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Smoking and Surgical Site Infection in Orthopedic Patients' Lower Extremity Arthroplasty

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Walden University

College of Health Sciences

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Alicia Mingo

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Walden University
2019

Abstract

Smoking and Surgical Site Infection in

Orthopedic Patients' Lower Extremity Arthroplasty

by

Alicia Mingo

BS, Anthem College, 2011

AA, Anthem College, 2006

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health: Community Health Education

Walden University

February 2019

Abstract

Cigarette smoking has been a public health concern for many years, and the possible impact of smoking on surgical site infection (SSI) has been studied broadly. However, a gap in understanding has persisted concerning whether there is an association between smoking tobacco and the development of SSI among patients who undergo lower extremity surgery, specifically total knee arthroplasty (TKA). The purpose of this study was to examine the association between smoking and lower extremity SSI. Andersen's behavioral model (BM) was used to understand the risk factors relevant to the interaction between smoking and SSI. Application of the BM categories of predisposing, enabling, need, and behavioral habits facilitated the discussion of surgical outcomes. A quantitative, cross-sectional approach was used to analyze data from a legacy registry of an east coast hospital. The research question addressed whether there was a relationship of the smoking status of three groups (i.e., smokers, nonsmokers, and previous smokers) and the variables in the BM categories (predisposing variables of age, gender, and body mass index [BMI]; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, rheumatoid arthritis [RA]) to postoperative SSI. Multiple logistic regression test was used and no statistical association was found between smoking status and SSI; however, RA had a significant association with SSI. Positive social change may occur through the dissemination of new knowledge to reduce the financial burden of the prevalence of SSI through behavioral changes and improvements to health wellness.

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Dedication

I dedicate this dissertation to my parents, Albert Mingo and Mildred Hawker, for their unconditional love and support. To my beautiful and loving children, my rocks, Tamika and Sheba, I thank you for praising my efforts, coming to every residency to support me, and keeping my spirits soaring with your humor and persuasion. To my darling oldest daughter, Tracy, who passed away just before I started this journey, you were my ray of sunlight who guided me to the end. I love all of you girls.

To the love of my life, Gleeworth, I recognize that it was challenging for me to not have enough time for you, so I thank you for your love, support, and patience over the past 4 years while I worked all of those late nights to achieve this academic goal. To my brothers and sisters, Eion, Lindon, Faye, Margaret, Diane, Andrea, and Michelle, and three who are no longer with us, Patrick, Keith, and Sandra, I thank you, my family, for your unwavering love, inspiration, and support. To my nieces and nephews, Alicia, Patrick Jr., Lexie, Patricia, Lateef, Ryan, Andray, Crystal, Brittany, and Lashae, and too many other names to mention, I love all of you, and I thank you for all your encouragement!

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Chapter 1: Introduction to the Study

Cigarette smoking has a detrimental impact on the health status of surgical patients (Jain, Shukla, Singh, & Kumar, 2015). Health-related issues that researchers have linked to smoking include surgical site infection (SSI), respiratory problems, heart disease, and several types of lung cancers (Centers for Disease Control and Prevention [CDC], 2016; Durand, Berthelot, Cazorla, Farizon, & Lucht, 2013; Jain et al., 2015; Proctor, 2012). Smoking also has a debilitating effect on joints, muscles, and bones (Abate, Vanni, Pantalone, & Salini, 2013). Helping patients to understand the extent to which smoking is related to SSI might improve their knowledge about its impact.

Smoking cigarettes has affected health status among the general population for years, with a high volume of people continuing to smoke despite knowing about the adverse effects of cigarette smoking (McDaniel & Browning, 2014). Researchers have found a correlation between smoking tobacco products and cancer, heart disease, and a delayed healing process following orthopedic procedures (McDaniel & Browning, 2014). Patients who use tobacco products have a higher chance of SSI of the lower extremities (Durand et al., 2013). SSI also prolongs the healing process of cartilage and ligaments (McDaniel & Browning, 2014). The use of tobacco products continues to be a burden to society.

Even though numerous researchers have examined the relationship between smoking and orthopedic SSI, a gap in the literature remains in determining whether there is an association between smoking and the development of SSI among patients with lower extremity surgery, particularly total knee replacement (TKR; Durand et al., 2013;

Jain et al., 2015; McDaniel & Browning, 2014; Proctor, 2012). In 2016, the Centers for Medicare & Medicaid Services (CMS) mandated and implemented a consulting assessment questionnaire into the EPIC system for all clinicians to ask patients about cigarette smoking prior to surgery (as cited in Physician Quality Reporting System [PQRS], 2016). Thereafter, the documented measurements had to be reported to the government to help to increase the quality of care (CMS, as cited in PQRS, 2016). One of the questions concerns whether the patient smoked on the day of surgery.

The focus of this study was examining the statistical association between the risk factor of smoking and SSI for three groups of orthopedic patients (i.e., current smokers, nonsmokers, and previous smokers) who had undergone TKR lower extremity surgery. The reason for conducting this study was to gain insight into the impact that smoking cigarette products on the day of surgery may have had on the development of infection in patients' lower extremities.

The results of this study may help health care workers and orthopedic surgeons to determine if patients who smoke are more susceptible than patients who do not smoke to developing SSI and whether the association can be modified by Andersen's (1968) behavioral model (BM). The findings may fill the gap in the current literature on the causes linked to lack of knowledge related to smoking on the baseline of surgery and SSI. Positive social change may result from having an improved understanding of the health impact of cigarette use on surgical site healing and the financial ramifications on cost and quality health care.

Included in the rest of Chapter 1 is information about the background of the study, the problem statement, and the purpose of the study. The chapter also presents the research question and hypothesis, theoretical framework, nature of the study, and assumptions. The following portion of the chapter holds information about the scope and delimitations, limitations, and significance of the study, and concludes with a summary.

Background

SSI is a severe health complication for patients. Patient behaviors such as tobacco use affect the healing process and potentially increase the risk of SSI (McDaniel & Browning, 2014). When planning for surgery, patients are asked to quit smoking and not return to smoking following any procedure (Jain et al., 2015). In the United States, approximately 16 million patients have SSI (Mawalla, Mshana, Chalya, Imirzalioglu, & Mahalu, 2011). Rates of abnormal stained tissue denoted as SSI in the lower extremities are significantly higher for patients who have undergone orthopedic surgeries within the year, such as patients with loosening metallic implants linked to factors such as gender, age, body mass index (BMI), smoking, or diabetes (Fisichella, Fenga, & Rosa, 2014). Although researchers have identified the harmful effects of smoking, researchers have provided limited information on smoking and the development of SSI in lower extremity TKR (Cherian & Mont, 2015; Fisichella et al., 2014). Researchers also have identified SSI as a process that occurs but is not the cause of infections (Berríos-Torres et al., 2017; Mawalla et al., 2011). Smoking tobacco remains an independent component that increases the risk of SSI.

The adverse effects of smoking increase the SSI nosocomial infection rate and complicate the postoperative healing of surgical sites. SSI also increases health care costs related to postoperative inflammatory circumstances (Mawalla et al., 2011). Postoperative outcomes depend on the stages of the healing process, so the use of tobacco can lead to increased risks of hematoma, compartment syndrome, inflammation, and methicillin-resistant *Staphylococcus aureus* (MRSA; Jensen et al., 2006).

Patients who use tobacco products have a high risk of SSI pathogens, both endogenous (i.e., the patient's own bacteria) and exogenous (i.e., based on the source or type of surgical procedure), as well as MRSA pathogens. Tobacco users also can experience resistance to antibiotics (Owens & Stoessel, 2008). By not using tobacco products after surgery, patients can help to prevent chronic health issues and reduce the costs of increased infection rates. Chronic health issues related to orthopedic complications include pneumonia, SSI, wound dehiscence, impaired bone healing, and tissue necrosis (Khullar & Maa, 2012; Sørensen, 2012). The treatment for SSI requires the use of antibiotics during and after surgery. When the body accumulates an excessive amount of pathogens, patients have increased resistance to treatment (Owens & Stoessel, 2008). Understanding the health implications surrounding the risk of cigarette smoking enables patients to make more informed decisions about not using tobacco products after surgery.

SSI rates tend to differ between patients who do and do not smoke. The estimated annual occurrence of SSI tends to vary considerably, with the number of incidents ranging between 160,000 and 300,000 patients in the United States (D. J. Anderson et al., 2014). However, the actual number of cases of patients with SSI might be much higher because of the difficulty of tracking every occurrence of SSI.

Financial expenditure on SSI is significant; SSI is among the costliest of hospital-acquired infections (D. J. Anderson et al., 2014). The yearly amount spent on SSI in the United States is between $3.5 billion and $10 billion (D. J. Anderson et al., 2014). Most of the medical expenses associated with SSI are the result of emergency room visits, extended hospital stays, and readmissions (Jain et al., 2015). SSI can lead to higher costs and contribute to undesirable patient outcomes.

SSI usually extends the length of a patient's hospital stay by 4 to 9 days, resulting in a $20,000 increase in costs per admission (D. J. Anderson et al., 2014). Annually, more than 90,000 patients are readmitted to hospital due to SSI, with the cost being an extra $700 million (Nåsell, Adami, Samnegård, Tønnesen, & Ponzer, 2010). The use of evidence-based practice can mean that 60% of cases of SSI are preventable; SSI has become a pay-for-performance measure, as well as a target of efforts directed toward quality improvement (Nåsell et al., 2010; PQRS, 2016). In defining SSI, the CDC (2016) provided a broad description to explain what SSI is, with the definition focusing on pay for performance, public reporting, quality improvement, and research comparisons.

