aiken, L. H. (2015). Changes in patient and nurse outcomes associated with magnet hospital recognition. *Medical Care, 53*(6), 550.

Lagisetty, P., Garpestad, C., Larkin, A., Macleod, C., Antoku, D., Slat, S., . . . Lin, L. A. (2021). Identifying individuals with opioid use disorder: Validity of International Classification of Diseases diagnostic codes for opioid use, dependence and abuse. *Drug and alcohol dependence, 221*, 108583.

Lake, E. T. (2002). Development of the practice environment scale of the nursing work index. *Research in nursing & health, 25*(3), 176-188.

Lake, E. T., Hallowell, S. G., Kutney-Lee, A., Hatfield, L. A., Del Guidice, M., Boxer, B., . . . Aiken, L. H. (2016). Higher quality of care and patient safety associated with better NICU work environments. *Journal of Nursing Care Quality, 31*(1), 24.

Lake, E. T., Riman, K. A., & Sloane, D. M. (2020). Improved work environments and staffing lead to less missed nursing care: A panel study. *Journal of nursing management*.

Lake, E. T., Sanders, J., Duan, R., Riman, K. A., Schoenauer, K. M., & Chen, Y. (2019). A meta-analysis of the associations between the nurse work environment in hospitals and 4 sets of outcomes. *Medical Care, 57*(5), 353.

Lake, E. T., Shang, J., Klaus, S., & Dunton, N. E. (2010). Patient falls: Association with hospital Magnet status and nursing unit staffing. *Research in nursing & health, 33*(5), 413-425.

Lasater, K. B., Aiken, L., Sloane, D., French, R., Anusiewicz, C. V., Martin, B., . . . McHugh, M. D. (2021). Is hospital nurse staffing legislation in the public's interest? An observational study in New York state. *Medical Care*.

Lasater, K. B., Jarrín, O. F., Aiken, L. H., McHugh, M. D., Sloane, D. M., & Smith, H. L. (2019). A Methodology For Studying Organizational Performance. *Medical Care, 57*(9), 742-749.

Lasater, K. B., & McHugh, M. D. (2016). Nurse staffing and the work environment linked to readmissions among older adults following elective total hip and knee replacement. *International Journal for Quality in Health Care, 28*(2), 253-258.

Lasater, K. B., Sloane, D. M., McHugh, M. D., Cimiotti, J. P., Riman, K. A., Martin, B., . . . Aiken, L. H. (2020). Evaluation of hospital nurse-to-patient staffing ratios and sepsis bundles on patient outcomes. *American journal of infection control*.

Li, B., Evans, D., Faris, P., Dean, S., & Quan, H. (2008). Risk adjustment performance of Charlson and Elixhauser comorbidities in ICD-9 and ICD-10 administrative databases. *BMC health services research, 8*(1), 1-7.

Lorch, S. A., Zhang, X., Rosenbaum, P. R., Evan-Shoshan, O., & Silber, J. H. (2004). Equivalent lengths of stay of pediatric patients hospitalized in rural and nonrural hospitals. *Pediatrics, 114*(4), e400-e408.

Lowenstein, M., Hossain, E., Yang, W., Grande, D., Perrone, J., Neuman, M. D., . . . Delgado, M. K. (2019). Impact of a state opioid prescribing limit and electronic medical record alert on opioid prescriptions: a difference-in-differences analysis. *Journal of general internal medicine*, 1-10.

Ma, C., McHugh, M. D., & Aiken, L. H. (2015). Organization of hospital nursing and 30-day readmissions in Medicare patients undergoing surgery. *Medical Care, 53*(1), 65.

Mahomed, N. N., Barrett, J. A., Katz, J. N., Phillips, C. B., Losina, E., Lew, R. A., . . . Baron, J. A. (2003). Rates and outcomes of primary and revision total hip replacement in the United States medicare population. *JBJS, 85*(1), 27-32.

Mäkelä, K. T., Häkkinen, U., Peltola, M., Linna, M., Kröger, H., & Remes, V. (2011). The effect of hospital volume on length of stay, re-admissions, and complications of total hip arthroplasty: a population-based register analysis of 72 hospitals and 30,266 replacements. *Acta Orthopaedica, 82*(1), 20-26.

