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Evaluation of Recovery Level and Surgical Site Infection for Hip Replacement Surgeries

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Walden University
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Abstract

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Dissertation Submitted in Fulfillment

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Abstract

Surgical site infection (SSI) is one of the most common healthcare associated infections and is a major cause of morbidity and mortality. Existing studies have focused primarily on perioperative intervention strategies to reduce infection risks following total joint replacement (TJA) procedures. However, postoperative (post-op) SSI risk factors may account for a significant percentage of hospital readmissions due to infections at the surgical site. Therefore, the purpose of this study was to examine the association between post-op recovery level and SSI among patients who underwent primary hip arthroplasty procedures. Using the social ecological model, which conceptualizes health broadly and focuses on multiple factors that might affect a patient's recovery level, a retrospective study design was used to examine possible associations between the variables of SSIs and recovery levels by examining readmissions data from electronic medical records at one hospital. SSIs were classified based on National Healthcare Safety Network (NHSN) criteria. Results indicated that recovery level had an influence on healthcare-associated hip infections but not on level of depth of primary hip infections. Further, variables including age, acuity, length of hospital stay, and insurance type were not predictors of healthcare-associated primary hip infections. This study is significant to epidemiology in terms of developing a baseline for identifying and addressing SSI risk factors at various post-op recovery levels and developing new initiatives to reduce healthcare associated SSI rates and therefore ultimately reducing healthcare expenditures in the United States.

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Dedication

This dissertation study is dedicated to my mother, Jamie Foster, and grandparents, James D. Simpson Sr. and Fannie M. Simpson. These 3 individuals were extremely influential and supportive not only throughout my academic journey but throughout my entire life. They each provided me the tools and resources necessary to gain the knowledge and build the skill sets that I have today. Their encouragement has enabled me to attain new academic heights and ultimately pursue my dreams.

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I would like to acknowledge Carlee Hoxworth, my Infection Prevention colleague, who gave me the idea to look for a research gap focused on recovery level and surgical site infection. In addition, I would like to thank my Managers Helen Wood and Lydia Grimes for supporting my decision to use internal data from Barnes-Jewish Hospital Infection Prevention Department to answer my research questions. I would be remiss not to acknowledge my Chair, Dr. Leah Miller and Second Committee Member, Dr. Howell Sasser, who went above and beyond to assist me with development of this dissertation study. The amount of guidance, support, and encouragement that I received from my committee, all while allowing me to work independently was instrumental for the development of this study. Last, I want to acknowledge my friends and family for their continued support and for keeping me motivated throughout this doctoral journey.

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Chapter 1: Introduction to the Study

Surgical site infection (SSI) is one of the most common nosocomial infections and is a major cause of morbidity and mortality, resulting in increased hospital stay and readmissions, as well as financial burden (Ashraf et al., 2018). Adeyemi & Trueman (2019) argued that SSI-related readmissions following surgical procedures account for almost 1 million additional inpatient days and $1.6 billion in costs. With an increasingly aging population presenting with comorbidities, managing the risk of postoperative complications, including SSIs, represents a significant challenge to healthcare providers (Adeyemi & Trueman, 2019). In addition, high SSI rates are associated with negative economic consequences (Turner & Migaly, 2019). A longer hospital stay represents a direct cost to the hospital system and the payer, but also has patient and societal economic implications from cost of supplies and nursing care, to extended loss of work/productivity (Turner & Migaly, 2019). As a result, financial incentives and penalties are associated with SSI outlier status through the Centers for Medicare and Medicaid Services (CMS; Turner & Migaly, 2019). Intrinsic costs of SSI to patient care are in the management of the infection include additional operations, procedures, nursing, wound management personnel time, infectious disease interventions, loss of time from work, and costs associated with home health (Turner & Migaly, 2019). Extrinsic costs are substantial, including time away from work, functional decline, litigation, the reputation of the medical center, and the impact of variable reimbursement and penalties based on performance (Turner & Migaly, 2019). Additional costs accrued by patients with an SSI have been reported in a wide range from $1,400 to $40,500, with superficial SSI accruing less cost than deep or organ/space infections (Turner & Migaly, 2019).

SSIs after total joint arthroplasty (TJA) places a significant burden on patients, surgeons, the healthcare system, and the economy (Mistry et al., 2017). Revision procedures that address infection after total hip arthroplasty (THA) are associated with more hospitalizations, longer hospital stay, more operations, and higher outpatient costs in comparison with primary THAs and revision surgeries for aseptic loosening (Mistry et al., 2017). If left untreated, an SSI can go deeper into the joint and develop into a periprosthetic joint (PJI) infection, which can pose more serious health complications and significantly higher financial costs to patients (Mistry et al., 2017). A recent PJI study that used a 2001 to 2009 Nationwide Inpatient Sample (NIS) data found that the cost of revision procedures increased from $320 million to $560 million and was projected to reach $1.62 billion by 2020, also incurring indirect costs on the economy (Mistry et al., 2017). Therefore, the issue of infection after TJA is concerning on both the individual and economic level.

Problem Statement

Total joint replacement remains a serious concern as it places a major burden on patients, healthcare workers, and the economy. Existing studies have focused primarily on peri-operative intervention strategies to reduce infection risks following total joint arthroplasty procedures however, post-operative SSI risk factors may account for a significant percentage of hospital readmissions due to infections at the surgical site. Perioperative nurses and surgeons practice a variety of evidence-based best practices to prevent SSIs and facilitate a safe surgical experience for their patients including hand hygiene, patient skin antisepsis, decolonization, antibiotic timing, normothermia, glycemic control, and antimicrobial irrigations (Bashaw & Keister, 2019). Bathing with antiseptic agents on the evening before and morning of surgery is recommended by the Centers for Disease Control and Prevention (Kapadia et al., 2016). Chlorhexidine is an antiseptic that exerts its bactericidal effects through direct disruption of the organisms' membrane permeability and is thus an effective broad-spectrum biocide agent (Kapadia et al., 2016). Several studies have shown that chlorhexidine was efficacious to decrease postoperative infection risk (Kapadia et al., 2016). Decolonization can be effective against endogenous organisms on the patient's skin by following protocols stipulating the use of intranasal mupirocin (Rohrer et al., 2020). One groundbreaking randomized controlled trial by Bode et al. (2010) analyzed the effect of preoperative decolonization of *Staphylococcus aureus* carriers on the incidence of hospital-associated infections and found that the procedure reduced infection rates from 7.7% in the control group to 3.4% in the intervention group (Rohrer et al., 2020). Current guidelines issued by the American Society of Health-System Pharmacists, the Society for Healthcare Epidemiology of America, and Infectious Diseases Society of America recommend the most optimal prophylaxis administration within 60 minutes prior to incision (de Jonge et al., 2017). However, there is a lack of research on the association of recovery location and SSI risks.

Purpose of the Study

This study investigated the association between postoperative recovery level and healthcare associated SSI among patients who underwent primary hip arthroplasty procedures. This study also examined whether there is an association between postoperative recovery level and level of depth of SSI among patients who underwent primary hip arthroplasty procedures.

Research Questions

Research Question 1: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and healthcare-associated surgical site infections (yes or no) among patients that underwent primary hip arthroplasty procedures?

$H_0$1: There is no association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and healthcare-associated surgical site infection (yes or no) among patients that underwent primary hip arthroplasty procedures.

H_a1: There is an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and healthcare-associated surgical site infections (yes or no) among patients that underwent primary hip arthroplasty procedures.

Research Question 2: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and level of depth of surgical site infection (superficial incisional, deep incisional, or organ/space) among patients that underwent primary hip arthroplasty procedures?

$H_0$2: There is no association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and level of depth of surgical site infection (superficial incisional, deep incisional, organ/space) among patients that underwent primary hip arthroplasty procedures.

H_a2: There is an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and level of depth of surgical site infection (superficial incisional, deep incisional, organ/space) among patients that underwent primary hip arthroplasty procedures.

Theoretical Foundation

The social ecological model (SEM) conceptualizes health broadly and focuses on multiple factors that might affect health (US Department of Health and Human Services, n.d.). The model, which advanced in the 1947 Constitution of the World Health Organization, includes physical, mental, and social well-being and exemplifies the interaction between the individual, the group/community, and the physical, social, and political environments (US Department of Health and Human Services, n.d.). Stokols (1996) proposed four core principles that underlie the ways the SEM can contribute to efforts to influence individuals and communities: (a) health status, emotional well-being, and social cohesion are influenced by the physical, social, and cultural dimensions of the individual's or community's environment and personal attributes; (b) the same environment may have different effects on an individual's health depending on a variety of factors, including perceptions of ability to control the environment and financial resources; (c) individuals and groups operate in multiple environments that influence each other; and (d) there are personal and environmental leverage points, such as the physical environment, available resources, and social norms, that exert vital influences on health and well-being (US Department of Health and Human Services, n.d.).

SEMs are used to explain the complex associations between social and structural factors (such as access to care), individual practices, the physical environment, and health (Baral et al., 2013). The SEM contextualizes individuals' behaviors using dimensions including individual, interpersonal, organizational, community, and public policy to provide a framework for describing the interaction between these levels (Baral et al., 2013). Application of the SEM can enable a better understanding of the factors determining recovery level among patients who have undergone primary hip procedures. A review of the literature pertaining to correlates of SSI will be conducted and applied to a social ecological perspective. Understanding social correlates of recovery level among patients who undergo primary hip arthroplasties was necessary to gain an understanding of potential confounding factors that could influence an individual's recovery level and risk for SSI.