Problem Statement

Tobacco consumption impacts how quickly patients can heal after surgery. Expenditures associated with SSI range between $3.5 billion and $10 billion (D. J. Anderson et al., 2014). Smoking tobacco products has an adverse effect on how quickly patients can heal after undergoing surgery that is the result of surgical complications

(Cherian & Mont, 2015). The use of tobacco can lead to an increase in postoperative musculoskeletal disorders (Fleisher, 2013). Cigarette smoking decreases blood flow to the surgical site, with the possibility of reducing bone growth while increasing the risk of infection (Jain et al., 2015). By providing patients and health care professionals with insight into the consequences and extent of smoking related to SSI after surgery, medical personnel can reduce SSI among patients.

Although tobacco use affects all consumers, orthopedic patients who smoke and have undergone surgical procedures are more prone than nonsmokers to developing SSI (Cherian & Mont, 2015). Because cigarette products remain in the human body for a long period, patients who smoke and have undergone surgical procedures are at a higher risk of SSI. Researchers have linked cigarette smoking to SSI, and the literature has indicated that regardless of the risks associated with smoking, a significant number of patients continue to smoke following operative procedures (Cherian & Mont, 2015; Fleisher, 2013; Nwachukwu et al., 2015). By helping patients to understand the consequences of smoking, health care professionals can help to reduce the development of surgical wound infections.

Purpose

The purpose of this study was to examine the effects of smoking behavior on the risk of SSI among patients who had undergone surgery of the lower extremities, particularly TKR. Secondary data were collected from the legacy registry of a hospital on the east coast of the United States. Using medical charts and the registry, I analyzed three patient groups: patients who had never smoked, patients who self-identified as previous smokers, and patients who self-reported as smokers at the baseline of surgery. Analysis of the data provided the foundation to examine the risk factor of smoking and the development of SSI among patients who had undergone TKR surgery. The findings also may help health care leaders gain insight into the relationship between the development of SSI and the smoking behaviors of surgery patients.

A cross-sectional research design was followed to investigate the relationship between the independent variable (IV) of smoking and the dependent variable (DV) of SSI. Researchers use cross-sectional designs to determine whether there is an association between and among the variables (Creswell, 2009; Frankfort-Nachmias & Nachmias, 2008). A cross-sectional design was appropriate for this study to look for a possible relationship between the IV of smoking and the DV of SSI.

Research Question and Hypothesis

One research question guided this study: Is there a relationship between smoking of three groups (i.e., smokers, nonsmokers, and previous smokers), defined as smoking within the baseline of surgery; BM-predisposing variables of age, gender, and BMI; the enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, and rheumatoid arthritis (RA), and postoperative SSI in patients with lower extremity orthopedic procedures, specifically TKR?

The hypothesis associated with this research question was as follows:

H_{01}: There is no relationship between smoking among the three groups, controlling for the BM-predisposing variables of age, gender, and BMI; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, and RA, and SSI.

H_{a1}: There is a relationship between smoking among the three groups, controlling for the BM-predisposing variables of age, gender, and BMI; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, and RA, with SSI.

Theoretical Framework

The theoretical framework of the study was Andersen's (1968) BM. Andersen developed a theory to understand the enabling category of variables such as access to health care insurance; the predisposing category of variables; and the need category of variables related to medical needs for health conditions. Andersen's (1995) BM has become more popular over the past 48 years, and since its introduction, researchers have used the model to understand socioeconomic status (SES) factors such as education. Researchers have continued to use behavioral theories to study systems in areas such as education, health, and economics, among others (Babitsch, Gohl, & Lengerke, 2012; Holford et al., 2014). Use of Andersen's (1995) BM provided new insight to explain the relationship among the risk factors and outcomes across the health care system. Researchers have used Andersen's (1995) BM to study the association between smoking and mortality (Holford et al., 2014). Andersen's (1995) version of the BM has been used more frequently in studies to examine the broader spectrum of diseases (Babitsch et al., 2012).

The factors examined in this study were addressed by measuring the three categories and variables in Andersen's model to understand the effect of human behaviors on health outcome and explain how these factors might contribute to the health risk of SSI. Andersen's (1995) BM was appropriate to examine three categories (i.e., predisposing, enabling, and need; see Table 1) and variables of the model in the relationship between smoking habits and SSI outcomes (Jahangir, Irazola, & Rubenstin, 2012; Jain et al., 2015).

Table 1

BM Categories and Variables for Orthopedic Smoking and SSI Patients

BM category	Variables
Predisposing	
	Age
	Gender
	BMI
Enabling	
	Health care coverage
	Medicare
	Medicaid
	Commercial
	Self-pay
Need	
	Health diagnoses
	TKA*
	Diabetes
	Hypertension
	Deficiency anemia
	RA
Behavior	
	Smoking cigarettes
Outcome	
	SSI

*Selection criterion.

Andersen's (1995) BM was appropriate to examine factors related to the internal and external factors of smoking status and SSI among patients. Andersen (1968) suggested that the model's categories of predisposing, enabling, and need factors could encourage people to address their smoking status and prevent medical issues. In this study, the predisposing variables were age, gender, and BMI; the enabling variable was access to health care insurance; and the need variables were related to health diagnoses, diabetes, hypertension, deficiency anemia, and RA. Application of the model facilitated the examination of ways that smoking tobacco products after surgery can prolong the healing process.

Andersen’s (1995) BM contributed new knowledge to the study by explaining the relationship among behavioral habits, risk factors, and health outcomes. Researchers have proven that the use of tobacco products has an adverse effect on how quickly patients heal after orthopedic surgery (Fisichella et al., 2014; Jain et al., 2015; Khullar & Maa, 2012). Because previous researchers have used the model to examine how internal and external parts of a system can affect the whole system, Andersen’s BM also was used in this study to investigate the incidence of lower-extremity SSI among orthopedic patients who smoked. The model served as the foundation of the study.

Nature of the Study

The study had a quantitative, cross-sectional design. Quantitative research is suitable for quantifying attitudes, presenting analyzed data in statistical form, and simplifying results (Brockington, 2014). Another unique aspect of quantitative research is that it can be used to examine the study hypotheses (Bishop & Lexchin, 2013).

The cross-sectional design uses statistical analysis to examine the association between or among the variables in a study, despite the cause, meaning that the method can be used to compare groups at a specific point of time (Bailey, 2014; Creswell, 2009;

Frankfort-Nachmias & Nachmias, 2008). The research strategy is the blueprint for any study, so researchers should choose designs that are suitable for their data collection and analysis purposes (Scammacca, Roberts, & Stuebing, 2014).

The cross-sectional design was relevant to the current study to examine the association between and among the variables. The purpose of this study was to determine the relationship between smoking tobacco products and SSI. Establishing the association between postoperative cigarette smoking and the prevalence of SSI-related complications in orthopedic surgery can provide insight into the ways that smoking after surgery can extend patients' healing process. The goal was to determine the association of each IV, namely, patients' smoking status, age, gender, BMI, insurance coverage, comorbid health conditions, and type of lower extremity orthopedic procedure, to the DV of SSI. Using a cross-sectional design eased the study examination between the variables, thus simplifying the statistical analysis of the quantitative research (Bailey, 2014; Creswell, 2009).

Definitions of Terms

Terms operationalized by this study included the following:

Anterior cruciate ligament: The ACL is connective tissue and one of the four major supportive structures of the knees of patients who smoke cigarettes have been identified as prone to meniscus failure and SSI (Blackwell, Schmitt, Flanigan, & Magnussen, 2016).

Baseline: Patients' self-reported information prior to surgery (Nubila, de Souza, Matarazzo, Lopes-Albers, & Gobbi, 2011).

Body mass index (BMI): A measurement tool commonly used in medical practice to determine patients' body fat as indicative of being normal weight, overweight, underweight, or obese.

Cigarette smoking: The burning of wrapped tobacco in paper with a filter at the end (CDC, 2009).

Surgical site infection (SSI): Also known as *surgical wound infection*; a nosocomial infection within or around a surgical incision (Cherian & Mont, 2015).

Total knee replacement (TKR): Also known as *total knee arthroplasty (TKA)*; reconstruction of an entire knee damaged by injury or arthritis that is replaced with metal and plastic implants (Badawy et al., 2017).

Assumptions

Assumptions are unconfirmed pieces of information that research investigators consider to be true (Madsen, 2013). The first assumption for this study was that there would be enough patient data in the legacy registry that fit the criteria for participation. Another assumption was that the patient data were truthful and accurate to ensure that there would be no difference between actual events and the surgery. For instance, a patient might express at the time of surgery that he or she is a nonsmoker and then report postoperatively that he or she has been smoking for the past 5 years. In such situations, if the patients acquired an SSI, the information that they provided about smoking status would have been inaccurate, prohibiting the ability of health care providers to follow the event of the SSI and the timeline from of the surgery. Finally, the last assumption of the study is related to the three groups (i.e., current smokers, nonsmokers, and previous smokers) abstinence from smoking on the baseline of the patients' surgery.

Scope and Delimitations

Delimitations are boundaries that researchers set for their investigations (Childers, 2014). Some delimitations were established to limit the scope of the project. First, all data of orthopedic patients in the legacy registry who met the criteria were chosen. Data pertained to three groups of orthopedic patients: smokers at the baseline of surgery, nonsmokers, and patients who used to smoke. Data on patients who smoked on the day of surgery were not analyzed because of limited access to those data. Data were collected only from orthopedic patients of the participating hospital, which was located on the east coast of the United States. The last delimitation was the sample size, meaning that the sizes of the three groups depended on the total number of patient cases in the legacy registry that fit the criteria.