Mark, T. L., & Parish, W. (2019). Opioid medication discontinuation and risk of adverse opioid-related health care events. *Journal of substance abuse treatment, 103*, 58-63.

Marks, L. R., Munigala, S., Warren, D. K., Liang, S. Y., Schwarz, E. S., & Durkin, M. J. (2019). Addiction medicine consultations reduce readmission rates for patients with serious infections from opioid use disorder. *Clinical Infectious Diseases, 68*(11), 1935-1937.

McHugh, M., Kang, R., & Hasnain-Wynia, R. (2009). Understanding the safety net: inpatient quality of care varies based on how one defines safety-net hospitals. *Medical Care Research and Review, 66*(5), 590-605.

McHugh, M. D., Brooks Carthon, J. M., & Kang, X. L. (2010). Medicare readmissions policies and racial and ethnic health disparities: a cautionary tale. *Policy, Politics, & Nursing Practice, 11*(4), 309-316.

McHugh, M. D., Brooks Carthon, J. M., Sloane, D. M., Wu, E., Kelly, L., & Aiken, L. H. (2012). Impact of nurse staffing mandates on safety-net hospitals: Lessons from California. *The Milbank Quarterly, 90*(1), 160-186.

McHugh, M. D., & Ma, C. (2013). Hospital nursing and 30-day readmissions among Medicare patients with heart failure, acute myocardial infarction, and pneumonia. *The Journal of nursing administration, 43*(10 Suppl), S11.

McHugh, M. D., Rochman, M. F., Sloane, D. M., Berg, R. A., Mancini, M. E., Nadkarni, V. M., . . . American Heart Association's Get With The Guidelines-Resuscitation Investigators. (2016). Better nurse staffing and nurse work environments associated with increased survival of in-hospital cardiac arrest patients. *Medical Care, 54*(1), 74.

McHugh, M. D., & Stimpfel, A. W. (2012). Nurse reported quality of care: a measure of hospital quality. *Research in nursing & health, 35*(6), 566-575.

McIlvennan, C. K., Eapen, Z. J., & Allen, L. A. (2015). Hospital readmissions reduction program. *Circulation, 131*(20), 1796-1803.

Medicare Learning Network. (2008). *Clarification of Patient Discharge Status Codes and Hospital Transfer Policies JA0801*. Retrieved from https://www.cms.gov/Medicare/Medicare-Contracting/ContractorLearningResources/Downloads/JA0801.pdf

Meghani, S. H., Byun, E., & Gallagher, R. M. (2012). Time to take stock: a meta-analysis and systematic review of analgesic treatment disparities for pain in the United States. *Pain Medicine, 13*(2), 150-174.

Melis, R. J., Rikkert, M. G. O., Parker, S. G., & van Eijken, M. I. (2004). What is intermediate care? In: British Medical Journal Publishing Group.

Menendez, M. E., Ring, D., & Bateman, B. T. (2015). Preoperative opioid misuse is associated with increased morbidity and mortality after elective orthopaedic surgery. *Clinical Orthopaedics and Related Research®, 473*(7), 2402-2412.

Menendez, M. E., van Dijk, C. N., & Ring, D. (2015). Who leaves the hospital against medical advice in the orthopaedic setting? *Clinical Orthopaedics and Related Research®, 473*(3), 1140-1149.

Merath, K., Mehta, R., Tsilimigras, D. I., Farooq, A., Sahara, K., Paredes, A. Z., . . . Dillhoff, M. (2020). Quality of care among Medicare patients undergoing pancreatic surgery: safety grade, Magnet recognition, and Leapfrog minimum volume standards—which quality benchmark matters? *Journal of Gastrointestinal Surgery*, 1-9.

Mirigian, L. S., Hendrick, L. A., Pringle, J. L., & Zemaitis, M. A. (2018). The Pennsylvania Prescription Drug Monitoring Program: Reducing the Misuse of Prescription Opioids. *Commonwealth, 20*(2-3).