Nature of the Study

This quantitative, retrospective study examined possible associations among level of postoperative recovery and healthcare-associated hip infections among patients that underwent primary hip arthroplasty procedures at Barnes-Jewish Hospital between January 2019 and December 2021 and were subsequently readmitted. This study also examined possible associations between post-operative recovery level and level of depth of SSI among patients who underwent primary hip arthroplasty procedures at Barnes-Jewish Hospital between January 2019 and December 2021 and were subsequently readmitted. Hip infections were determined to be healthcare associated or not healthcare associated based on case reviews by infection prevention specialists at Barnes-Jewish Hospital's Infection Prevention Department. National Healthcare Safety Network (NHSN) definitions were used to determine if hip infections met criteria for healthcare-associated infections. The following details were used verbatim: "An NHSN Operative Procedure is a procedure that is included in the ICD-10-PCS and or/ CPT NHSN operative code mapping; takes place during an operation where at least one incision (including laparoscopic approach and cranial Burr holes) is made through the skin or mucous membrane; and takes place in an operating room (OR), defined as a patient care area that met the Facilities Guidelines Institute (FGI) or American Institute of Architects' (AIA) criteria for an operating room when it was constructed or renovated" (NHSN, 2021).

Definitions

The criteria used to define SSIs and a patient's SSI risk index categories were established according to the Centers for Disease Control and Prevention's NHSN definitions.

Date of Event: For an SSI, the date of event is the date when the first element used to meet the SSI infection criterion occurs for the first time during the SSI surveillance period (NHSN, 2021).

Infection Window Period: The infection window period is defined as the 7 days during which all site-specific criteria must be met (NHSN, 2021).

Superficial Incisional SSI: In order for a SSI to meet criteria for superficial SSI: the date of event must occur within 30 days after the NHSN operative procedure (where Day 1 = the procedure date); and involves only skin and subcutaneous tissue of the incision; and patient has either purulent drainage from the superficial incision, organism(s) identified from an aseptically-obtained specimen from the superficial incision or subcutaneous tissue, or the superficial incision was deliberatively opened by a surgeon, physician or physician designee and the patient has symptoms of localized pain or tenderness, localized swelling, erythema, or heat (NHSN, 2021).

Deep incisional SSI: In order for an SSI to meet criteria for a deep incisional SSI: the date of event must occur between 30 and 90 days after the NHSN operative procedure (where Day 1 = the procedure date); and involves deep soft tissues of the incision; and the patient has either purulent drainage from the deep incision, a deep incision that spontaneously dehisces or is deliberately opened or aspirated by a surgeon, physician or physician designee and organism(s) are identified from the deep soft tissues of the incision and the patient has a fever (greater than 38* C), localized pain or tenderness; or an abscess or evidence of infection involving the deep incision (NHSN, 2021).

Organ/space SSI: In order for an SSI to meet criteria for organ/space SSI: the date of event must occur within 30 to 90 days after the NHSN operative procedure (where Day 1 = the procedure date); and involves any part of the body deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure; and the patient either has purulent drainage from a drain that is placed into the organ/space, organism(s) identified from fluid or tissue in the organ/space, or an abscess or other evidence of infection involving the organ space; and meets at least one criterion for a specific organ/space infection (NHSN, 2021).

SSIs were classified into three groups: (a) superficial, involving skin and subcutaneous tissue; (b) deep, involving muscle and fascia; and (c) organ space (Hamza et al., 2018). According to the NHSN, these criteria were adapted from the American College of Surgeons classification where wounds were classified into four classes: clean, clean-contaminated, contaminated, or dirty-infected (Hamza et al., 2018). The American Society of Anesthesiologist (ASA) score was based on an assessment by the anesthesiologist of the patient's preoperative physical condition using the ASA classification (Hamza et al., 2018). Patients are assigned an ASA score of 1-6 at time of surgery (National Healthcare Safety Network, 2021). Patients with an ASA score of 1-5 are eligible for NHSN SSI surveillance (NHSN, 2021). An ASA score of 1 is assigned to healthy patients; an ASA score of 2 is assigned to patients with mild systemic disease; an ASA score 3 is assigned to patients with moderate to severe systemic disease; an ASA score 4 is assigned to patients with severe systemic, life-threatening disease; and an ASA score 5 is assigned to patients without expected survival through surgery (Daabiss, 2011). Patients who are assigned an ASA score of 6 (a declared brain-dead patient whose organs are being removed for donor purposes) are not eligible for NHSN SSI surveillance (NHSN, 2021). Patients with SSIs were defined as patients who underwent primary TJA during the study period at Barnes-Jewish Hospital, were readmitted with an infection at the surgical site within 90 days of the index procedure date, and met NHSN SSI criteria.

Assumptions

The instrument used for determination of SSIs is assumed to elicit consistent results. There was no subjectivity around determinations of whether an SSI was healthcare-associated, based on objective NHSN definitions. The Centers for Diseases Control and Prevention's (CDC's) NHSN is the nation's most widely used healthcare-associated infection tracking system (CDC, n.d.). NHSN provides facilities, states, regions, and the nation with data needed to identify problem areas, measure progress of prevention efforts, and ultimately eliminate healthcare-associated infections (CDC, n.d.).

Scope and Delimitations

This study excludes patients who underwent revision TJA procedures, therefore, only includes patients who underwent primary TJA and patients who were assigned an ASA score of 5 or less were included. Despite the ability of TJA to improve the functional status and quality of life for many patients, compared with primary TJA, revision TJA is technically challenging and may require extensive surgical exposure and careful management of periprosthetic bone loss (Ong et al., 2010). The complexity of revision TJA also is reflected by the higher hospital cost, longer length of stay, and longer operative time compared with primary procedures (Ong et al., 2010). Revision TJAs are associated with elevated risks of complications such as dislocations, infections, venous thromboembolism, and mortality (Ong et al., 2010). Improvement in quality of life after revision surgery also may be more limited in comparison to primary TJA (Ong et al., 2010). This study focused on primary TJA to reduce the introduction of other extraneous risk factors resulting from subsequent procedures done at the primary incision site.

Limitations

Data were obtained from electronic medical records of patients readmitted to a Level 1 trauma hospital in the heart of a metropolitan area in St. Louis, MO and excluded data from other hospitals or regions around the world. In addition, many of the patients included in this study were older and posed a higher risk for post-operative complications. A potential limitation of this study includes possible measurement error in terms of capturing SSIs among infected patients who were not readmitted. Measurement error is one of the key challenges to making valid inferences in clinical research (Brakenhoff et al., 2018). Errors in measurements can arise due to inaccuracy or imprecision of measurement instruments, single measurements of variable longitudinal processes, or non-adherence to measurement protocols (Brakenhoff et al., 2018). In addition, various facility types may report SSIs more timely and accurately than others, thus giving a false representation of the true incidence of SSIs at each type of facility. In addition, there was no consensus on guidance to follow for post-discharge surveillance as there is for inpatient surveillance of SSI. To minimize this issue, coefficient of variation was used as a measure of variability of a distribution of repeated scores or measurements. Errors in measuring exposure or disease can be an important source of bias in epidemiological studies (The BMJ, n.d.).

Significance of the Study

This study is significant to epidemiology in terms of developing a baseline for risk stratification by postoperative recovery level, and development of new initiatives to reduce healthcare associated SSI rates, ultimately reducing healthcare expenditures in the United States. This study is significant to theory and practice as it may serve as evidence-based literature that a specific level of postoperative recovery is better for best outcomes for patients following TJA and could be used as a reference for healthcare workers when making recommendations for post-operative patients at discharge. In addition, this research may serve as a baseline for understanding barriers based on components of the SEM which may influence a patient's choice of post-operative recovery level.

Little is known about patient safety risks in outpatient surgery; however, inpatient surgical adverse events risk factors include patient- (e.g., advanced age), process- (e.g., inadequate preoperative assessment), or structure-related characteristics (e.g., low surgical volume; Mull et al., 2021). Perioperative strategies to prevent SSIs include hand hygiene, patient skin antisepsis, decolonization, antibiotic timing, normothermia, and glycemic control (Bashaw & Keister, 2019). However, these SSI risk factors may be more challenging to control within various levels of post-operative recovery. This dissertation study used the SEM as a framework for understanding the problem of SSI risks stratified by levels of post-operative recovery. This dissertation study is significant to social change as it may highlight common risk factors within various post-discharge care facilities and serve as a baseline for eliminating those risks.

Chapter 2: Literature Review

Total joint replacement remains a serious concern as it places a major burden on patients, healthcare workers, and the economy. Existing studies have focused primarily on perioperative intervention strategies to reduce infection risks following total joint arthroplasty procedures; however, postoperative SSI risk factors may account for a significant percentage of hospital readmissions due to infections at the surgical site. This study investigated the association between postoperative recovery level and healthcare associated SSI among patients who underwent primary hip arthroplasty procedures. This study also examined whether there was an association between postoperative recovery level and level of depth of SSI among patients who underwent primary hip arthroplasty procedures. An extensive literature review was conducted, focusing on total joint arthroplasty, modifiable and nonmodifiable SSI risk factors, perioperative SSI risk factors, and post-discharge surveillance.

Literature Search Strategy

Databases used for the literature review included MEDLINE with Full Text/PubMed, EBSCO, CINAHL, PsycInfo, SocIndex, ScienceDirect, Academic Search, and Education Source. Keywords used within these databases included *SSIs, risk factors, readmissions, inpatient or outpatient facility, discharge facility*, and *recovery facility*. There were 122 articles reviewed and 78 articles retrieved for this study.