Limitations

Limitations are constraints that researchers have no control over (Connelly, 2013). The first limitation was that the patients' honesty and truthfulness would affect the quality of the collected data. Although patients might have intended to provide accurate information, some participants might unintentionally have provided inaccurate data. Secondary data from the legacy registry for the hospital on the east coast were used to examine patients' characteristics and the time when patients acquired SSI. Durand et al. (2013) recommended that researchers use standardized definitions of tobacco history to control compounding variables that might have an effect on the validity of a study. To determine how tobacco consumption might have increased the patients' risk of SSI, standardized definitions of tobacco history to control the compounding variables of the study were used to improve validity.

Significance

SSI is a common infection that requires immediate medical treatment (Glanz, Rimer, & Viswanath, 2015). The significance of this study relates to the practice of arthroplasty surgery. Examining the effect of cigarette use on SSI can provide valuable information that might benefit health care professionals, patients, and researchers. Results also could lead to new insights to help doctors and nurses reduce orthopedic complications resulting from an increase in the risk factors associated with smoking.

Annual expenditures related to SSI range between $3.5 billion and $10 billion in the United States (D. J. Anderson et al., 2014). Most of the medical expenses associated with SSI are the result of emergency room visits, extended hospital stays, and readmissions (Jain et al., 2015). SSI can lead to higher costs and contribute to undesirable outcomes for patients. By understanding how the use of tobacco affects the body and the healing process after surgery, health care professionals can help to reduce the risks of SSI, which will help to save money.

Summary

Chapter 1 presented the background of the problem, the purpose of the study, the significance of the study, and definitions of terms. Chapter 2 includes a review of the literature, presenting a thorough analysis of studies examining the extent of tobacco use and the healing process. Chapter 3 details the research method and design. Chapter 4 presents the results of the statistical analysis. Chapter 5 provides the interpretation of the findings and offers recommendations for future research and practice.

Chapter 2: Literature Review

Chapter 2, the review of the literature, provides an exhaustive synthesis of current literature related to tobacco use, surgical site infection (SSI), and lower limb orthopedic surgeries impacted by patients' smoking behaviors. This chapter is divided into eight sections. The first section contains an explanation of the search strategy used to obtain relevant literature. In the second section is a discussion of the theoretical underpinnings that guided the study. The third section offers supporting and opposing theories. Described in the fourth section are the modifiable patient risk factors for smoking and SSI. The fifth section includes information about the guidelines for prevention. Included in the sixth section are explanations of contributing factors and associated complications, including diabetes and the underlying relationship between smoking and SSI. The seventh section provides details about other contributing factors that affect SSI. The eighth section is a summary of the chapter.

Literature Search Strategy

The literature review includes articles from EMBASE, MEDLINE, PubMed, the Cochrane Database of Systematic Reviews, and Database of Abstracts of Reviews of Effects. The relevant literature included peer-reviewed articles published between 2009 and 2017 in particular. The search was guided by the following key terms: *orthopedic total knee replacement arthroplasty*, *elective orthopedic patients' lower extremity infection*, *osteoarthritis*, *surgical site infection*, *risk factors and smoking*, *smoking and healing after surgery*, *the effects of tobacco*, *smoking, and infection after surgery*, and *risks associated with using tobacco*.

In reviewing the titles, abstracts, and full texts of articles, I assessed them against established inclusion criteria, as well as discrepancies related to articles among reviewers. Inclusion criteria required the literature to have been published in peer-reviewed journals. Studies for which reviewed abstracts indicated possible eligibility were assessed further in full-text format. Reasons for excluding articles in the literature database were documented. Extracted data encompassed operative characteristics; baseline populations; institutional factors; incidence of SSI risk factors such as p-values < .0, no significance of SSI, or > .05; significance of SSI; confidence intervals for statistical significance; time until the onset of SSI; and superficial incisions and study design.

Theoretical Foundation

The theoretical foundation of the study was Andersen's (1995) BM. Theoretical frameworks give researchers a foundation to examine business problems (Creswell & Creswell, 2017). Andersen (1968) developed the BM, a behavioral change theory, to understand the effect of human behaviors. The model was used in this study to examine variables related to three categories: predisposing (variables of age, gender, and BMI); enabling (variable of health care insurance status); and need (health diagnoses, diabetes, hypertension, deficiency anemia, and RA) and the risk of SSI.

Although Andersen's (1995) BM has been used to explain the utilization of services, it also has been used to predict outcomes (Gelberg, Andersen, & Leake, 2000). Researchers have used the model to help in identifying the effect of patients' smoking behaviors and to encourage patients to adopt change (Gelberg et al., 2000; Holford et al., 2014). Researchers on SSI have used behavioral models to understand the effect of smoking on the healing process (Fertman & Allensworth, 2010; Glanz & Bishop, 2010; Holford et al., 2014; Jahangir et al., 2012; Jain et al., 2015). Andersen's (1995) BM has given researchers a strong foundation to focus on patients' smoking behaviors and the ways that such behaviors affect the healing process of the lower extremities (Glanz & Bishop, 2010; Holford, 2014).

Researchers have used Andersen's (1995) model to understand patients' behaviors and the effects of changing such behaviors (Stokols, 1996). When compared to nonsmokers, patients who smoke have been disproportionately affected by SSI because of the ways that tobacco consumption affects the healing process. Andersen's behavioral model was used to examine the relationship between smoking and lower extremity SSI.

Application of the Model

Andersen's (1995) BM represents changes in the practices of patients who smoke and the outcomes of surgery (Gelberg et al., 2000). The model also clarifies the effects of unhealthy habits and behaviors (Jahangir et al., 2012). The effectiveness of treatments depends on patients' ability to adopt the healthier lifestyles recommended by medical services professionals (Andersen, 1995; Gelberg et al., 2000; Jahangir et al., 2012). Application of the model also may help to determine outcomes by adding to the understanding of the effects of patients' behaviors and explaining whether smoking tobacco products on the day of surgery increases the likelihood of SSI. The categories in the model and their variables are discussed next.

Predisposing Variables

The demographic variables were, age, gender, and BMI. The three variables were used to measure smoking status and development of SSI among male and female orthopedic patients. The study examined who accounted for the prevalence of SSI, namely, cigarette smokers, nonsmokers, or previous smokers.

Enabling and Need Variables

Andersen's (1995) BM refers to the ways that patients' behavioral habits affect their health outcomes (e.g., SSI). The role of the enabling and need categories of the model is to explain the ways in which health care coverage; medical needs for health diagnoses, diabetes, hypertension, deficiency anemia, and RA; and external factors of family members, friends, and other social networks can influence patients. This influence, in turn, may have either a positive or a negative impact on the effectiveness of treatment (Jahangir et al., 2012; Sallis, Owen, & Fisher, 2015).

Patients need positive encouragement to follow the guidelines suggested by medical professionals (Glanz et al., 2015). The goal of Andersen's (1995) BM is for patients to build positive relationships with family members, friends, and social networks (Sallis et al., 2015). By educating family members and friends about the importance of promoting a healthy environment for patients, medical professionals can reduce the incidence of SSI.

Supporting and Opposing Theories

Social Cognitive Theory

Bandura (1986) developed social cognitive theory (SCT), which was derived from social learning theory, to explain human behaviors and emotions. Bandura described human behaviors as involving personal factors and environmental influences. According to Bandura, changing people's behaviors requires that therapists treat their clients' cognitive, behavioristic, and emotional issues. Medical professionals can use the SCT in counseling interventions as well as for disease prevention and management (Glanz et al., 2015). The SCT represents a self-learning technique based on individuals' own experience as well as their observations of other people's actions.

The SCT provides a strong foundation for understanding how behaviors affect patients (Tri, 2017). According to Bandura (1986), recognizing the ways that people's behaviors affect their daily lives is important to understand the consequences of behaviors. Medical researchers have used the SCT to understand the impact of patients' behaviors on the effectiveness of medical treatment (Tri, 2017). The constructs supporting the SCT are reinforcement, observational learning, self-efficacy, and self-control.

Tri (2017) found that the SCT can provide researchers with a foundation to examine the challenges facing health care professionals. The SCT has been used by researchers to understand the impact of human behaviors, decisions, and choices on other variables (Chen, Sin, Theng, & Lee, 2015; Dervent & İnan, 2015; Lin & Hsu, 2013). Chen et al. (2015), for example, found that the SCT was effective when used to identify patients' behaviors associated with negative and positive outcomes. Dervent and İnan (2015) found that using the SCT was foundational to their success in examining the relationship between human behavior and demographic variables. Researchers continue to use the SCT to gain insight into challenges in the health care industry, so based on the four constructs of the SCT not having the ability to clarify the link between smoking status and lower extremity arthroplasty SSI, using Andersen's (1995) BM was appropriate.

Modifiable Risk Factors

Researchers have examined various risk factors related to the effects of patients' behaviors on SSI. Having information regarding patient characteristics and surgical procedures that might influence the development of SSI is useful because it can facilitate the stratification of procedures, ensure comprehensive data surveillance, and help to create a database of risk factors (Glanz et al., 2015). Following is a discussion about the different risk factors associated with smoking and SSI.

Nicotine tends to be a substantial, modifiable patient-related risk for SSI. Nicotine-mediated tissue hypoperfusion usually results in an unfavorable shift of oxobutanoic acid dissociation curve that eventually leads to impaired healing of tissue (Durand et al., 2013). Tobacco consumption also inhibits the synthesis of collagen, leading to dysfunction of the vascular endothelium and inflammation (Glanz et al., 2015). Researchers have found that nitric oxide, carbon monoxide, and nicotine affect the postoperative healing of wounds (Durand et al., 2013; Glanz et al., 2015) and that smoking cessation leads to reduced risk of SSI (Durand et al., 2013). By educating patients about the benefits of avoiding nicotine before and after surgery, health care professionals may be able to reduce the prevalence of SSI.