Mitchell, P. H., Ferketich, S., Jennings, B. M., & American Academy of Nursing Expert Panel on Quality Health Care. (1998). Quality health outcomes model. *Image: The Journal of Nursing Scholarship, 30*(1), 43-46.

Mitchell, P. H., & Lang, N. M. (2004). Framing the problem of measuring and improving healthcare quality: has the Quality Health Outcomes Model been useful? *Medical Care, 42*(2), II-4-II-11.

Mnatzaganian, G., Ryan, P., Norman, P., Davidson, D., & Hiller, J. (2012). Length of stay in hospital and all-cause readmission following elective total joint replacement in elderly men.

Morche, J., Mathes, T., & Pieper, D. (2016). Relationship between surgeon volume and outcomes: a systematic review of systematic reviews. *Systematic reviews, 5*(1), 204.

Moreno, J. L., Wakeman, S. E., Duprey, M. S., Roberts, R. J., Jacobson, J. S., & Devlin, J. W. (2019). Predictors for 30-day and 90-day hospital readmission among patients with opioid use disorder. *Journal of addiction medicine, 13*(4), 306-313.

Mularski, R. A., White-Chu, F., Overbay, D., Miller, L., Asch, S. M., & Ganzini, L. (2006). Measuring pain as the 5th vital sign does not improve quality of pain management. *Journal of general internal medicine, 21*(6), 607-612.

Muncan, B., Walters, S. M., Ezell, J., & Ompad, D. C. (2020). "They look at us like junkies": influences of drug use stigma on the healthcare engagement of people who inject drugs in New York City. *Harm reduction journal, 17*(1), 1-9.

Myers, J., & Compton, P. (2017). Addressing the Potential for Perioperative Relapse in Those Recovering from Opioid Use Disorder. *Pain Medicine, 19*(10), 1908-1915. doi:10.1093/pm/pnx277

National Academies of Sciences Engineering and Medicine. (2019). *Medications for Opioid Use Disorder Save Lives.* National Academies Press.

National Academies of Sciences Engineering and Medicine. (2020). *Framing Opioid Prescribing Guidelines for Acute Pain: Developing the Evidence.* National Academies Press.

National Center for Health Statistics & National Hospital Discharge Survey. (2010). *National hospital discharge survey.* US Department of Health and Human Services, Centers for Disease Control and Prevention.

National Conference of State Legislatures. (2017). Prescribing policies: states confront opioid overdose epidemic.

National Drug Intelligence Center. (2011). *The economic impact of illicit drug use on American society.* United States Department of Justice, Washington, DC.

National Institute on Drug Abuse. (2021). *Opioid Overdose Crisis*. Retrieved from https://www.drugabuse.gov/drug-topics/opioids/opioid-overdose-crisis

National Quality Forum. (2014). *Risk adjustment for socioeconomic status or other sociodemographic factors*.

Neale, J. E. (2001). Patient outcomes: A matter of perspective. *Nursing outlook, 49*(2), 93-99.

Needleman, J., Buerhaus, P., Mattke, S., Stewart, M., & Zelevinsky, K. (2002). Nurse-staffing levels and the quality of care in hospitals. *New England Journal of Medicine, 346*(22), 1715-1722.

Oderda, G. M., Evans, R. S., Lloyd, J., Lipman, A., Chen, C., Ashburn, M., . . . Samore, M. (2003). Cost of opioid-related adverse drug events in surgical patients. *Journal of pain and symptom management, 25*(3), 276-283.

Olufajo, O. A., Metcalfe, D., Yorkgitis, B. K., Cooper, Z., Askari, R., Havens, J. M., . . . Salim, A. (2016). Whatever happens to trauma patients who leave against medical advice? *The American Journal of Surgery, 211*(4), 677-683.

Om, A. (2018). The opioid crisis in black and white: the role of race in our nation's recent drug epidemic. *Journal of Public Health, 40*(4), e614-e615.

Orgera, K., & Tolbert, J. (2019). The Opioid Epidemic and Medicaid's Role in Facilitating Access to Treatment. *Kaiser Family Foundation*.