Theoretical Foundation

The Social Ecological Model (SEM) is a framework put in place in order to understand the multifaceted levels within a society and how individuals and the environment interact within a social system (Aronica et al., 2010). Different factors and determinants exist at all levels of health, making prevention, control, and intervention most effective when the model is addressed from all levels (Aronica et al., 2010). According to the CDC, in order to prevent certain risk factors, it is necessary to take action with multiple levels of the model at the same time (CDC, 2018). When approaching a potential problem, it has been proven that in order to best sustain prevention efforts, action should be taken at multiple levels of the model at the same time.

The SEM is composed of five stages including individual, interpersonal, organizational, community, and public policy. The individual level is concerned with an individual's knowledge and skills; knowledge about SSI risks helps the individual understand more about it and helps inform them about their susceptibility to infection, as well as severity and overall threat of SSI (Aronica et al., 2010). The interpersonal level involves a person's relationships with other people. At this level, friends and family of the individual may have regular talks in regard to options the patient has for recovery level after discharge following primary total hip arthroplasty. The organizational level has the opportunity to reach more people in different sectors of the community (Aronica et al., 2010). Organizations like hospitals and medical insurance companies can provide post-discharge education and recommendations for recovery level tailored to best fit the individual's needs. In this model, a community refers to the culmination of the various organizations in an area and these organizations can pool resources and ideas together in order to improve community health (Aronica et al., 2010). For example, a hospital may agree to have some of its nurses teach postoperative joint care education for all surgical patients. Organizations could coordinate health events designed to educate and equip healthcare affiliates with knowledge and materials to help prevent SSI risks (Aronica et al., 2010). At the final level, public policy, the governing bodies lead the prevention effort (Aronica et al., 2010). They do this by establishing agencies and laws at every level of government to do research on preventing SSIs and figure out more effective ways of dealing with the problem (Aronica et al., 2010).

Wong & Leland (2018) sought to identify rehabilitation providers' perspectives on barriers and facilitators of patient engagement in hip fracture patients in skilled nursing facilities within the SEM. Wong & Leland (2018) used the SEM as a framework to organize the subthemes that arose from the data, distinguishing between barriers and facilitators of patient engagement and identifying strategies to overcome those barriers. Clinicians identified barriers and facilitators of patient engagement across all levels of the SEM: public policy (e.g., insurance), organizational (e.g., facility culture), interpersonal (e.g., clinicians fostering self-reflection), and intrapersonal (e.g., patients' anxiety; Wong & Leland, 2018). In a cross-sectional study aiming to assess whether socioecological variables of 100 families of patients who received dental treatment under general anesthesia would return for postoperative care, Mathu-Muju et al. (2010) found that 47% of patients returned for postop care. Rose & Newman (2016) conducted a scoping review to identify key factors affecting patient safety during the process of postoperative handovers. Factors at multiple levels of the SEM affecting patient safety and handovers were identified: intrapersonal factors included individual communication styles, interpersonal factors were related to anesthesia and to PACU provider team dynamics, organizational environmental factors described the dynamic PACU environment, and organizational policy-level factors included emphasizing a culture of patient safety (Rose & Newman, 2016).

Total Joint Arthroplasty

Total Joint Arthroplasty (TJA) is one of the most performed elective surgical procedures in the US and the volume of primary and revision TJA has risen dramatically over the past several decades (Sloan et al., 2018). Wilson et al. (2008) reported that the US TJA marked doubled in value from 2002 to 2005, reaching $5 billion. Kurtz et al. (2014) reported on the epidemiology of TJA in the US, projecting that primary TKA annual volume will reach 1.37 million by 2020, 3.48 million by 2020 and 3.48 million by 2030; and primary THA volume will reach 511,000 by 2020 and 572,000 by 2030.

The overall incidence of SSI for total hip arthroplasty (THA) and total knee arthroplasty (TKA) is 1.69% and 2.82%, respectively, and it increased up to 3.68% in revision hip surgery (Ashraf et al., 2018). As life expectancy continues to improve, healthcare administrators anticipate a corresponding rise in the incidence of total hip and knee replacement procedures (Adeyemi & Trueman, 2019). The projected demand increase for total knee replacement procedures by 2030 has also been projected to have a corresponding increase in Medicare payments to hospitals (Adeyemi & Trueman, 2019). Adeyemi & Trueman (2019) stated that SSIs following total joint replacement are associated with significant healthcare utilization and worsened quality of life in patients. Batty & Lanting (2020) argued that prosthetic joint infection remains a serious concern in lower limb arthroplasty and studies have focused primarily on peri-operative intervention strategies to reduce infection risks following hip and knee arthroplasties. However, post-operative SSI risk factors may account for a significant percentage of hospital readmissions due to infections at the surgical site.

Modifiable and Non-modifiable Risk Factors

Numerous pre-existing risk factors have been identified for SSI, including non-modifiable risk factors such as diabetes, renal disease, rheumatoid arthritis, male gender in total knee arthroplasty (TKA) and female gender in total hip arthroplasty (THA; Almustafa, M. A. et al., 2018). Diabetes prevalence is increasing in the United States, and the appropriate control of patients with diabetes has become increasingly important for the prevention of hospital-acquired infections (Al-Mohawis et al., 2021). There is a significant body of existing literature about the impact of diabetes on increased rates of SSI and the potentially related impact of hyperglycemia on SSI (Al-Mohawis et al., 2021). In a recent study to identify for which procedures male or female sex represents an independent risk factor for SSI, Aghdassi et al. (2019) found that; for orthopedics, trauma and abdominal surgery, SSI-rates were significantly higher for male patients; for heart and vascular surgery, SSI-rates were significantly higher for female patients; and other included surgical categories and individual procedures yielded diverse results (Aghdassi et al., 2019). Similar results were found when solely analyzing deep and organ-space SSI (Aghdassi et al., 2019).

Modifiable risk factors that have been identified in existing literature include obesity, smoking, anemia, post-operative blood transfusion, steroid therapy and malnutrition (Almustafa, M. A. et al., 2018). Bhakta et al. (2016) reported that a within-group analysis investigating the independent variables associated with SSI, determined that male sex, obesity, diabetes mellitus control, and smoking were discovered to be significantly associated with SSI. In a study investigating whether the addition of a “colorectal closure bundle” in enhanced recovery after surgery pathway decreased SSI rates; Ghuman et al. (2015) reported that the results of univariate and multivariate analyses of potential SSI risk factors indicated that smoking, diabetes mellitus control, and incision location were found to be significant factors. After controlling for perioperative antibiotic use, Al-Niaimi et al (2015) identified independent hazard factors for SSI, including excessive BMI, perioperative blood transfusion, low socioeconomic status, and prolonged operative time, along with the presence of diabetes mellitus (Al-Niaimi et al., 2015).

There are various other modifiable factors that increase the risk of acquiring SSI, such as the patient’s clinical condition, length of hospital stay prior to the operation, inappropriate application of antibiotic prophylaxis, duration of the surgery, contamination potential of the procedure, technical expertise of the surgical team, physical environment of the operating room, immunodeficiency, and presence of preexisting diseases (Reis & Rodrigues, 2017).

Perioperative Risk Factors

Perioperative risk factors such as antibiotic timing, nasal decolonization, preoperative bathing, normothermia, and hyperglycemia have been well studied. In a recent study, Morris et al. (2020) analyzed SSI rates by dose of cefazolin used for surgical prophylaxis for hip and knee arthroplasty and determined that performance of revision arthroplasties and cefazolin underdosing was associated with higher SSI rates. In a retrospective study, de Jonge et al. (2017) assessed the effect of preoperative timing of surgical antibiotic prophylaxis on SSI and found that the results of a quantitative analysis determined that administration of antibiotic prophylaxis greater than 120 minutes before incision or after incision is associated a higher risk of SSIs than administration less than 120 minutes before incision (de Jonge et al., 2017). Many efforts have been made to define an optimal timing interval for prophylaxis antibiotic within 120 minutes with conflicting results (de Jonge et al., 2017). Weber et al. (2008) conducted a prospective observational cohort study to obtain precise information on the optimal time window for surgical antimicrobial prophylaxis; and found that cefuroxime is used as a prophylactic antibiotic, administration 59 to 30 minutes before incision is more effective than administration during the last half hour (Weber et al., 2008). In a prospective study, Steinberg et al. (2009) found that there is a lower SSI risk when antimicrobial timing with cephalosporins and other antibiotics with short infusion times were given within 30 minutes prior to incision (Steinberg et al., 2009). Hawn et al. (2013) found in a large retrospective cohort study that there was no significant association between timing of antimicrobial prophylaxis and SSI. Vicas & Safdar (2019), conducted a review to identify the most common strategies currently used for Staphylococcus aureus decolonization and SSI and found that both decolonization with intra-nasal mupirocin or providine-iodine, in addition to preop chlorhexidine bathing were important SSI prevention strategies.

In another study analyzing the reasons for vascular surgery readmission, Hicks et al. (2016) found that operative time and inpatient operations are associated with increased odds of post-discharge infection of 1.2 per hour and 2.0, respectively. The presence of a preoperative wound and discharge to a rehabilitation facility were also among the top five predictive variables for post-discharge infection after vascular surgery however, procedure type was the most important determinant of infection risk (Hicks et al., 2016).