There are an estimated 1.2 billion smokers worldwide, 690 million of whom are addicted to nicotine (Hawn et al., 2011). Globally, more than 6 million deaths per year are linked to tobacco, with more than 5 million of these deaths representing former and current tobacco users (Laniado-Laborín, 2009). In addition, more than 600,000 individuals have direct exposure to secondhand smoke (Kim, Han, Lee, Chun, & Park, 2015).

Laniado-Laborín (2009) concluded that 50% of tobacco users will die from complications related to smoking, including cardiovascular disease and pulmonary disease. Health care researchers have had a difficult time determining the relationship between tobacco consumption and SSI. Statistical projections indicate that by 2030, 400 million new incidents related to these complications will be linked to smoking and a 20% increase in smoking-related deaths per year (D. J. Anderson et al., 2014; Laniado-Laborín, 2009). Durand et al. (2013) asserted that chronic exposure to smoke results in physiological changes that tend to modify individuals' responses to interventions. This chronic disease can lead to postprocedure morbidity, eventually compounding the risks to the wound-healing process, reduced blood circulation, and respiratory difficulties postsurgery (Durand et al., 2013).

The literature identified smoking cessation as valuable in some cases (Alexander, Solomkin, & Edwards, 2011). Sørensen (2012) suggested that patients who smoke attend smoking cessation training to prevent some of the risks associated with SSI. Researchers have asserted that smoking cessation training is useful and can help some patients (Alexander et al., 2011; Durand et al., 2013). Sørensen (2012) recommended that patients undergoing surgical procedures attend smoking cessation training to avoid postoperative complications. However, researchers have not established the optimal time period for smoking cessation training that might lead to a decrease in the development of SSI.

Cigarette smoking is the most significant risk linked to postoperative complications (Abdul-Jabbar et al., 2012). Smoking postsurgery can have an adverse effect on wound healing (Abdul-Jabbar et al., 2012; Durand et al., 2013). Abdul-Jabbar et al. (2012) confirmed that the percentages of complications tend to be significantly higher among cigarette smokers than among nonsmokers. Problems linked to smoking include molecular and cellular problems and a higher occurrence of tissue reconstruction and resurfacing (Abdul-Jabbar et al., 2012). Cigarettes contain vasoconstrictor substances that impair blood circulation, reduce the diameters of blood vessels, restrict the blood supply, and lead to cell death (Abdul-Jabbar et al., 2012). As such, the presence of these conditions might predispose patients to infection and delay hospital discharge, both of which can lead to increased institutional and personal costs.

Durand et al. (2013) contended that inhaling cigarette smoke increases the flow of blood into the coronary artery, which results in a higher heart rate and impairs the contraction of the myocardium. As a significant constituent of cigarettes, nicotine usually acts on the body by transporting concentrated levels of carbon monoxide to the red blood cells (Abdul-Jabbar et al., 2012). Carbon monoxide binds to red blood cells, reduces patients' oxygen-carrying ability, and prevents the release of oxygen by patients' hemoglobin (Durand et al., 2013).

Smoking tobacco inhibits the most supportive connective tissue fibroblasts that merge between the edges of a surgical site (Durand et al., 2013). Thus, wounds take significantly more time to heal. Surgical tissue trauma also decreases the supply of oxygen and blood to the tissue (Durand et al., 2013). Hypoxia can trigger patients' inspiration for oxygen and the colonization of tissue by bacteria, resulting in multiplication of the consumption of blood sugar (Abdul-Jabbar et al., 2012). Cigarette smoking heightens levels of contaminated oxygen, impairs bone healing and surgical sites, and may result in increased blood sugar levels in orthopedic patients with diabetes after operative procedures.

Respiration tends to release extreme amounts of oxygen species composed of chemicals that emerge from molecular oxygen (G. Q. Li, Guo, Ou, Dong, & Zhou, 2013). A higher volume of reactive oxygen usually develops from cigarette smoke, including radical hydroxyl, hydrogen peroxide, nitric oxide, and superoxide toxins (G. Q. Li et al., 2013). It also can result in the alteration of cell functioning and structural damage to tissues and by directly tampering with cellular components (G. Q. Li et al., 2013). Therefore, cigarette smoking affects the wound healing process, resulting in adverse effects to individuals who have undergone surgical procedures.

In cigarette smokers, antioxidant levels usually are reduced; this is particularly true for vitamin C, which is important to the production of collagen, a critical protein needed for the development of connective soft fleshy tissues (Sloan, Hussain, Maqsood, Eremin, & El-Sheemy, 2010). Collagen is produced by vitamin C and transported outside the cell, after which it is shaped into the structure of triple-helix collagen through the activities of polymerizing enzymes (Sloan et al., 2010). The three protein helices comprise lysine, proline, and glycine (Sloan et al., 2010). Some of the reviewed studies revealed that cigarette smokers who refrained from smoking for at least 4 to 5 weeks before the procedure, when compared to individuals who continued smoking, had fewer complications related to wound healing (Nåsell et al., 2010).

Research clearly has identified the detrimental effects of cigarette smoking and the process of tissue healing following surgical procedures. However, some physiological factors also are involved, including healing damage via oxidative techniques, decreased inflammatory response, and inadequate supply of blood to the tissue, which can result in necrosis (Nåsell et al., 2010). Nåsell et al. (2010) noted that cessation of smoking 2 weeks prior to surgery had a noneffect on the incidence of SSI and wound healing complications. Four weeks after cessation of smoking, restoration of the endothelial progenitor cells was affected, indicating endothelial dysfunction and injury (Nåsell et al., 2010). Vitamin C deficiency is reduced because of cigarette abstinence and elapsed time, but it is quickly reversed within 4 weeks after cessation of cigarette smoking (Sørensen, 2012). Quitting smoking for 4 weeks resulted in increased inflammation of macrophages, white cells that increase the risk of complications such as SSI (Nåsell et al., 2010). Nåsell et al. (2010) found that reversing the effect of short-term abstinence from smoking might increase the postoperative incidence of SSI.

Some researchers have assessed cigarette smoking in the postoperative period via patients' self-reported instruments, an approach that can lead nonsmoking and smoking study participants to record their smoking habits inaccurately (Sørensen, 2012). Adequate and dependable techniques might be needed to evaluate the biological consumption of tobacco, nicotine, and carbon monoxide absorptions (Cavichio, Pompeo, Oller, & Rossi, 2014). Researchers also have investigated different aspects of smoking tobacco postoperatively, a condition that can increase complications in wound healing. Jain et al. (2015), for example, conducted research with 108 patients undergoing orthopedic surgery. Results indicated that smoking cigarettes had a significant risk only for superficial SSI. In this retrospective cohort, Durand et al. (2013), who evaluated the risk factors of cigarette smoking on postsurgery complications, found that the tobacco users tended to have higher rates of SSI and major respiratory complications.

Skråmm, Moen, Årøen, and Bukholm (2014) found that the prevalence of nasal carriage of S. aureus remains a high risk for postoperative SSI in patients with arthroplasty implant components. The aim of their study was to examine the relationship between cigarette smoking and the risk of infection. Results indicated a positive correlation between smoking and SSI.

In a prospective research of 3,908 participants who had been scheduled for orthopedic procedures with implanted material (i.e., orthopedic joint replacement implants and components), Durand et al. (2013) identified smoking as a risk for SSI for the duration of the year of postoperative follow-up. In recent guidelines from the CDC (2016), tobacco use was reported as a risk factor in increasing SSI (Berríos-Torres et al., 2017). A prospective, observational study revealed that of 300 cases, 20% of them had no significant, modifiable, patient-related risk factors associated with SSI; however, results also showed significantly higher SSI complications found in orthopedic patients dealing with anemia, urinary tract infections, and obesity (Pruzansky, Bronson, Grelsamer, Strauss, & Moucha, 2014). Two other studies on orthopedic surgical procedures have found cigarette smoking to be a risk for SSI, even though the retrospective study had lower patients' numbers of 69 and 50 (Cherian & Mont, 2015). Smoking cigarettes might have a positive relationship to the lower extremity SSI wound healing process in orthopedic patients.

Guidelines and Community

Over the years, hospital guidelines have been developed to prepare patients to reduce pre- and postoperative risks. The risk of SSI is approximately 2% to 5%, with the costs of such a risk ranging from $3,000 to $29,000 per patient (D. J. Anderson et al., 2014). Cigarette smoking has been identified as an independent and key risk for SSI, with the habit resulting in delayed wound healing (Zaidi, Tariq, & Breslin, 2009). Clinical standards from the Care of Excellence have reported that some factors tend to be critical to some surgical procedures, whereas some are not applicable to other types of surgeries. For example, in a significantly large prospective study of 16,000 participants, 9,398 of whom were smokers, to determine the risk of smoking in relation to cardiovascular surgery, cigarette smoking was revealed to be a nonrisk factor for SSI (as cited in Uçkay, Hoffmeyer, Lew, & Pittet, 2013). The association between SSI and smoking in the postsurgery stage of the first year identified early infections or mechanism failures that could occur later.

Research has suggested that smoking significantly increases the proportion of such wound healing complications as dehiscence, discharge, or wound hematoma in the postoperative stage (Sørensen, 2012). Smoking impacts the normal process of wound healing and might lead to more infectious complications (Sørensen, 2012). Smoking causes inflammation, endothelial dysfunction, and the progression of oxidative stress (Sørensen, 2012). Some of these factors might indicate a relationship between cigarette smoking and SSI, along with the heightened risk of septicemia in cigarette smokers.