Owens, P. L., Barrett, M. L., Weiss, A. J., Washington, R. E., & Kronick, R. (2014). Hospital inpatient utilization related to opioid overuse among adults, 1993–2012: statistical brief# 177. *Rockville: Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*.

Owens, P. L., Weiss, A. J., & Barrett, M. L. (2020). Hospital Burden of Opioid-Related Inpatient Stays: Metropolitan and Rural Hospitals, 2016: Statistical Brief #258.

Paquette, C. E., Syvertsen, J. L., & Pollini, R. A. (2018). Stigma at every turn: health services experiences among people who inject drugs. *International Journal of Drug Policy, 57*, 104-110.

Paschkis, Z., & Potter, M. L. (2015). Acute pain management for inpatients with opioid use disorder. *The American journal of nursing, 115*(9), 24-32.

Pennsylvania Department of Health. (2017). ACT 122 of 2016: Safe Emergency Prescribing Act.

Porat-Dahlerbruch, J. (2021). Are Variations in Baccalaureate Nursing Education Pathways Associated with Patient Outcomes? *[Doctoral dissertation, University of Pennsylvania]*.

Press, M. J., Scanlon, D. P., Ryan, A. M., Zhu, J., Navathe, A. S., Mittler, J. N., & Volpp, K. G. (2013). Limits of readmission rates in measuring hospital quality suggest the need for added metrics. *Health Affairs, 32*(6), 1083-1091.

Priest, K. C., Lovejoy, T. I., Englander, H., Shull, S., & McCarty, D. (2020). Opioid Agonist Therapy During Hospitalization Within the Veterans Health Administration: a Pragmatic Retrospective Cohort Analysis. *J Gen Intern Med, 35*(8), 2365-2374. doi:10.1007/s11606-020-05815-0

Pugely, A. J., Callaghan, J. J., Martin, C. T., Cram, P., & Gao, Y. (2013). Incidence of and risk factors for 30-day readmission following elective primary total joint arthroplasty: analysis from the ACS-NSQIP. *The Journal of arthroplasty, 28*(9), 1499-1504.

Ramos, N. L., Karia, R. J., Hutzler, L. H., Brandt, A. M., Slover, J. D., & Bosco, J. A. (2014). The effect of discharge disposition on 30-day readmission rates after total joint arthroplasty. *The Journal of arthroplasty, 29*(4), 674-677.

Ringwalt, C., Roberts, A. W., Gugelmann, H., & Skinner, A. C. (2015). Racial disparities across provider specialties in opioid prescriptions dispensed to Medicaid beneficiaries with chronic noncancer pain. *Pain Medicine, 16*(4), 633-640.

Roux, A. V. D., Merkin, S. S., Arnett, D., Chambless, L., Massing, M., Nieto, F. J., . . . Watson, R. L. (2001). Neighborhood of residence and incidence of coronary heart disease. *New England Journal of Medicine, 345*(2), 99-106.

Rozell, J. C., Courtney, P. M., Dattilo, J. R., Wu, C. H., & Lee, G.-C. (2017). Preoperative opiate use independently predicts narcotic consumption and complications after total joint arthroplasty. *The Journal of arthroplasty, 32*(9), 2658-2662.

Rubenstein, W., Grace, T., Croci, R., & Ward, D. (2018). The interaction of depression and prior opioid use on pain and opioid requirements after total joint arthroplasty. *Arthroplasty Today, 4*(4), 464-469. doi:10.1016/j.artd.2018.07.002

Rudd, R. A., Seth, P., David, F., & Scholl, L. (2016). Increases in drug and opioid-involved overdose deaths—United States, 2010–2015. *Morbidity and mortality weekly report, 65*(50 & 51), 1445-1452.

Rutkow, L., Chang, H.-Y., Daubresse, M., Webster, D. W., Stuart, E. A., & Alexander, G. C. (2015). Effect of Florida’s prescription drug monitoring program and pill mill laws on opioid prescribing and use. *JAMA internal medicine, 175*(10), 1642-1649.

Saunders, J. B., Jarlenski, M. P., Levy, R., & Kozhimannil, K. B. (2018). Federal and state policy efforts to address maternal opioid misuse: gaps and challenges. *Women's health issues, 28*(2), 130-136.