Inpatient Total Joint Arthroplasty Risks

Inpatient arthroplasty procedure's patients typically spend anywhere from two nights to one week in the hospital whereas, presently same-day discharge is becoming increasingly more common (Darrith et al., 2019). As surgical and anesthetic techniques become more advanced, the primary joint arthroplasty patient's typical postoperative length of stay has decreased substantially (Darrith et al., 2019). Darrith et al. (2019) raised concerns that discharging patients too soon increases the risk for postoperative complications and readmissions. Triantafyllopoulos et al. (2017) found that additional surgery related SSI risk factors following TJA included: allogeneic blood transfusion; DVT prophylaxis and coagulopathy; bearing surface and fixation type; bilateral procedures; anesthesia; hospital and surgeon volume of procedures; and admission from a healthcare facility.

Outpatient Total Joint Arthroplasty Risks

Goyal et al. (2017) provided evidence for the safety and effectiveness of same-day discharge protocols for a variety of arthroplasty procedures. According to Goyal et al. (2017) outpatient arthroplasty procedures may provide psychological benefits for patients. However, nationwide data from a private insurance database demonstrated a higher risk of perioperative surgical and medical complications including component failure, SSI, knee stiffness, and deep vein thrombosis (Arshi et al., 2017). Darrith et al. (2019) compared the outcomes of patients undergoing inpatient and outpatient procedures performed at an ambulatory surgery center and found that the risk of 90-day complications, readmissions, and reoperations was similar. Darrith et al. (2019) also found instability after THA and arthrofibrosis after TKA were the most common major complications identified.

Outpatient follow-up requires more trained personnel and a more elaborate physical structure (Reis & Rodrigues, 2017). It also depends on the collaboration of healthcare teams and the physical and financial conditions of patients, who need to come again to the institution (Reis & Rodrigues, 2017). Reis & Rodrigues (2017) argued that patients are generally not able to self-diagnose, as demonstrated by the fact that they are not qualified to provide reliable information about possible SSI, further highlighting the importance of post-discharge surveillance. Although inpatient procedures potentially pose a more significant risk for SSI in terms of increased length of hospital stay, measures for SSI prevention are more controlled for patients who undergo impatient procedures; whereas outpatient surgery requires the patient to be in full control of nasal decolonization and preop bathing.

Post-discharge Surveillance

Post-discharge surveillance has an important role in the reduction of the risk of infection (Ashraf et al., 2018). Most surveillance systems of healthcare associated infections (HAI) focus on hospital settings, but numerous infectious events occur after discharge Le Meur et al., 2016). There are limitations to the reporting of SSI by hospitals as they only bank on readmissions and up to 17% of the SSIs could be underreported (Ashraf et al., 2018) as numerous infectious events occur after discharge (Le Meur et al., 2016). Post-acute care is important to unburden acute care hospitals given the growing focus on financial considerations in a value-based health-care market (Aziz et al., 2020). Comparison of facilities for quality assessment requires thorough risk stratification considering patient characteristics, surgical management and postoperative recovery including pre-discharge complications (Aziz et al., 2020). While several studies aimed to define criteria and indications for discharging patients to home or a specific facility type, critical evaluation of these facilities through analysis of *post*-discharge complications and readmission rates is important to identify potential quality improvement initiatives (Aziz et al., 2020). In a recent study, Aziz et al. (2020) compared post-operative complications occurring after discharge to home, skilled, and unskilled care facilities to identify potential pitfalls and found that 30-day morbidity within different post-discharge settings revealed higher post-discharge complication-, readmission- and mortality rates associated with skilled care when compared to unskilled care and home destinations (Aziz et al., 2020).

Interhospital comparison may not be valid if the sensitivity and specificity of the post-discharge surveillance methods are not used similar (Mannien et al., 2006). Unlike for inpatient SSI surveillance, there is no international consensus on the optimal method for post-discharge surveillance (Mannien et al., 2006). Mannien et al. (2006), proposed two challenges for a good method of post-discharge surveillance are to follow up all patients and to accurately diagnose the presence or absence of an SSI. Direct examination of the wounds of all patients by a trained professional is often used as the “gold standard” for detection of SSIs (Mannien et al., 2006). However, for post-discharge surveillance this method is labor-intensive (Tyrer, 2019), difficult to perform routinely, and very expensive (Mannien et al., 2006).

In addition to outpatient follow-up and phone calls, some institutions use questionnaires administered to patients or surgeons, home visits, analysis of medical records, and microbiological testing; however, it is important to note that none of these methods are totally efficient on their own (Reis & Rodrigues, 2017). The ideal is to mix various strategies to reach a larger number of patients and obtain quality information (Reis & Rodrigues, 2017). Many difficulties arise within the social context of patients that hinder them from returning to the health service for outpatient assessment, such as long distances between the home and the institution, low socioeconomic status, difficult access to transportation services, lack of third party help in the case of dependent patients, and that some patients are also told to return to the health service in the weeks following their first consultation when, at the physician’s discretion, they need to be reassessed (Reis & Rodrigues, 2017).

Summary

TJA remains a serious concern for patients, healthcare workers, and the economy however, most surveillance is done during the inpatient visit. Measures to control modifiable risk factors, such as BMI and smoking; and perioperative risk factors, such as antibiotic timing, decolonization, and preop bathing for SSIs are critical for preventing infections following TJA. However, surgical incisions may still become infected after the patient has been discharged, as a result of risk factors unrelated to their time in the hospital. Therefore, it is crucial to focus efforts not only on understanding and controlling perioperative risk factors but also around identifying post-operative risk factors as well. To better understand post-operative risk factors and to risk stratify recovery level following TJA, this study focuses on possible associations between recovery level and SSI occurrence, as well as recovery level and level of depth of SSI. In the next chapter I will discuss the proposed research methodology for investigating these associations.

Chapter 3: Research Method

A quantitative approach with a retrospective design was used to investigate the association between recovery level and SSI as well as recovery level and level of depth of SSI. A convenience sampling design was used to select cases. An electronic medical record system was used to extract data variables. Data analyses were performed using SPSS statistical software. Descriptive statistics, including frequencies, were used to describe the demographic characteristics of the subjects. Pearson's chi-square test for independence was employed to compare the frequency of occurrence or association between level of postoperative recovery and SSI. Binary logistic regression was done to control for confounding variables or effect modifiers including age, insurance type, length of stay, and risk index.

Research Design and Rationale

A retrospective study design was utilized to assess healthcare associated SSIs based on patients who were readmitted following primary hip arthroplasty procedures. In a retrospective study, the outcome of interest has already occurred at the time the study initiated, and the data is not collected for purposes of research (National EMSC Data Analysis Resource Center NEDARC, 2010). A retrospective study design allows the investigator to formulate ideas about possible associations and investigate potential relationships (NEDARC, 2010). An investigator conducting a retrospective study typically utilizes administrative databases, medical records, or interviews with patients who are already known to have a disease or condition (NEDARC, 2010). Many retrospective studies have helped shape clinical practices. An example of the utility of retrospective studies is the landmark paper that described the association between smoking and lung cancer, which revealed that smokers were at a significantly higher risk of developing carcinoma of the lung compared to nonsmokers (Talari & Goyal, 2020). Another landmark retrospective chart review in the 1990s found that spinal anesthesia was faster, easier to administer, more comfortable, and safer for the patient for caesarean section, as compared to epidural anesthesia (Talari & Goyal, 2020). This retrospective study design may be beneficial for examining possible associations between postoperative recovery level and SSI and postoperative recovery level and level of depth of SSI, and may aid in determinations of best level of postoperative recovery for patients post TJA

Participant Selection Logic

A convenience sampling design was used to select patients who underwent a primary TJA procedure between January 1, 2019 and December 31, 2021 at Barnes-Jewish Hospital, a Level 1 trauma hospital in St. Louis, MO and had at least one subsequent readmission. There were 297 participants selected for answering Research Question 1, who had undergone primary total hip arthroplasty procedures between January 2019 and December 2021. The *n* was determined based on a total of 1,302 primary total hip arthroplasty procedures performed in the years 2019-2021 at this facility. To answer Research Question 2, an *n* of 22 was calculated based on a total of 23 healthcare-associated hip or knee infections following primary arthroplasty procedures between January 2019 and December 2021.

Convenience sampling is a type of nonprobability or nonrandom sampling where members of the target population who meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate are included for the purpose of the study (Etikan et al., 2016). Convenience sampling was appropriate for this study, as Barnes-Jewish Hospital is one of the largest nonprofit healthcare organizations in the United States, serving metro St. Louis, and has a large volume of patients that undergo surgical procedures annually, with a wide-variety of characteristics. Participants that were readmitted with a possible infection at the surgical site within 30 to 90 days of the index procedure were included. Only primary procedures were included to eliminate possible extraneous risk factors associated with revision TJAs. Patients were excluded if they, had a revision arthroplasty procedure, had an ASA score higher than 5 or their medical records did not have documentation of post-operative recovery level.

Sample Size Calculation:

To answer research question 1, a sample size of 297 was calculated based on a population size of 1,302, as there were 1,302 patients that underwent primary hip arthroplasty procedures between January 2019 and December 2021. To answer research question 2, a sample size of 22 was calculated based on a total of 23 healthcare-associated hip or knee infections following primary arthroplasty procedures between January 2019 and December 2021. A 95% confidence interval and a 5% margin of error were chosen, as the precision of statistics depends on the sample size and variability (NEDARC, 2010). A larger sample size or lower variability will result in a tighter confidence interval with a smaller margin of error (NEDARC, 2010). A 50% population proportion was selected because the sample proportion is unknown. The sample size calculator was retrieved from https://www.calculator.net/sample-size-calculator.html. The calculation is shown below.