Contributing Factors and Associated Complications

Bischoff-Ferrari et al. (2012) examined the functioning status, referred to as the WOMAC score, of their 50 study participants who were Medicare recipients with 3 years of postoperative TKR. In their univariate evaluations, the researchers did not link current cigarette smoking to reduced financial status. F. A. Anderson and Spencer (2003) also studied the predictors of postoperative complications such as venous thromboembolism (VTE) in patients having TKR. Cigarette smoking was, however, a nonrisk factor for increased danger of VTE. Gray (2016) examined the risk associated with VTE in a sample of 1,947 patients undergoing TKR at a single facility. Gray found that cigarette smoking was not regarded as a considerable risk for the loosening of implants after evaluating the multivariable and univariable model. Postoperatively, there was no improvement within the year in extension or flexion following closed manipulation.

Nwachukwu et al. (2015) examined a retrospective study, Peersman's series single-center study, that identified 113 infections in 6,489 TKRs. Results linked cigarette smoking to the risk of SSI following TKR. A biological reason exists between the heightened risk of SSI and pneumonia interrelated to cigarette smoking (Nwachukwu et al., 2015); however, other clinical studies have issued opposing findings regarding cigarette smoking and surgical outcomes in postoperative joint replacements that can be explained partially by the lack of conclusive results. Smoking cigarettes is a significant probability for patients undergoing TKR. Therefore, behavioral changes might help to reduce the consequences of smoking.

Interventions also can offer patients a convincing argument to consider cessation of smoking. Giving consideration to the benefits of quitting smoking is notably higher among individuals attending intensive programs that last 4 to 8 weeks preoperative versus shortened, less intense programs (Kehlet, Schroeder, & Tønnesen, 2015). Health care providers view the postoperative period as a teachable moment to motivate clients to cease smoking. Because more than 95% of joint arthroplasty surgical procedures are elective, the postoperative period also provides opportunities for objective and meaningful deliberations with patients, as well as enough time to implement intensive smoking cessation programs (Durand et al., 2013). The benefits of short- or long-term cessation of smoking cigarettes on the overall health status of patients are enhanced if the patients do not smoke again after undergoing surgical procedures.

Other Contributing Factors Affecting SSI

Although some researchers have identified several of the factors and complications associated with smoking (Cherian & Mont, 2015; Sørensen, 2012; Uçkay et al., 2013), other researchers have argued that smoking does not affect the healing process of patients who have undergone surgery (F. A. Anderson & Spencer, 2003; Bischoff-Ferrari et al., 2012; Durand et al., 2013). Singh (2011), who examined predictive outcomes of closed manipulation following total knee arthroplasty and total hip replacement, found that the odds ratio (*OR*) for current smokers was 1.24 and 1.32 for former smokers, both of which were significantly associated with an OR of 1.69 for postoperative complications and death. Although some researchers have found no correlation between smoking and SSI, many other researchers have linked tobacco use to SSI.

Another complication associated with smoking is diabetes (Moucha, Clyburn, Evans, & Prokuski, 2011). Hyperglycemia has an adverse effect on cell and humoral-mediated immunity, notably impairing neutrophil function (Møller, Pedersen, Villebro, & Munksgaard, 2003). Macro- and microvascular disease, along with glycated hemoglobin, affect the transport of tissue oxygen and inhibit collagen fusion and fibroblast during wound healing (Moucha et al., 2011). Perioperative hyperglycemia in individuals diagnosed with diabetes leads to a heightened incidence of SSI. A glucose level of 180mg/dl and a postoperative level less than 110 mg/dl with HbA1c of 7% are suggested for patients having elective surgical procedures (D. J. Anderson et al., 2014; Cross, Yi, Thomas, Garcia, & Della Valle, 2014). Diabetic patients who can have nothing by mouth at midnight preoperative need their blood sugar levels evaluated before surgical procedures occur, especially if their blood levels are less than the threshold level.

Obesity, arthritis, and anemia are three of the most common risk factors for total joint replacement SSI. Obesity heightens the circumference of surgical procedures that can lead to more oxygen, deeper surgical instrumentation, extensive incisions, and prolonged healing times (Johnson et al., 2013; Korol et al., 2013; Pruzansky et al., 2014). Helm, Gould, and Higgins (2017), who found that obesity increases the chances of SSI, also asserted that dosages of certain medications might not be as effectively for obese patients. Because some dosages of medications might not be as effective in obese patients, these patients are at a higher risk of SSI.

The lack of nutritional supplement, particular deficiencies in protein, tends to impair the synthesis of proteoglycan and collagen, thus undermining the healing of tissue (Cross et al., 2014). Reduced levels of lymphocyte also can result in a decline in the ability for the immune system to fight infection, thus multiplying the probability of SSI (Pruzansky et al., 2014; Schoenfeld, Carey, Cleveland, Bader, & Bono, 2013). Sensitivity of serum albumin greater than 3.5g/dl is an indicator of the risk of orthopedic joint replacement SSI (Cross et al., 2014; Pruzansky et al., 2014; Schoenfeld et al., 2013). There is a correlation between acute protein-calorie malnutrition and postoperative infection and wound healing after some kinds of surgical procedures (Pruzansky et al., 2014). However, it is challenging to identify an association between malnutrition and SSI for all subspecialties of surgery.

Another contributing factor to SSI is RA, which has a significant risk for bacterial infections. Moucha et al. (2011) found that RA affects the body's immune responses to various pathogenic organisms and wound healing. Medications administered for RA tend to inadvertently affect patients' surgical sites postoperatively (Bongartz et al., 2008). Carpenter et al. (2017) found that patients with RA are more likely to develop SSI. Because patients diagnosed with RA are considered at higher risk for SSI, medical professionals need to know if patients who are preparing for surgery have arthritis.

Prescription drugs can increase the chance of SSI (Moucha et al., 2011). Corticosteroid injections are among the most acknowledged cause of SSI. Torres and Cilloniz (2016) found that taking corticosteroids after surgery increases the risk of SSI. Corticosteroids inhibit phagocytoses, adhesion, leukocyte chemotaxis, and vascular permeability, all of which impair cell-interceded immune responses (Moucha et al., 2011). Patients who take corticosteroids have an increased risk of SSI.

Comorbid medical conditions that involve deficiencies of the immune system are considered common risk factors for SSI. For example, HIV, uncontrollable loads, and CD counts less than the excepted range have been linked to the risk of SSI among patients undergoing joint surgery (Parvizi et al., 2011). HIV-infected individuals appear to have a heightened vulnerability to bacterial infections and are at higher risk of infections because of their compromised host status (Parvizi et al., 2011). Calvo-Sanchez and Martinez (2014) found that HIV patients who need to undergo surgery are at significantly higher risk of SSI. Because HIV patients have a higher risk of SSI, doctors need to consider if surgery is in the best interests of HIV-infected patients.

In combination with obesity and arthritis, anemia has been viewed as a preventable and predisposing risk factor for SSI. Preoperative anemia heightens the risk of postoperative blood transfusions. Even though the use of topical or intravenous tranexamic acid reduces the risk of anemia, blood transfusions can increase the life-threatening functions of SSI (Johnson et al., 2013; Moucha et al., 2011). The method of transfusion can be costly for and detrimental to patients.

Predisposing Factors for SSI

In addition to smoking status on the day of surgery, patients' ages have been used to determine a correlation with SSI. Older patients have a higher probability of postoperative complications (Aquina et al., 2017). Older patients without health care coverage also are more prone to severe medical issues and are costly to insurance providers (Lorio et al., 2008). In current study, the interrelated factors of smoking status and age were used to determine lower extremity SSI.

The number of patients who experience chronic issues such as SSI continues to rise because of the lack of health care coverage. The percentage of adults with health insurance in the United States increased by 0.3% between 2014 and 2015 (Barnett & Vornovitsky, 2016). Ninety-one percent of married adults were insured, compared to 83% of never-married adults and 79% of separated adults. In 2014, 33 million hospital patients in the United States were uninsured; by 2015, the uninsured rate dropped by 1.3% (Barnett & Vornovitsky, 2016). Despite decreases in uninsured rates, a coverage disparity exists between full-time workers and part-time workers. In 2015, 84% of full-time workers, compared to 52% of part-time workers and nonworkers, held private insurance coverage (Barnett & Vornovitsky, 2016). Health insurance coverage for employed and unemployed patients might be cost prohibitive, even if their procedures are partially covered (Glassman, Meschbach, & Everhart, 2018).

Addressing Smoking and Other Potential SSI Risk Factors

Fisichella et al. (2014) examined the relationship between SSI and the possible risk factors of BMI and diabetes using a quantitative approach. The researchers did not specify the theoretical foundation and framework used. The researchers' data set included information on patients with superficial and deep SSI, as well as uninfected patients diagnosed with diabetes and/or a BMI greater than 30. The researchers found a correlation among age, smoking, and diabetes in patients over the age of 65 years and had smoked for 20 years or more.

A similar study by Duchman et al. (2015) examined the relationship between smoking cigarettes and postoperative outcomes in the United States. The aim of the study was to pinpoint morbidity and mortality rates for patients who had undergone hip and knee arthroplasties based on their smoking histories. Duchman et al. used the American College of Surgeons' NSQIP database to identify patients' smoking histories and counts of packs of cigarettes smoked per year, as well as morbidity and mortality within 30 days following the arthroplasties. The researchers determined that patients who currently smoked or previously smoked had a higher chance of wound complications.

Williams et al. (2017) conducted a case control of 1,329 postoperative patients who had received joint replacements. Results indicated that the untenable increase of costs for quality health care decreased the delivery of appropriate care to patients with

TKR after an extended length of stay of more than 90 days and readmissions for SSI among TKR patients. Results showed significant risk factors of OR of 1.928 and financial risk to providers.

In contrast, Durand et al. (2013) researched smoking and other potential variables as risk factors for SSI within the human body organ and joint space. Data were collected over 3 years from 3,908 patients. Although Durand et al. found a statistically significant correlation between smoking cigarettes and organ and space infection, the researchers did not examine the relationship of financial cost and exposure to smoking to SSI.