Sayal, P., Bateman, B. T., Menendez, M., Eikermann, M., & Ladha, K. S. (2018). Opioid use disorders and the risk of postoperative pulmonary complications. *Anesthesia and analgesia, 127*(3), 767-774. doi:10.1213/ANE.0000000000003307

Schairer, W. W., Vail, T. P., & Bozic, K. J. (2014). What are the rates and causes of hospital readmission after total knee arthroplasty? *Clinical Orthopaedics and Related Research®, 472*(1), 181-187.

Schechter, M. S., Shelton, B. J., Margolis, P. A., & FitzSimmons, S. C. (2001). The association of socioeconomic status with outcomes in cystic fibrosis patients in the United States. *American journal of respiratory and critical care medicine, 163*(6), 1331-1337.

Schoenfeld, A. J., Jiang, W., Harris, M. B., Cooper, Z., Koehlmoos, T., Learn, P. A., . . . Haider, A. H. (2017). Association between race and postoperative outcomes in a universally insured population versus patients in the state of California. *Annals of surgery, 266*(2), 267-273.

Scholl, L., Seth, P., Kariisa, M., Wilson, N., & Baldwin, G. (2019). Drug and opioid-involved overdose deaths—United States, 2013–2017. *Morbidity and mortality weekly report, 67*(51-52), 1419.

Segel, J. E., Shi, Y., Moran, J. R., & Scanlon, D. P. (2019). Revenue Losses to State and Federal Government From Opioid-related Employment Reductions. *Medical Care, 57*(7).

Sharfstein, J. M., & Olsen, Y. (2019). Lessons learned from the opioid epidemic. *Jama, 322*(9), 809-810.

Silber, J. H., Kennedy, S. K., Even-Shoshan, O., Chen, W., Koziol, L. F., Showan, A. M., & Longnecker, D. E. (2000). Anesthesiologist direction and patient outcomes. *Anesthesiology: The Journal of the American Society of Anesthesiologists, 93*(1), 152-163.

Silber, J. H., Rosenbaum, P. R., McHugh, M. D., Ludwig, J. M., Smith, H. L., Niknam, B. A., . . . Aiken, L. H. (2016). Comparison of the value of nursing work environments in hospitals across different levels of patient risk. *JAMA Surgery, 151*(6), 527-536.

Silber, J. H., Williams, S. V., Krakauer, H., & Schwartz, J. S. (1992). Hospital and patient characteristics associated with death after surgery: a study of adverse occurrence and failure to rescue. *Medical care*, 615-629.

Simon, R., Snow, R., & Wakeman, S. (2019). Understanding why patients with substance use disorders leave the hospital against medical advice: a qualitative study. *Substance Abuse*, 1-7.

Sinatra, R. (2010). Causes and consequences of inadequate management of acute pain. *Pain Medicine, 11*(12), 1859-1871.

Sing, D. C., Barry, J. J., Cheah, J. W., Vail, T. P., & Hansen, E. N. (2016). Long-acting opioid use independently predicts perioperative complication in total joint arthroplasty. *The Journal of arthroplasty, 31*(9), 170-174. e171.

Sledge, W., Bozzo, J., White-McCullum, B., & Lee, H. (2016). The cost-benefit from the perspective of the hospital of a proactive psychiatric consultation service on inpatient general medicine services. *Health Econ Outcome Res Open Access, 2*(4), 122.

Sloane, D. M., Smith, H. L., McHugh, M. D., & Aiken, L. H. (2018). Effect of changes in hospital nursing resources on improvements in patient safety and quality of care: a panel study. *Medical Care, 56*(12), 1001.

Small, D. (2001). The war on drugs is a war on racial justice. *Social Research*, 896-903.

Smith, S. B. (2010). Exploration of the evidence to support clinical practice to decrease hospital readmission rates for patients with chronic pancreatitis. *[Thesis, University of South Carolina]*.

Song, Y., Tang, R., Roses, R. E., Fraker, D. L., DeMatteo, R. P., Kelz, R. R., & Karakousis, G. C. (2019). Opioid Use Disorder is Associated With Complications and Increased Length of Stay After Major Abdominal Surgery. *Annals of surgery*.