RQ 1: n = [1.96^2 x 0.50 x (1 – 0.50)] / 0.05^2
= [3.8416 x 0.5 x 0.5] / 0.0025
= 384.16

n’ = 384.16 / [1 + (384-1 / 1302)]
= 297

RQ 2: n = [1.96^2 x 0.50 x (1 – 0.50)] / 0.05^2
= [3.8416 x 0.5 x 0.5] / 0.0025
= 384.16

n’ = 384.16 / [1 + (384-1 / 23)]
= 22

Instrumentation

Electronic Privacy Information Center **(**EPIC), an electronic medical record system, was utilized to review medical records and extract confirmed SSIs and postoperative recovery level. EPIC dashboards provide situational awareness with real time data and predictive analytics, so information for the entire organization is visible and actionable (EPIC, n.d.). EPIC also enables interoperability such that when patient care is transitioned between organizations the patient’s chart can be shared.

Procedures for Recruitment, Participation, and Data Collection

The source of data was Barnes-Jewish Hospital EPIC system. A retrospective chart review was done looking at surgical cases that were flagged manually by an abstract coding team between January 2019 and December 2021, to be reviewed by Infection Prevention Specialists using specific indicators including positive tissue/bone cultures, imaging, post-prophylaxis antibiotics, abscesses, purulent drainage, and symptoms such as fever, localized pain, and tenderness. Cases were reviewed by Infection Prevention Specialists and determined to be healthcare-associated (HAI) or not HAI based on strict NHSN criteria for superficial, deep, and organ/space infections. Data were extracted by Barnes-Jewish Hospital Epidemiology Analyst, including; SSI cases (HAI/not HAI) and level of depth of SSI from infection cases previous created in EPIC by Infection Prevention Specialists between January 2019 and December 2021. Level of postoperative recovery was extracted from patient discharge records obtained from EPIC.

Data Analysis Plan

Research Question 1: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and healthcare-associated surgical site infections (yes or no) among patients that underwent primary hip arthroplasty procedures?

Research Question 2: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and level of depth of surgical site infection (superficial incisional, deep incisional, or organ/space) among patients that underwent primary hip arthroplasty procedures?

Statistical analysis of the collected data was performed with SPSS statistical software. Statistical indicators that were applied in the study included arithmetic mean, median, standard deviation, and 95% confidence interval. Descriptive statistics including count and percentage, were used to describe the demographic characteristics of the subjects (age, insurance type, length of stay, and ASA score). To compare the frequency of occurrence or association between level of postoperative recovery and SSI, Pearson's chi-square test for independence was employed. *P-value* <0.05 was accepted as statistically significant. Pearson's Chi-Square test for independence will thus answer both research questions (1) Is there an association between recovery level and SSI; (2) Is there an association between recovery level and level of depth of SSI.

Binary logistic regression was used to test whether SSI and level of depth of infection can be predicted by confounding variables including age, insurance type, length of stay and ASA score. The statistical program first calculates the baseline odds of having the outcome versus not having the outcome without using any predictor. This gives us the constant also known as the intercept (Ranganathan et al., 2017). Then, the chosen independent (input/predictor) variables are entered into the model, and a regression coefficient, known also as "beta" and "*P*" value for each of these are calculated (Ranganathan et al., 2017). The "P" value indicates whether a particular variable contributes significantly to the occurrence of the outcome or not; and these results can also be expressed as an equation, which includes the constant term and the regression coefficient for each variable (Ranganathan et al., 2017). The equation provides a model which can be used to predict the probability of an event happening for a particular individual, given his/her profile of predictor factors (Ranganathan et al., 2017).

Issues of Validity

Internal validity methods were used to establish credibility within this study. Quantitative researchers evaluate trustworthiness by how well the threats to internal validity have been controlled, the validity of instruments and measurements used in a study; and by analyzing data through statistical test measures (Moon et al., 2016). Internal validity is supported when changes in the dependent variable happen from only the independent variable and not from other confounding variables (Moon et al., 2016). Threats to internal validity were minimized in this study, as one electronic record system was used to collect variable data and a strict set of definition criteria were used to determine SSIs and level of depth of infections. In addition, revision procedures were excluded to eliminate other confounding variables, by only including data from patients that underwent primary hip arthroplasty procedures Dependability refers to the consistency and reliability of the research findings and the degree to which research procedures are documented, allowing someone outside the research to follow, audit, and critique the research process (Moon et al., 2016). To achieve confirmability, researchers must demonstrate that the results are clearly linked to the conclusions in a way that can be followed and replicated (Moon et al., 2016). All facilities that conduct operative procedures in the United States follow the same NHSN criteria to determine and report healthcare associated SSIs. These criteria is provided under a sub-section of the Centers for Disease Control and Prevention and are publicly available.

Ethical Procedures

The study protocol was reviewed and approved by Barnes-Jewish Hospital Proposal Review Committee; and patient confidentiality was protected. All data variables obtained for this study were extracted from EPIC and de-identified; and data cleaning was performed by Epidemiology Analysts. Data were stored on a hospital provided laptop and secure hospital network which requires a 2-step verification. The proposal was submitted to Walden University IRB for approval prior to collecting data. IRB approval # 03-30-22-0977906. Human participants were not involved in this study. No patient information was provided in addition to the variables extracted for research purposes. There are no ethical concerns related to data collection.

Summary

This retrospective study highlights the association between recovery level and SSI as well as recovery level and level of depth of SSI. The convenience sampling method enabled selection of all primary hip infection cases at Barnes-Jewish Hospital. Descriptive statistics, describing the demographic characteristics of the subjects provided a baseline understanding of potential non-modifiable risk factors for SSI for each individual infection case. Pearson’s chi-square test for independence was useful in terms of answering each research question in regard to association between level of postoperative recovery and SSI; and association of postoperative recovery level and level of depth of SSI. Binary logistic regression was used to determine if age, insurance type, length of stay, and ASA score are predictors of SSI and level of depth of SSI.

Chapter 4: Results

The aim of this study was to establish if recovery level has a role in SSI and level of depth of SSI. The exploratory hypothesis stated there would be a relationship between recovery level and SSI; and recovery level and level of depth of SSI.

Research Setting

This research study was conducted within Barnes-Jewish Hospital (BJH) electronic medical records system, EPIC, which is also shared by the BJC Healthcare system. BJH is the largest non-profit healthcare organization in the United States, serving metro St. Louis, mid-Missouri, and Southern Illinois areas (BJC Healthcare, n.d.). It is the adult teaching hospital for the Washington University School of Medicine and is a major component of the Washington University Medical Center (BJC Healthcare, n.d.). It is ranked no. 17 on the Best Hospitals Honor Roll; and is nationally ranked in 11 adult specialties. BJH is rated high performing in 1 adult specialty and 16 procedures and conditions (US News, n.d.). Also ranked the No. 1 hospital in Missouri & St. Louis metro area, Barnes-Jewish Hospital excels at caring for the sickest, most medically complex patients in these specialties and more. All included patients had primary hip arthroplasty procedures at Barnes-Jewish Hospital between January 2019 and December 2021, and were readmitted within 30- or 90-days post-op for evidence of infection at the surgical site.

Demographics

There were 1,233 patients selected for this study as there were 76 patients excluded that underwent revision total hip arthroplasty procedures, therefore did not meet exclusion criteria of having undergone only a primary total hip arthroplasty. Tables 1-5; Figures 1-4 indicate patient demographics that represent minimum requirements sought as described in chapter 3. Patients included in this study had a mean age of 64.4, standard deviation 14.5, and ranged from 12 to 99 years (Table 1). The mean length of hospital stay following primary hip arthroplasty was 3.25 days, standard deviation 5.88, and ranged from 0 to 119 days (Table 1). The mean ASA score was 2.58, standard deviation of .626, and ranged from a score of 1-4 (Table 1). All included patients had primary hip arthroplasty procedures and were readmitted within 30- or 90-days post-op for evidence of infection at the surgical site. Of the 1,233 patients included in this study, 20 (1.6%) had healthcare-associated SSIs and 1,213 (98.4%) did not have healthcare-associated SSIs (Table 2). Of the 23 healthcare-associated infections, 10 were organ/space infections, 6 were deep infections, and 4 were superficial infections (Table 3). Most patients recovered at home with home health skilled care 720 (58.4%), followed by 232 (18.8%) at a skilled nursing facility, 164 (13.3%) at home with self-care, 117 (9.4%) at a rehabilitation facility (Table 4). Most patients had Medicare only insurance (53.0%), followed by preferred provider organization (14.4%), health maintenance organization (13.9%), both Medicare and Medicaid (10.2%), Medicaid only (6.7%), and no insurance (1.7%; Table 5).

Table 1

Descriptive Statistics – Age, Length of Stay, ASA score

Variable	Min	Max	Mean		*SD*
			Statistic	*SE*	
Age	12	99	64.43	.411	14.446
Length of Stay	0	119	3.25	.168	5.883
ASA Score	1	4	2.58	.018	.626

Note. N = 1233.