Badawy et al. (2017) examined various surgical procedures and the duration of surgical procedure time for low-risk orthopedic patients affected with deep SSI using the Norwegian Arthroplasty Register as the primary data set for the study, which included surgical procedures conducted between 2005 and 2015. A total of 28,262 primary surgery patients and 311 TKR patients comprised the sample. Results showed a significant association between length of procedure and SSI; however, no significant correlation was found between duration of procedure and the presence of SSI.

Summary and Conclusion

The review of the extant literature revealed that in comparison and contrast studies, nonsmokers had no significant risk rate versus the substantial increase among current smokers and former cigarette smokers of a significantly higher risk rate of postsurgery complications. In procedures such as TKR, there also was an increased risk of SSI (Namba, Inacio, & Paxton, 2013). The most significant risk based on identified evidence was a global death rate of 50% and 69% in the United States among former tobacco users and 62% in current tobacco smokers; nonsmokers had no significant postoperative TKR (Laniado-Laborín, 2009; Singh et al., 2015). Cigarette smoking remains the most persistent and preventable behavioral habit in the United States; therefore, understanding the effects of smoking cigarettes on postsurgery difficulties needed to be established, and the effect of cessation programs needed further exploration. The outcomes of smoking cessation on lower extremity arthroplasty remain unknown (Cherian & Mont, 2015). Therefore, this study was an attempt to fill the gap in the literature regarding the association between smoking status and lower-extremity arthroplasty SSI.

Chapter 2 included a review of relevant literature, an explanation of the literature search strategy, and discussions of the theoretical foundation as well as supporting and opposing theories. The chapter also presented details about modifiable patient risk factors, as well as other predisposing factors and complications associated with SSI. In Chapter 3, the research method and design of this study, along with an explanation for choosing them, are discussed.

Chapter 3: Research Method

Chapter 3 provides information about the research methodology used to conduct the study. The purpose of this study was to examine the statistical association between smoking status and SSI in orthopedic patients. The chapter provides a deeper understanding of the statistical methods guiding this inquiry. Postoperative electronic medical data were analyzed to determine the frequency of SSI following lower-extremity orthopedic surgery. The results may provide orthopedic surgeons and other medical staff with important data on the influence of smoking status and the risk factors for SSI. The chapter commences with an overview of the research question, hypothesis, research design, and rationale, followed by explanations of the data sets, instrument, and data collection protocols. Chapter 3 concludes with a discussion of the institutional review board (IRB) process, ethical considerations, and data management procedures.

Research Question and Hypothesis

One research question guided this study: Is there a relationship between smoking of the three groups (i.e., smokers, nonsmokers, and previous smokers), defined as smoking within the baseline of surgery; BM predisposing variables of age, gender, and BMI; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, RA, and postoperative SSI in patients with lower extremity orthopedic procedures, specifically TKR?

The hypothesis associated with this research question was as follows:

H_{01}: There is no relationship between smoking among the three groups, controlling for the BM predisposing variables of age, gender, and BMI; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, and RA, and SSI.

H_{a1}: There is a relationship between smoking among the three groups, controlling for the BM predisposing variables of age, gender, and BMI; enabling variable of health care insurance coverage; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, RA, and SSI.

Research Design and Rationale

A quantitative research design was used. Secondary patient data from a legacy registry of an east coast hospital were used to obtain demographic information, smoking status, and any incidence of lower-extremity SSI for analysis. A cross-sectional design was used to answer the research question. The cross-sectional approach required the participation of patients who smoked and had undergone orthopedic surgery to represent one subset at a specific point of time. The findings may provide orthopedic health care professionals with data identifying smoking status as a risk for developing lower-extremity SSI.

Prior to conducting the study, permission was received to use the data set from the east coast hospital. Walden University's IRB protocols were followed. The research focused on the smoking status of three patient groups: current smokers, nonsmokers, and previous smokers. Patients who smoked cigarettes on the same day of surgery were excluded because of lack of access. Data were collected on smoking status, age, gender, BMI, insurance coverage, comorbid health conditions, type of orthopedic surgical procedure, and SSI. The presence of SSI was used to identify a potential relationship between orthopedic patients' smoking status and the incidence of lower extremity SSI.

Sample

In this quantitative study, anonymized data were collected from the legacy registry of one hospital located on the east coast of the United States. The secondary data were deidentified information on patients who had undergone orthopedic surgical procedures at the hospital site. The data from the east coast hospital were requested once Walden University gave approval to conduct the study (IRB #05-22-18-0527348).

Consecutive sampling, a nonprobability sampling design that relies on randomization, was used to select the participant data for the sample. Consecutive sampling is appropriate for selecting multiple subsamples in a sample until all inclusion criteria have been met (Frankfort-Nachmias, Nachmias, & DeWaard, 2015). Results of the G*Power analysis represent the data needed for the study.

Power Analysis

G*Power 3.1.9.2 statistical software (Faul, Erdfelder, Buchner, & Lang, 2009) logistic regression was used to determine the quantity of participant data needed to obtain a statistical power of .80, given a two-tailed alpha of .05, an event rate of .50 (under the null hypothesis); binomial distribution for each predictor; an unbalanced design (i.e., X parm $\pi = .2$); and minimal correlation of the predictors, with each other (R^2 other than X = .1). Table 2 shows that with an effect size of $OR = 1.30$, data from 3,201 participants would have been needed to obtain a statistical power of .80. However, with an $OR = 2.00$, data from only 488 participants were needed to obtain a statistical power of .80.

Table 2

Power Analysis to Assess the Likelihood of SSI

OR	*N*
1.30	3,201
1.50	1,360
2.00	488

Threats to Validity

Validity and reliability measures ensure that collected data are accurate and trustworthy (Frankfort-Nachmias et al., 2015). Because secondary data were used, maintaining the validity of the collection process meant that the measurements had to be precise, even though several issues could have affected the test; reliability tests the stability of the measurements (Kimberlin & Winterstein, 2008). By using all cases that met the selection criteria (i.e., the data had to be from patients who were at least 18 years of age between 2007 and 2014), cases were gathered through the use of consecutive sampling. Baseline was defined as patients' self-reported information prior to surgery (Nubila et al., 2011). Secondary data were obtained from the hospital's legacy registry to collect patients' self-reported information to determine if an association existed between patients' smoking habits and orthopedic outcomes following surgery.

Data Collection

Patient data were retrieved from the legacy registry of an orthopedic hospital on the east coast of the United States. The registry provided access to surgical information, patient demographics, and data on the presence of SSI. The IVs were smoking status, age, gender, BMI, insurance coverage, comorbid health conditions, and type of lower extremity orthopedic procedure.

Smoking Status

Patients' smoking histories were collected using patient data from the hospital's legacy registry. Three variables were used to determine patients' smoking histories:

1. CURRENT_SMOKERS_BASELINE: Current smokers who smoked at the baseline of the surgery.
2. PREVIOUS_SMOKERS: Patients who previously smoked at least one cigarette per week but did not currently smoke.
3. NON_SMOKERS: Patients who did not have a history of smoking. The three variables were dummy coded to denote patient smoking status. Responses were yes (0) and no (1).

Demographics

The hospital's legacy registry was used to obtain the racial and ethnic demographics of patients who had undergone lower extremity surgery. The IVs were smoking status, age, gender, BMI, insurance coverage, comorbid health conditions, and type of lower extremity orthopedic procedure; the DV was SSI.

Age. Patient age was classified as a continuous variable with a minimum value of 18 years of age. Data from the legacy registry were recoded as ages between 18 and 68 years or older.

Gender. Patient gender was coded as male (0) or female (1).

Body mass index. BMI is a measure commonly used in medical practice to determine if patients are medically overweight or underweight. A BMI greater than 30 indicates that patients are medically obese. The variable BMI_30_PLUS denoted whether patients in the data set were medically obese. Possible values for BMI_30_PLUS were yes (0) and no (1).

Insurance coverage. Patient insurance coverage was dummy coded into four categories: Medicare, Medicaid, commercial coverage, and self-pay/no coverage. Patients might have presented with more than one type of coverage (e.g., commercial coverage and self-pay), so the values for insurance coverage were dummy coded to ensure that all possible coverage combinations were accurately represented in the data.

Comorbid health conditions. Based on the review of the literature, the following comorbid health conditions were operationalized for the study: deficiency anemia, diabetes, hypertension, and RA. These variables were dummy coded to account for all comorbid conditions present in the patients' records.

Orthopedic surgical procedure. Data about the sites of the patients' most recent lower extremity surgical procedures were obtained from the legacy registry and coded individually. Procedure sites were in the lower extremities (i.e., TKR).

Data Analysis

Chi-square tests of independence were used to determine the association among patients' smoking histories; demographics, insurance coverage, and comorbid health conditions, and SSI. A multivariable logistic regression model was used to determine whether an association existed between patients' smoking histories and SSI while controlling for demographics. Categorical variables were dummy coded as needed to be included in the regression model.

Ethical Considerations

It was imperative to protect patients' rights during the data collection process. Before any data were collected, the approved proposal and IRB applications were submitted to the east coast hospital (IRB approval #2018-1608 04-23-18) and to Walden University to ensure ethical compliance. The National Institutes of Health (NIH) code of ethics (as cited in Uçkay et al., 2013) was used to increase the validation and credibility of the study (Creswell, 2014). All identifiable patient information, including patient names, addresses, and phone numbers, was removed from the final data set to ensure patient confidentiality (VanWey, Rindfuss, Gutmann, Entwisle, & Balk, 2005). Nuremberg coding was used to minimize the risk of any ethical issues when processing the patients' health information (Ölvingson, Hallberg, Timpka, & Lindqvist, 2002).