Southern, W. N., Nahvi, S., & Arnsten, J. H. (2012). Increased risk of mortality and readmission among patients discharged against medical advice. *The American journal of medicine, 125*(6), 594-602.

Stimpfel, A. W., Sloane, D. M., McHugh, M. D., & Aiken, L. H. (2016). Hospitals known for nursing excellence associated with better hospital experience for patients. *Health services research, 51*(3), 1120-1134.

Stimson, C., Chang, S. S., Barocas, D. A., Humphrey, J. E., Patel, S. G., Clark, P. E., . . . Cookson, M. S. (2010). Early and late perioperative outcomes following radical cystectomy: 90-day readmissions, morbidity and mortality in a contemporary series. *The Journal of urology, 184*(4), 1296-1300.

Strang, J., Volkow, N. D., Degenhardt, L., Hickman, M., Johnson, K., Koob, G. F., . . . Walsh, S. L. (2020). Opioid use disorder. *Nature Reviews Disease Primers, 6*(1), 1-28.

Stromer, W., Michaeli, K., & Sandner-Kiesling, A. (2013). Perioperative pain therapy in opioid abuse. *European Journal of Anaesthesiology, 30*(2), 55-64. doi:10.1097/EJA.0b013e32835b822b

Theisen-Toupal, J., Ronan, M. V., Moore, A., & Rosenthal, E. S. (2017). Inpatient Management of Opioid Use Disorder: A Review for Hospitalists. *Journal of hospital medicine, 12*(5), 369.

Ti, L., & Ti, L. (2015). Leaving the hospital against medical advice among people who use illicit drugs: a systematic review. *American journal of public health, 105*(12), e53-e59.

Tolarba, J. (2015). The Role Of The Psychiatric-Mental Health Advanced Practice Nurse In The Behavioral Intervention Team (bit) Model Of Care.

Toney-Butler, T. J., & Thayer, J. M. (2019). Nursing process.

Tsai, T. C., Joynt, K. E., Orav, E. J., Gawande, A. A., & Jha, A. K. (2013). Variation in surgical-readmission rates and quality of hospital care. *New England Journal of Medicine, 369*(12), 1134-1142.

UCLA. (n.d.). *Institute for Digital Research & Education Statistical Consulting. Zero-Truncated Negative Binomial | STATA Data Analysis Examples.* Retrieved from https://stats.idre.ucla.edu/stata/dae/zero-truncated-%20negative-binomial/

United States Census Bureau. (2016). *Core-Based Statistical Areas*. Retrieved from https://www.census.gov/topics/housing/housing-patterns/about/core-based-statistical-areas.html

Van Boekel, L. C., Brouwers, E. P., Van Weeghel, J., & Garretsen, H. F. (2013). Stigma among health professionals towards patients with substance use disorders and its consequences for healthcare delivery: systematic review. *Drug and alcohol dependence, 131*(1-2), 23-35.

Volkow, N. D., & McLellan, A. T. (2016). Opioid abuse in chronic pain—misconceptions and mitigation strategies. *New England Journal of Medicine, 374*(13), 1253-1263.

Voskuijl, T., Hageman, M., & Ring, D. (2014). Higher Charlson Comorbidity Index Scores are associated with readmission after orthopaedic surgery. *Clinical Orthopaedics and Related Research®, 472*(5), 1638-1644.

Wakeman, S. E., Metlay, J. P., Chang, Y., Herman, G. E., & Rigotti, N. A. (2017). Inpatient addiction consultation for hospitalized patients increases post-discharge abstinence and reduces addiction severity. *Journal of general internal medicine, 32*(8), 909-916.

Waljee, J., Cron, D., Steiger, R., Zhong, L., Englesbe, M., & Brummett, C. (2017). The Effect of Preoperative Opioid Exposure on Healthcare Utilization and Expenditures Following Elective Abdominal Surgery. *Annals of surgery, 265*(4), 715.