Table 2

Frequencies – HAI

Presence of HAI	Frequency	Percent	Cumulative Percent
N	1213	98.4	98.4
Y	20	1.6	100.0
Total	1233	100.0	

Table 3

Frequencies – SSI Level of Depth

Level of Depth	Frequency	Percent
Deep incisional primary (DIP)	6	.5
Organ/space	10	.8
Superficial incisional primary (SIP)	4	.3

Table 4

Frequencies - Recovery Level

Level of Recovery	Frequency	Percent
Home with home health skilled care	720	58.4
Home with self-care	164	13.3
Rehabilitation facility	117	9.5
Skilled nursing facility	232	18.8
Total	1233	100.0

Table 5

Frequencies – Insurance Type

Type of Insurance	Frequency	Percent
Health Maintenance Organization	172	13.9
Medicaid	83	6.7
Medicare	653	53.0
Medicare and Medicaid	126	10.2
No insurance	21	1.7
Preferred Provider Organization	178	14.4
Total	1233	100.0

Data Collection

EPIC Information System served as the source of research data. Healthcare-associated SSI, level of depth of SSI, recovery level, age, ASA score, insurance type, and length of hospital stay were all extracted directly from EPIC onto an Excel spreadsheet by an Epidemiology Analyst within the BJH Infection Control Department. All data were cleaned, transformed, and de-identified by Epidemiology Analyst. NHSN criteria were used to determine whether infections were HAI as well as level of depth of SSI.

Data Analysis

Data analyses were performed with SPSS version 28. Descriptive statistics showed that 50.4% of participants had moderate to severe systemic disease; 42.2% had mild systemic disease; 4.9% had severe systemic life-threatening disease; and 2.4% were healthy (Figure S1).. Research question one investigated if there is an association between level of postoperative recovery following primary THA and healthcare-associated SSI. Chi-Square Test for Indpendence was used to determine if there was an association between recovery level and healthcare-associated hip SSI. There are two main assumptions of Chi-square analysis to include: variables should be measured at an ordinal or nominal level and variables should consist of two or more categorical, independent groups (Laerd Statistics, 2018). Non-parametric tests, such as Chi-Square assume the data were obtained through random selection however, it is not uncommon to find inferential statistics used when data are from convenience samples rather than random samples (McHugh, 2013). To have confidence in the results when the random sampling assumption is violated, several replication studies should be performed with similar result obtained (McHugh, 2013).

The analysis resulted in a Chi-Square value of 7.761, with 3 degrees freedom and a significance value of .048 (Table 6). Therefore indicating that there is a statistically significant association between postoperative recovery level following primary THA and healthcare-associated SSI. In this case, the null hypothesis was rejected and the null hypothesis was accepted. Crosstabulation reflects that of the 20 patients that had a healthcare-associated hip infection, 7 recovered at home with home health/skilled care, 5 recovered at a rehabilitation facility, 4 recovered at a skilled nursing facility, 4 recovered at home with self-care (See Figures 1,2; Appendix K).

Research question 2 investigated if there is an association between postoperative recovery level and level of depth of SSI. Chi-Square Test for Independence was also employed to test the association between recovery level and level of depth of SSI however because the calculated sample size of 22 participants (patients) was not met, Fisher's Exact Test was conducted to investigate research question 2. The analysis resulted in a Chi-Square value of 3.874, with 6 degrees freedom, and a significance value of .773 (Table 7). Crosstabulation reflects that of the 4 superficial incisional SSIs; 2 recovered at a rehabilitation facility, 1 at home with home-health/skilled care, and 1 at a skilled nursing facility (See Appendix P). Of the 6 deep incisional SSIs: 1 recovered at home with self-care, 1 at a rehabilitation facility, 2 at home with home-health/skilled care, and 2 at a skilled nursing facility (See Appendix P). Of the 10 organ/space infections; 3 recovered at home with self-care, 2 at a rehabilitation facility, 4 at home with home-health/skilled care, and 1 at a skilled nursing facility (See Figure 3; Appendix P).

The Chi-square test is very useful to determine if a significant difference is observed however, it is sensitive to small frequencies (Lewis, 2021). If the expected frequencies in cells are below 5, or more than 20% of cells are below 5, the method of approximation used to calculate the chi-square becomes unreliable and risks either a type I or type II error (Lewis, 2021). The chi-square test for recovery level and SSI level of depth included a small sample size of only 20 SSI cases. Therefore, the Fisher's exact test was done, as it does not use an approximation like the chi-square test and therefore remains valid for small sample sizes (Lewis, 2021). When the sample size becomes large enough the p-value generated from a chi-square will approach that of a Fisher's exact (Lewis, 2021). Fisher's exact test statistic testing the association between postoperative recovery level and HAI was 7.427, with a p-value of .042. Fisher's exact test statistic testing the association between postoperative recovery level and level of depth of primary hip SSI was 3.923, with a p-value of .849. Therefore indicating that there is not a statistically significant association between postoperative recovery level following primary THA and level of depth of SSI. In this case, the null hypothesis for research question 2 was accepted.

Table 6

*Chi-Square Test - Recovery level*HAI*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	7.761[a]	3	.051	.048
Likelihood Ratio	6.399	3	.094	.134
Fisher-Freeman-Halton Exact Test	7.427			.042
N of Valid Cases	1233			

a. 3 cells (37.5%) have expected count less than 5. The minimum expected count is 1.90.

Table 7

*Chi-Square Test - Recovery level*SSI Level of Depth*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)
Pearson Chi-Square	3.874[a]	6	.694	.773
Likelihood Ratio	4.441	6	.617	.843
Fisher-Freeman-Halton Exact Test	3.923			.849
N of Valid Cases	20			

a. 12 cells (100.0%) have expected count less than 5. The minimum expected count is .80.

Figure 1

*Bar Chart - Recovery Level*HAI*

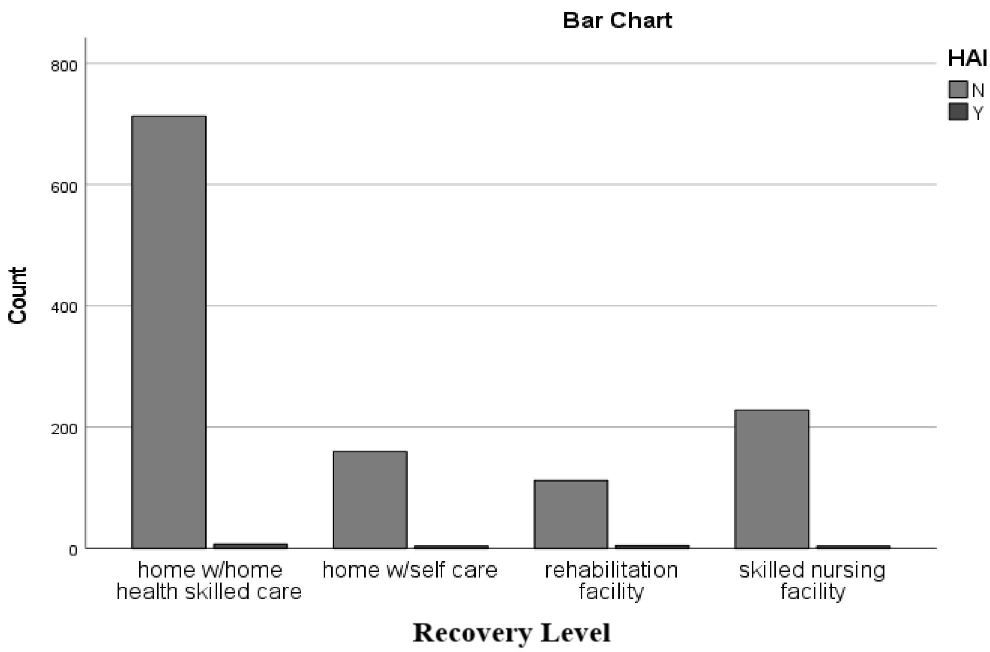

Bar Chart
HAI
N
Y
Count
800
600
400
200
0
home w/home health skilled care
home w/self care
rehabilitation facility
skilled nursing facility
Recovery Level