Data Storage and Security

The legacy registry contained vital and confidential information that required essential storage and security. A hard copy with all relevant data was stored in a locked drawer in a locked office location. Identifiable patient information were removed from the data set prior to receipt. Electronic documents, analytic notes, research articles, and media files were stored and secured on a computer with password protection and an external hard drive. Only this researcher, along with members of the dissertation committee, had access to the data. All collected data will be secured for 5 years following the conclusion of this study, at which time all relevant documents and data will be expunged.

Institutional Review Board

Walden University and the east coast hospital had to grant IRB approval to conduct this study. Researchers are warned not to initiate data collection until IRB approval has been granted. The study was submitted with the research ethics worksheet and full IRB application to Walden University's IRB for consideration. The east coast hospital employed similar guidelines prior to granting study approval. Because this study was retrospective and involved the use of archival data, the hospital's key concern was the protection and privacy of the patient data contained in the legacy registry.

Conclusion

The purpose of this study was to determine whether an association existed among the smoking histories, demographics, insurance coverage, and comorbid health conditions of patients who had undergone lower-extremity orthopedic surgery and SSI. A quantitative, cross-sectional research design was used to determine whether patients who smoked were at higher risk for SSI. Chapter 4 presents the results based on statistical analysis of the medical data set.

Chapter 4: Results

Chapter 4 provides the results of the analysis of the secondary data collected for this study from the participating hospital located on the east coast of the United States. The purpose of this study was to examine the association between smoking behavior and SSI. Because the number of SSI cases is difficult to track in the United States, the results might be different from what other researchers might find. Evaluating the three groups based on their smoking status (i.e., current smokers, nonsmokers, and previous smokers) and variables relevant to orthopedic patients might help to identify the relationship between cigarette smoking and SSI postsurgery.

Data Collection

As discussed in Chapter 3, archival patient data were retrieved from the legacy registry of the orthopedic hospital on the east coast that participated in this study. The registry provided access to surgical information, patient demographics, and data on the presence of SSI. The IVs were smoking status, age, gender, BMI, insurance coverage, comorbid health conditions, and type of lower extremity orthopedic procedure. The DV was SSI. Analysis of the data from the legacy registry was performed after IRB approval was obtained from the hospital site on April 23, 2018 and from Walden University on May 22, 2018.

Data Summary

The original data set for 327 patients was obtained from the legacy registry at the participating hospital. The data file was cleaned to remove incomplete patient entries. A patient entry was considered incomplete if it did not contain data for the key variables of gender, age, BMI, insurance coverage, diabetes, deficiency anemia, hypertension, RA, smoking history, and SSI. Fifteen patient entries missing BMI information were removed from the data set. Three more patient entries missing information about smoking status were removed. As a result, the final data set comprised 309 patient entries, or 94.5% of the entries in the original data set.

Descriptive Statistics

Patient Demographics

The sample comprised the cases of 177 female patients (57.2%) and 132 male patients (42.8%). The mean age of the patient sample was 61.4 years, ranging from 26 to 86 years, with a standard deviation of 10.19. Approximately 72% of the sample was over the age of 55 years. A total of 141 patients (46.5%) did not have a history of smoking, 72 patients (23.3%) were current smokers, and 96 patients (31.1%) were previous smokers at the time of data collection. Of the 309 patient cases in the sample, only one patient did not use some form of insurance to cover medical expenses. An overview of patient demographics by smoking status is presented in Table 3.

Table 3

*Frequency Distribution of Patient Demographics by Smoking Status (*N *= 309)*

Demographics	Never smoked		Current smoker		Previous smoker	
	N	%	*N*	%	*N*	%
Gender						
Male	60	45.4	27	20.5	45	34.1
Female	81	45.8	45	25.4	51	28.8
Age						
26-35	0	0.0	1	50.0	1	50.0
36-45	5	45.5	2	18.2	4	36.4
46-55	35	47.3	19	25.7	20	27.0
56-65	29	42.6	21	18.3	45	39.1
66+	52	48.6	29	27.1	26	24.3
Insurance type						
Medicare	83	46.4	42	23.5	54	30.2
Medicaid	4	66.7	0	0.0	2	33.3
Commercial	131	44.4	70	23.7	94	31.9
Self-pay	65	49.2	28	21.2	39	29.5

Health Diagnoses

An overview of health diagnoses for the patient sample by smoking status is presented in Table 4. The present study examined six health diagnoses: BMI, diabetes, deficiency anemia, RA, hypertension, and SSI.

BMI. Over 48% (149) of patients had a BMI greater than 30.0, meaning that the patients were obese at the time of data collection. Approximately 34% (104) of patients were considered overweight, signified by a BMI between 25.0 and 30.0. Seventeen percent (n = 53) of patients were considered of normal weight (18.5 < BMI < 25.0) and 1% (n = 3) were considered underweight (BMI < 18.5). Over 60% (89) of obese patients and approximately 52% (n = 54) of overweight patients were current or former smokers at the time of data collection.

Table 4

*Frequency Distribution of Patient Health Statistics by Smoking Status (*N *= 309)*

Health statistics	Never smoked		Current smoker		Previous smoker	
	N	%	*N*	%	*N*	%
BMI						
< 18.5	1	33.3	1	33.3	1	33.3
18.5 < 25.0	30	56.6	7	13.2	16	30.2
25.0 < 30.0	50	48.1	25	24.0	29	27.9
> 30.0	60	40.3	39	26.2	50	33.6
Diabetes						
Yes	18	46.2	8	20.5	13	33.3
No	123	45.6	64	23.7	83	30.7
Deficiency anemia						
Yes	16	38.1	14	33.3	12	28.6
No	125	46.8	58	21.7	84	31.5
Hypertension						
Yes	77	45.8	43	25.6	48	28.6
No	64	45.4	29	20.6	48	34.0
RA						
Yes	9	47.4	4	21.1	6	31.6
No	132	45.5	68	23.4	90	31.0
SSI						
Yes	38	48.1	18	22.8	23	29.1
No	103	44.8	54	23.5	73	31.7

Diabetes. A total of 39 patients (12.6%) presented with a history of diabetes. Of these 39 patients, 20.5% (*n* = 8) were current smokers, and 33.3% (13) were former smokers.

Deficiency anemia. Forty-two patients (13.6%) presented with a history of deficiency anemia. Of these 42 patients, 33.3% (*n* = 14) were current smokers, and 28.6% (*n* = 12) were previous smokers.

Hypertension. A total of 168 patients (54.4%) presented with a history of hypertension. Of these 168 patients, 25.6% (*n* = 43) were current smokers, and 28.6% (*n* = 48) were previous smokers.

RA. Nineteen patients (6.1%) presented with a history of RA. Of these 19 patients, 10 (52.7%) were either current or former smokers.

SSI. A total of 79 patients (25.6%) were treated for SSI. Of these 79 patients, 22.8% (*n* = 18) were current smokers, and 29.1% (*n* = 23) were previous smokers.

Data Analysis Protocol

SPSS v.25 was used to perform all quantitative analyses. Categorical variables were dummy coded for the research question to ensure the accurate representation of each required variable used in each statistical test. The following IVs were used for the analysis:

- Smoking status (never smoked, current smoker, or previous smoker).
- Age range (26-35 years, 36-45 years, 46-55 years, 56-65 years, 66+ years).
- BMI type (underweight, normal, overweight, or obese).
- Gender (male/female).
- Medicare insurance (yes/no).
- Medicaid insurance (yes/no).
- Commercial insurance (yes/no).
- Self-pay insurance (yes/no).
- Diabetes (yes/no).
- Deficiency anemia (yes/no).
- Hypertension (yes/no).
- RA (yes/no).

SSI served as the DV for the chi-square analyses.

Results

Smoking Status and SSI

The frequency distribution of patient smoking status by SSI is summarized in Table 5. Approximately 48% (*n* = 38) of patients who experienced SSI never smoked prior to surgery, as compared to approximately 45% (*n* = 103) of patients who did not experience SSI. Current smokers represented 22.8% (*n* = 18) of the sample that presented with SSI; 29.1% (*n* = 23) of SSI patients were previous smokers. More than 23% (*n* = 54) of patients who did not experience SSI were current smokers, and approximately 32% (*n* = 73) of the non-SSI group were previous smokers. The relationship between smoking status and SSI was not significant, χ^2 (2, N = 309) = .285, p = .87.

Table 5

*Frequency Distribution of Smoking Status by SSI (*N *= 309)*

	SSI presence			
	Yes		No	
Smoking status	*N*	%	*N*	%
Never smoked	38	48.1	103	44.8
Current smoker	18	22.8	54	23.5
Previous smoker	23	29.1	73	31.7

Note. χ^2 = .285 df = 2.
*p < .10 **p < .05 ***p < .01

Age and SSI

The frequency distribution of patient age range by SSI is summarized in Table 6. Five age ranges were used for the analysis: 26-35 years, 36-45 years, 46-55 years, 56-65 years, and 66+ years. Approximately 37% (*n* = 29) of patients who presented with SSI were 66 years of age or older, versus approximately 34% (*n* = 78) of patients who did not present with SSI. Similarly, 39% (*n* = 31) of patients who presented with SSI were between the ages of 56 and 65 years, versus 36.5% ($n = 84$) of patients who did not present with SSI. Cumulatively, patients between the ages of 26 and 55 years represented 23.1% ($n = 19$) of the SSI group, versus 29.6% ($n = 68$) of the non-SSI group. The relationship between age range and SSI was not significant (Fisher's exact test, $p = .63$).