Weick, J., Bawa, H., Dirschl, D. R., & Luu, H. H. (2018). Preoperative opioid use is associated with higher readmission and revision rates in total knee and total hip arthroplasty. *JBJS, 100*(14), 1171-1176.

Weil, A. (2003). There's something about Medicaid. *Health Affairs, 22*(1), 13-30.

Weiss, A. J., Heslin, K. C., Stocks, C., & Owens, P. L. (2020). Hospital Inpatient Stays Related to Opioid Use Disorder and Endocarditis, 2016: Statistical Brief# 256.

Weissman, J. S., Stern, R. S., & Epstein, A. M. (1994). The impact of patient socioeconomic status and other social factors on readmission: a prospective study in four Massachusetts hospitals. *Inquiry*, 163-172.

Werner, R. M., Goldman, L. E., & Dudley, R. A. (2008). Comparison of change in quality of care between safety-net and non–safety-net hospitals. *Jama, 299*(18), 2180-2187.

White, E. M., Smith, J. G., Trotta, R. L., & McHugh, M. D. (2018). Lower Postsurgical Mortality for Individuals with Dementia with Better-Educated Hospital Workforce. *Journal of the American Geriatrics Society*.

Wickramatilake, S., Zur, J., Mulvaney-Day, N., Klimo, M. C. v., Selmi, E., & Harwood, H. (2017). How states are tackling the opioid crisis. *Public Health Reports, 132*(2), 171-179.

Williams, L. B., Bourgault, A. B., Valenti, M., Howie, M., & Mathur, S. (2018). Predictors of underrepresented nursing students' school satisfaction, success, and future education intent. *Journal of Nursing Education, 57*(3), 142-149.

Wilson, J. M., Farley, K. X., Aizpuru, M., Wagner, E. R., Bradbury, T. L., & Guild, G. N. (2019). The impact of preoperative opioid use disorder on complications and costs following primary total hip and knee arthroplasty. *Advances in orthopedics, 2019*.

Wiltse Nicely, K. L., Sloane, D. M., & Aiken, L. H. (2013). Lower mortality for abdominal aortic aneurysm repair in high-volume hospitals is contingent upon nurse staffing. *Health services research, 48*(3), 972-991.

World Health Organization. (1996). *Cancer pain relief: with a guide to opioid availability* World Health Organization.

Wu, L.-T., Zhu, H., & Swartz, M. S. (2016). Treatment utilization among persons with opioid use disorder in the United States. *Drug and alcohol dependence, 169*, 117-127.

Wyman, M. F., Kallio, P., Allred, E., & Meyer, D. (2014). A group-based brief intervention for surgery patients with high-risk substance use. *General Hospital Psychiatry, 36*(6), 637-643. doi:http://dx.doi.org/10.1016/j.genhosppsych.2014.08.002

Yakusheva, O., Lindrooth, R., & Weiss, M. (2014). Economic evaluation of the 80% baccalaureate nurse workforce recommendation: a patient-level analysis. *Medical Care*, 864-869.

Young, S. R., Azari, S., Becker, W. C., Edelman, E. J., Liebschutz, J. M., Roy, P., . . . Merlin, J. S. (2020). Common and challenging behaviors among individuals on long-term opioid therapy. *Journal of addiction medicine, 14*(4), 305-310.

Zmistowski, B., Karam, J. A., Durinka, J. B., Casper, D. S., & Parvizi, J. (2013). Periprosthetic joint infection increases the risk of one-year mortality. *JBJS, 95*(24), 2177-2184.

Zmistowski, B., Restrepo, C., Hess, J., Adibi, D., Cangoz, S., & Parvizi, J. (2013). Unplanned readmission after total joint arthroplasty: rates, reasons, and risk factors. *JBJS, 95*(20), 1869-1876.

Zoorob, M. (2019). Fentanyl shock: The changing geography of overdose in the United States. *International Journal of Drug Policy, 70*, 40-46.

Zuckerman, R. B., Sheingold, S. H., Orav, E. J., Ruhter, J., & Epstein, A. M. (2016). Readmissions, observation, and the hospital readmissions reduction program. *New England Journal of Medicine, 374*(16), 1543-1551.