Figure 2

*Bar Chart – Recovery Level*HAI_Yes*

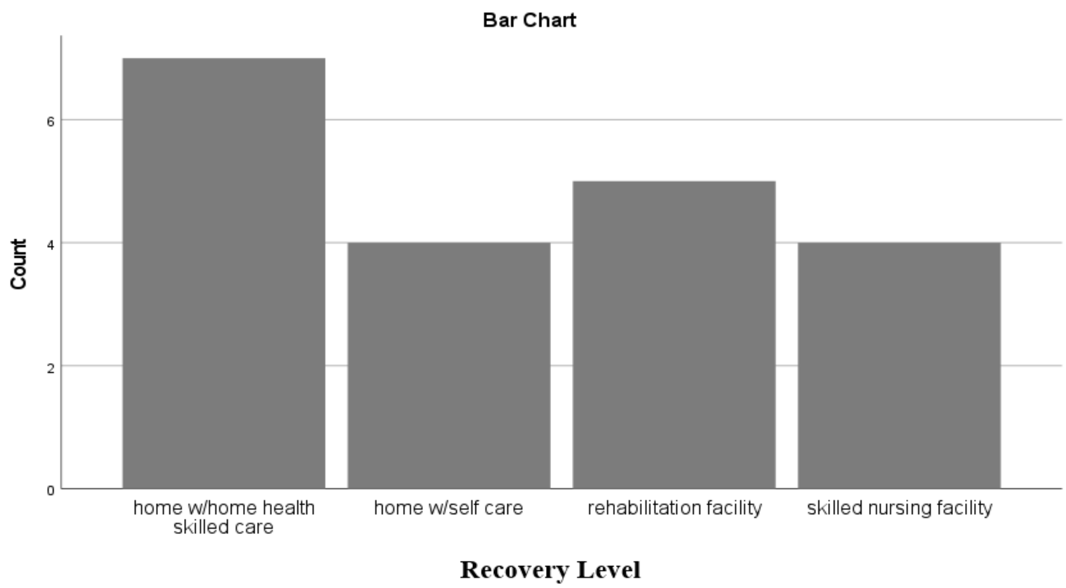
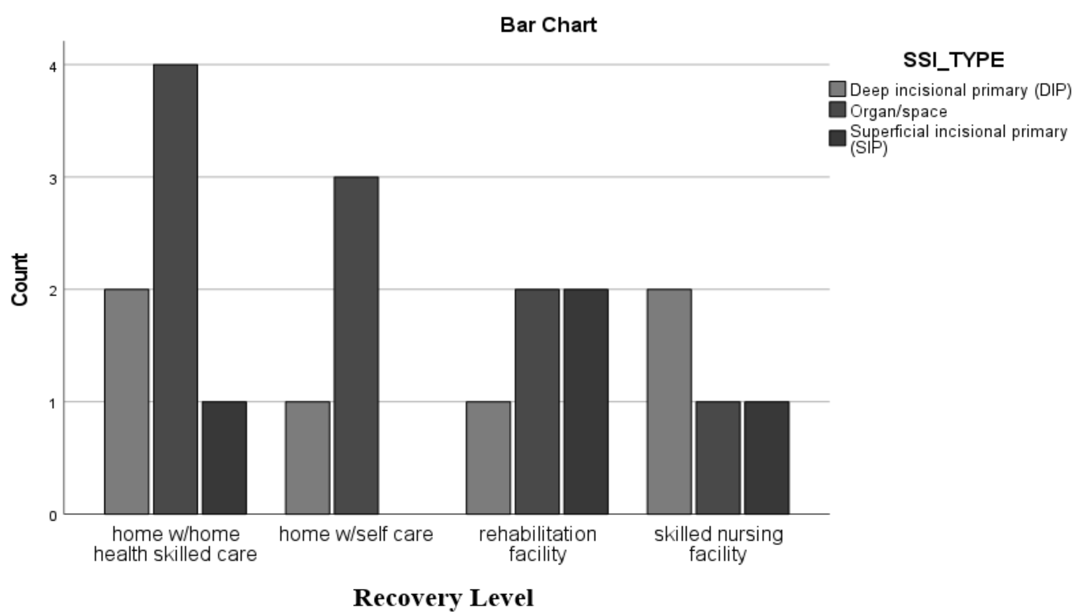


Figure 3

*Bar Chart - Recovery Level*SSI Level of Depth*



The logistic regression method assumes that: the outcomes is a binary or dichotomous variable such as yes or no, positive vs negative, 1 vs 0; there is a linear relationship between the logit of the outcome and each predictor variables; there are no influential values (extreme values or outliers) in the continuous predictors; and there is no high intercorrelations among the predictors (Kassambara, A. 2018). Binary logistic regression was used to test whether HAI can be predicted by confounding variables including age, ASA score, insurance type, length of stay. Table 9 shows that 0% of cases had the observed characteristic (yes HAI) and 100% of cases did not have the observed characteristic (no HAI). Table 10 shows that none of the predictor variables, age (p = .307), ASA score (p = .423), length of stay (p = .211), or insurance type (p = .804) added significantly to the null model/prediction.

Table 8

Classification Table

	Predicted		
	HAI		Percentage Correct
Observed	N	Y	
HAI N	1213	0	100.0
HAI Y	20	0	.0
Overall Percentage			98.4

Table 9

Binary Logistic Regression – Variables in the Equation

		B	*SE*	Wald	*df*	Sig.	Exp(B)	95% CI	
								Lower	Upper
Step 1	Concat_reporting_group			1.627	4	.804			
	Concat_reporting_group(1)	17.244	3054.456	.000	1	.995	30843585.049	.000	
	Concat_reporting_group(2)	17.378	3054.455	.000	1	.995	35263688.144	.000	
	Concat_reporting_group(3)	18.211	3054.456	.000	1	.995	81047208.613	.000	
	Concat_reporting_group(4)	16.653	3054.456	.000	1	.996	17065818.505	.000	
	ASA_Score	.317	.397	.641	1	.423	1.374	.631	2.989
	AgeATOS	-.018	.018	1.045	1	.307	.982	.948	1.017
	LOS	.022	.018	1.564	1	.211	1.023	.987	1.05
	Constant	-20.997	3054.456	.000	1	.995	.000		

Note. Variable(s) entered on Step 1: Concat_reporting_group, ASA_Score, AgeATOS, LOS.

Evidence of Trustworthiness

The validity of a research study refers to how well the results among the study participants represent true findings among similar individuals outside the study (Patino & Ferreira, 2018). Internal validity makes the conclusions of a causal relationship credible and trustworthy (Patino & Ferreira, 2018). Without high internal validity, an experiment cannot demonstrate a causal link between two variables (Patino & Ferreira, 2018). In this study threats to internal validity were minimized by using only one instrument, EPIC, to collect data from all patients who received primary hip arthroplasty procedure at Barnes-Jewish Hospital. The results among the study participants represent true findings among similar individuals outside of the study as, Barnes-Jewish Hospital takes majority of patients undergoing total joint procedures in the Metropolitan region. In addition to only selected patients that underwent primary arthroplasty procedures, this study only included patients that had clean wounds to avoid other risk factors for SSI. Clean wounds are not inflamed or contaminated and do not involve operating on an internal organ (Johns Hopkins Medicine, n.d.). Clean-contaminated wounds have no evidence of infection at the time of surgery but involve operating on an internal organ (Johns Hopkins Medicine, n.d.). Contaminated wounds involve operating on an internal organ with a spilling of contents from the organ into the wounds (Johns Hopkins Medicine, n.d.). Dirty wounds are wounds in which a known infection is present at the time of surgery (Johns Hopkins, n.d.), as is often the case with revision arthroplasty procedures.

In addition, internal validity was increased by using adequate data collection strategies, as a strict NHSN criteria was used to determine SSI level of depth and whether an infection was HAI or not HAI. Recovery level, insurance type, ASA score, age, and length of stay were also documented the same way in EPIC. Binary logistic regression analysis, used to study possible confounding variables and utilizing a large sample size also increased internal validity of this study. External validity captures the extent to which inferences drawn from a given study's sample apply to a broader population or other target populations (Findley et al., 2021). When an inference concerns the broader population of a predefined sample, it is referred as generalizability (Findley et al., 2021). When an inference applies to other target populations, it is referred as transportability (Findley et al., 2021).

External validity bias arises from differences between the study and target populations in subject characteristics; setting, such as geography or type of health center;

treatment, such as antibiotic timing, dosage, or staff training; and outcomes, such as length of follow-up (Inoue et al., 2021). In this study, generalizability was achieved by using broad inclusion criteria that resulted in a study population that closely resembles the true population of patients undergoing primary hip arthroplasty procedures in Midwestern U.S. each year. Dependability refers to the consistency and reliability of the research findings and the degree to which research procedures are documented, such that someone outside of the study could replicate the methodology and obtain similar results (Moon et al., 2016). To achieve confirmability, researchers must demonstrate that the results are clearly linked to the conclusions in a way that can be followed and replicated (Moon et al., 2016). All facilities that conduct operative procedures in the United States follow the same NHSN criteria to determine and report healthcare associated SSIs. These criteria are provided under a sub-section of the Centers for Disease Control and Prevention and are publicly available. The methodology of this study outlines a detailed procedure in which data were collected, reviewed and analyzed in this study such that any person outside of the study could replicate and obtain the same results as reported here.

Summary

The study sample well exceeded the calculated sample size of 297 participants (patients) needed to answer research question 1; and was just under the calculated sample size of 22 participants (patients) needed to answer research question 2. Of the total participants selected for this study. There were a few patients included in this study, who were under the age of 18 due to undergoing primary arthroplasty procedures at Barnes-

Jewish Hospital. Demographics showed that the study participants represented various ages; with variation in acuity (indicated by ASA score), length of stay, and insurance types. It was expected that most patients would recover at home with home health/skilled care or at a rehabilitation facility, as majority of patients had Medicare/Medicaid insurance coverages, which could aid affordability to manage patients' recovery with extended skilled care. There was not much variation in terms of where patients recovered after the procedure. There were trends associated with SSI level of depth, as most infections were organ/space infections whereas fewer infections were superficial. It was expected that majority of infections would be superficial incisional SSIs, as superficial incisions are more likely to become infected due to colonization of infectious organisms on the skin near the incision, opposed to deep incisional or organ/space. The Fisher's exact test results determined that there is a statistically significant association between postoperative recovery level and healthcare-associated surgical site hip infections. Fisher's exact test also determined that there is no association between postoperative recovery level and level of depth of surgical site hip infections. Binary logistic regression determined that none of the predictor variables: ASA score, length of stay, age or insurance type had confounding effects on postoperative recovery level and HAI.

Chapter 5: Discussion, Conclusions, and Recommendations

The management of wound problems following THA surgery remains poorly investigated, with no clinical guidelines available for how to manage blistering, erythema, and serous drainage (Carli et al., 2017). However, in a study comparatively evaluating THA recipients who received electronic patient rehabilitation application along with home health services vs to THA recipients who only received electronic patient rehabilitation application, it was found that there was no significant difference in terms of recovery outcomes (Davidovitch et al., 2018). In a study by Carli et al. (2017), it was found that use of a non-invasive secure skin closure following total knee arthroplasty was associated with fewer wound complications and no patient home care visits compared to surgical staples. In a retrospective data analysis to determine which variables are significant in predicting discharge destinations of THA patients; it was determined that discharge to extended care facilities was more likely for patients with more comorbidities and an older age; and the strongest predictors were Medicaid and black or Asian race (Mukamel et al., 2015). The strongest predictor for discharge to home with home care was black race relative to whites (Mukamel et al., 2015). Race, insurance, and morbidity were highly significant predictors on patient discharge to a nursing facility (Mukamel et al., 2015). More studies focusing on recovery site SSI risks is necessary to prevent SSIs after hospital discharge post THA.

This study aimed to explore if there is an association between recovery level and healthcare-associated hip infections. This study also aimed to explore whether there is a relationship between recovery level and level of depth of primary hip infections. Study results rejected the null hypothesis for research question 1, as Fisher's exact test reflected a statistically significant association between postoperative recovery level and healthcare-associated hip infections. However, results failed to reject the null hypothesis for research question 2, as there was no statistically significant association between recovery level and level of depth of primary hip infections.

Interpretation of Findings

The reduction of SSI rates in the US requires effective interventions. This study evaluated the association between postoperative recovery level following primary THA and healthcare-associated SSI; and postoperative recovery level following primary THA and level of depth of SSI, by applying a socio-ecological approach. Binary logistic regression included predictor variables that determined whether differences in multiple levels of the socio-ecological model influenced the association between postoperative recovery level and healthcare associated SSI following THA. Although predictor variables did not significantly change the null model in this study, other studies with larger sample sizes have found that socio-ecological factors such as age, insurance type, ASA score, and length of stay were determinants for patient's recovery level and/or SSI risk. Understanding and addressing these different factors/determinants that exist across all levels of the SEM enable implementation of effective SSI prevention, control, and intervention strategies.

Research Question 1: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and healthcare-associated surgical site infections (yes or no) among patients that underwent primary hip arthroplasty procedures? Chi-square test of independence and Fisher's exact test was used to answer research question 1. The results determined that most patients recovered at home with home health/skilled care and were more likely to have healthcare-associated hip infections. Findings were consistent with the null hypothesis, as the results of the Chi-square test of independence and Fisher's exact test determined that there was a statistically significant association between recovery level and healthcare-associated primary hip infections.

Research Question 2: Is there an association between postoperative recovery level (skilled nursing, orthopedic rehabilitation, acute care, home w/home health care, home w/self-care), and level of depth of surgical site infection (superficial incisional, deep incisional, or organ/space) among patients that underwent primary hip arthroplasty procedures? Fisher's exact test was used to answer research question 2. Fisher's exact test also revealed that there was not a statistically significant relationship between recovery level and level of depth of SSI. This finding was not consistent with expectations, as it was expected that there would be a higher frequency of association among superficial incisional hip infections and patients who recovered at home with self-care or with home health skilled care. The rationale behind this expectation was that patients have a higher risk of contaminating their incision at home due to exposure to pets, children, and contaminated surfaces within the home; opposed to recovering in a healthcare facility with a more controlled environment. In a study exploring patient's perspectives about barriers experienced while seeking care for post-discharge SSI, 3 major challenges were identified which impacted patients' ability to manage post-discharge surgical woundcomplications: including required knowledge for wound monitoring from discharge teaching, self-efficacy for wound monitoring at home, and accessible communication with providers about wound concerns (Sanger et al., 2014). Sanger et al. (2014) findings revealed gaps and frustrations with post-discharge care after surgery which could negatively impact clinical outcomes and quality of life. It is also possible that this finding resulted from the small sample available of patients that had HAIs, as majority of patients included in this study did not have HAIs. Small sample sizes influence research findings by undermining the internal and external validity of a study (Faber & Fonseca, 2014).

Binary logistic regression was used to ascertain the effects of age, ASA score, insurance type, and length of stay on the likelihood that patients had an HAI. Binary logistic regression showed that age, acuity, length of hospital stay, and insurance type were not predictors of whether a patient acquired a healthcare associated SSI or level of depth of SSI. Results indicated that neither of these predictors had an effect on HAI or on level of depth. This finding is inconsistent with existing literature. Kaya et al. (2006) found that prolonged hospital stay greater than 8 days and age greater than 75 years proved to be independent risk factors for SSI. Two other studies found that increased age was associated with increased risk for SSIs following appendicectomy (Rotermann et al., 2004) and cholecystectomy (Romy et at., 2008). In other studies, investigating risk factors for SSIs, (Walz, J. et al., 2006) and (Tang, R. et al., 2001) found that age was not a risk factor for colorectal surgery. Ansari et al. (2019) found that SSIs were more common among elderly patients, those with longer preoperative hospital stay, and patients with a high ASA index. Rooh-ul-Muqim et al. (2010) found that ASA score has strong influence on SSI rates in clean contaminated surgical wound cases, as there were significantly higher SSI rates among patients in ASA classes II and III than those with ASA class I in clean contaminated surgeries. In a large prospective study in a Swiss tertiary-care hospital, exploring whether health insurance status may affect the risk for SSI, Duggan (2019) found no evidence of a difference in SSI risk among individuals with basic versus semiprivate or private insurance in a setting with universal health insurance coverage. However, in a cross-sectional study Qi et al. (2019) found that Medicaid insurance status and living in low-income zip code were associated with higher SSI rates after colectomy, even after adjusting for clinical risk. It is likely that the small sample size available for research question 2 contributed to inconsistency of this study's finding compared to results of previous studies; and is also the case for the supplemental question evaluating the effects of age, length of stay, ASA score, and insurance type on the association between postoperative recovery level following primary THA and healthcare-associated SSI.

Limitations of the Study

There were several limitations of this study. Majority of patients included in this study did not have healthcare-associated SSIs, representing over 98% of the sample size. Therefore, a new sample size calculation was done to determine the appropriate n number to answer research question 2, which investigated the association between recovery level and level of depth of SSI. In addition, the data were impacted by the COVID-19 pandemic, as elective surgical procedures were suspended for several months throughout the pandemic and only emergency procedures were performed. During this time, only complex procedures for patients with high acuity were performed at Barnes-Jewish Hospital.

Recommendations and Implications for Social Change

Although this study did not show a statistically significant association between postoperative recovery level and SSI, further studies of this type, a larger sample size of cases that meets criteria for HAI, may yield more significant results. This study sets a precedent for future studies to identify differences or similarities in SSI risk factors stratified by postoperative recovery level. Identifying risk factors based on postoperative recovery level may prove beneficial for improving discharge planning following various procedure types beyond primary hip arthroplasty. Enhanced recovery after surgery programs have shown improvements in patient recovery after joint replacement, as measured by length of hospital stay, improved early mobilization, and patient satisfaction (Tan et al., 2018). However, wider uptake of comprehensive enhanced recovery after surgery programs has been slow or incomplete, likely due to the requirement for multidisciplinary collaboration, and organizational factors that delay the change (Tan et al., 2018). Understanding variation in risk factors based on postoperative recovery level provides an alternative to this obstacle by enabling health care providers to make better evidence-based recommendations on the most appropriate level of postoperative recovery to meet individual patient needs and eliminate risks for SSI.

Furthermore, implementing initiatives to improve discharge planning could reduce hospital readmissions and SSI rates, thus overall improving population health and the economy. In October 2008, the Centers for Medicare and Medicaid Services (CMS) discontinued reimbursements for certain HAI that were deemed preventable (Grace et al., 2012). The Hospital Readmission Reduction Program (HRRP) was designed as a Medicare value-based purchasing program that decreases payments to hospitals that have disproportionately high readmissions (Upadhyay et al., 2019). The HRRP also assesses penalties based on a hospital's performance on six conditions or procedures including elective primary total hip and knee arthroplasty, AMI, chronic obstructive pulmonary disease, heart failure, PN, and coronary artery bypass graft surgery readmissions (Upadhyay et al., 2019). Hospitals rely on reimbursements from outside agencies such as CMS and private insurers for payments regarding readmissions however, it can become challenging for hospitals to obtain funding from external resources when readmission rates are high readmissions (Upadhyay et al., 2019). In addition, hospitals must pay financial penalties for having excess readmission rates (Upadhyay et al., 2019). Reducing readmission rates can improve financial performance of hospitals.

Conclusions

SSIs place a major burden on multiple social ecological level however, existing studies focus primarily on peri-operative intervention strategies for prevention. Therefore, this this exploratory study evaluated association between post-operative recovery level and SSI; and postoperative recovery level and level of depth of SSI amongst patients that underwent primary hip arthroplasty procedures at Barnes-Jewish Hospital in St. Louis, MO between January 2019 and December 2021. The results indicated that recovery level does influence healthcare-associated hip infections but did not have a significant impact on level of depth of primary hip infections. Several confounding variables including age, acuity (ASA score), length of hospital stay, and insurance type were not predictors of healthcare-associated primary hip infections. These findings are not consistent with expectations based on existing literature, likely due to the small number of SSI events. Potentially repeating this study with a more balanced distribution of patients with healthcare-associated primary hip infections compared to not healthcare-associated primary hip infections would result in more statistically significant study results. In addition, repeating this study with exact logistic regression may yield a more statistically significant result, as this technique is more appropriate when the outcome variable is binary and the sample size is small.

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