Table 6

Frequency Distribution of Patient Age Range by SSI (N = 309)

Age range	SSI presence			
	Yes		No	
	N	%	*N*	%
26-35 years	1	1.3	1	0.4
36-45 years	3	3.8	8	3.5
46-55 years	15	19.0	59	25.7
56-65 years	31	39.2	84	36.5
66+ years	29	36.7	78	33.9

Note. Fisher's exact test, $p = .63$
$^{*}p < .10$ $^{**}p < .05$ $^{***}p < .01$

Because of the large number of patients over the age of 55 years, a second chi-square analysis was conducted to determine if there was a relationship between age over 55 years and SSI. The frequency distribution of patient age below and above 55 years of age by SSI is summarized in Table 7. Approximately 76% ($n = 60$) of patients who presented with SSI were 56 years of age or older, versus 70.4% ($n = 162$) of patients who did not present with SSI. Twenty-four percent ($n = 19$) of patients who presented with SSI were 55 years of age or younger, compared to 29.6% ($n = 68$) of patients who did not present with SSI. The relationship between age below or above 55 years and SSI was not significant, χ^2 (1, $N = 309$) = .884, $p = .35$.

Table 7

*Frequency Distribution of Patient Age Category by SSI (*N *= 309)*

Age	SSI presence Yes		No	
	N	%	*N*	%
55 years or younger	19	24.1	68	29.6
56 years or older	60	75.9	162	70.4

Note. $\chi^2 = .884$, $df = 1$.
$^*p < .10$ $^{**}p < .05$ $^{***}p < .01$

BMI and SSI

The frequency distribution of patient BMI by SSI is summarized in Table 8. Approximately 76% (n = 60) of patients who presented with SSI were classified as overweight (25.0 < BMI < 30.0) or obese (BMI > 30.0), versus approximately 84% (n = 193) of patients who did not present with SSI. Patients of normal BMI (18.5 < BMI < 25.0) represented 22.8% (n = 18) of patients who presented with SSI, versus 15.2% (n = 35) of patients who did not present with SSI. Patients whose BMIs fell below normal weight guidelines (BMI < 18.5) accounted for 1.3% of the SSI subsample and approximately 1% of the non-SSI subsample. A significant relationship was found between BMI and SSI (Fisher's exact test, p = .04).

Table 8

*Frequency Distribution of BMI by SSI (*N *= 309)*

BMI	SSI presence Yes		No	
	N	%	*N*	%
Underweight	1	1.3	2	0.9
Normal weight	18	22.8	35	15.2
Overweight	17	21.5	87	37.8
Obese	43	54.4	106	46.1

Note. Fisher's exact test, $p = .04$.**
$^*p < .10$ $^{**}p < .05$ $^{***}p < .01$

Gender and SSI

The frequency distribution of patient gender by SSI is summarized in Table 9. Of the patients who presented with SSI, 54.4% (*n* = 43) were female patients, and 45.6% (*n* = 36) were male patients. Conversely, 58.3% (*n* = 134) of patients who did not present with SSI were female patients, and 41.7% (*n* = 96) were male patients. The relationship between patient gender and SSI was not significant, χ^2 (1, *N* = 309) = .353, *p* = .55.

Table 9

*Frequency Distribution of Patient Gender by SSI (*N *= 309)*

Gender	SSI presence			
	Yes		No	
	N	%	*N*	%
Male	36	45.6	96	41.7
Female	43	54.4	134	58.3

Note. χ^2 = .353, *df* = 1.
**p* < .10 ***p* < .05 ****p* < .01

Insurance Coverage and SSI

The patients in the sample used one or more forms of insurance to cover medical expenses: Medicare, Medicaid, commercial insurance, or self-pay coverage. An overview of the prevalence of SSI based on insurance coverage is provided in Table 10.

Table 10

*Prevalence of SSI Based on Insurance Coverage (*N *= 309)*

Insurance coverage	SSI presence					
	Yes		No			
	N	%	*N*	%	χ^2	*P*
Medicare	46	58.2	133	57.8	.004	.95
Medicaid	1	1.3	5	2.2	--*	1.00
Commercial	77	97.5	218	94.8	.981	.32
Self-pay	34	43.0	98	42.6	.004	.95

Note. *Fisher's exact test.
*p < .10 **p < .05 ***p < .01

Medicare and SSI. A total of 179 patients (57.9%) received Medicare insurance benefits. Approximately 58% (*n* = 46) of patients who presented with SSI received Medicare benefits. Similarly, 58% (*n* = 133) of patients who did not present with SSI received Medicare benefits. The relationship between Medicare coverage and SSI was not significant, $\chi2$ (1, *N* = 309) = .004, *p* = .95.

Medicaid and SSI. Six patients (1.9%) received Medicaid benefits. Of the patients who presented with SSI, 1.3% (*n* = 1) received Medicaid benefits. Approximately 2% (*n* = 5) of patients who did not present with SSI received Medicaid benefits. The relationship between Medicaid coverage and SSI was not significant (Fisher's exact test, *p* = 1.00).

Commercial coverage and SSI. A total of 295 patients (95.4%) had commercial insurance coverage. Approximately 98% (*n* = 77) of patients who presented with SSI held commercial insurance coverage, versus approximately 95% (*n* = 218) of patients who did not present with SSI. The relationship between commercial insurance coverage and SSI was not significant, $\chi2$ (1, *N* = 309) = .981, *p* = .32.

Self-pay and SSI. One hundred and thirty-two patients (42.7%) used personal funds to pay for health care services in whole or in part. The relationship between self-pay coverage and SSI was not significant, $\chi2$ (1, *N* = 309) = .004, *p* = .95.

Health Diagnoses and SSI

Four health diagnoses were used to determine if there was a relationship between diagnosis and SSI: diabetes, deficiency anemia, hypertension, and RA. The frequency distribution of the health diagnoses by SSI is summarized in Table 11.

Table 11

*Prevalence of SSI Based on Health Diagnosis (*N *= 309)*

Health diagnosis	SSI presence Yes		No			
	N	%	*N*	%	χ^2	*P*
Diabetes	12	15.2	27	11.7	.635	.43
Deficiency anemia	9	11.4	33	14.3	.437	.51
Hypertension	44	55.7	124	53.9	.075	.78
RA	9	11.4	10	4.3	--[a]	.03**

Note. [a]Fisher's exact test.
*$p < .10$ **$p < .05$ ***$p < .01$

Diabetes and SSI. A total of 39 patients (12.6%) presented with a history of diabetes. Of the patients who presented with SSI, 15.2% (*n* = 12) also presented with a history of diabetes. Conversely, 11.7% (*n* = 27) of patients who did not present with SSI were diabetics. The relationship between diabetes and SSI was not significant, $\chi2$ (1, *N* = 309) = .635, *p* = .43.

Deficiency anemia and SSI. A total of 42 patients (13.6%) presented with a history of anemia. Approximately 11% (*n* = 9) of patients who presented with SSI also presented with a history of anemia, versus approximately 14% (*n* = 33) of patients who did not present with SSI. The relationship between deficiency anemia and SSI was not significant, $\chi2$ (1, *N* = 309) = .437, *p* = .51.

Hypertension and SSI. A total of 168 patients (54.4%) presented with a history of hypertension. Of the patients who presented with SSI, 55.7% (*n* = 44) also had received a diagnosis of hypertension. Approximately 54% (*n* = 124) of patients who did not present with SSI were diagnosed with hypertension. The relationship between hypertension and SSI was not significant, $\chi2$ (1, *N* = 309) = .075, *p* = .78.

RA and SSI. Approximately 6% (n = 19) of patients presented with a history of RA. Only 4.3% (n = 10) of patients who did not present with SSI were diagnosed with RA. Conversely, 11.4% (n = 9) of patients who presented with SSI also were arthritic. A significant relationship was found between RA and SSI (Fisher's exact test, p = .03.)

Multiple logistic regression. The test was conducted to determine the relationship between smoking and SSI while controlling for the potential confounders of age, gender, BMI, insurance type, and comorbid conditions. Age was included in the regression as a continuous variable, with a minimum value of 26 and a maximum value of 86. The variables for gender, smoking status, BMI, insurance type, and comorbid conditions were dummy coded for inclusion in the logistic regression model:

- Gender: male (reference indicator), female.
- Smoking status: never smoked (reference indicator), present smoker, previous smoker.
- BMI: normal weight (reference indicator), underweight, overweight, obese.
- Insurance type: Medicare, Medicaid, commercial, self-pay.
- Comorbid conditions: diabetes, deficiency anemia, hypertension, and RA.

Regression model. The results of the regression model are presented in Table 12. When controlled for patient demographics and health diagnoses, smoking status was not found to have a statistically significant association with SSI risk. The coefficients for smoking status suggested a negative relationship between smoking history and risk for SSI, but the true impact of smoking was not statistically significant (OR_{current} = 0.94, p = .86; OR_{previous} = 0.81, p = .52).

Table 12

*Summary of Logistic Regression Analysis Predicting SSI (*N *= 309)*

Variable	*B*	*SE*	*OR*	95% CI	Wald statistic	*P*
Age	0.02	0.01	1.02	[0.99, 1.05]	1.60	0.21
Female	-0.36	0.28	0.70	[0.40, 1.22]	1.60	0.21
Underweight	0.48	1.29	1.61	[0.13, 20.30]	0.14	0.71
Overweight	-0.89	0.42	0.41	[0.18, 0.93]	4.55	0.03**
Obese	-0.06	0.39	0.94	[0.44, 2.01]	0.03	0.87
Medicare insurance	0.29	0.67	1.33	[0.36, 4.94]	0.18	0.67
Medicaid insurance	0.55	1.75	1.73	[0.06, 52.91]	0.10	0.75
Commercial insurance	1.52	1.34	4.57	[0.33, 63.36]	1.28	0.26
Self-pay	0.30	0.67	1.35	[0.36, 5.01]	0.20	0.66
Diabetes	0.16	0.41	1.17	[0.53, 2.60]	0.15	0.70
Deficiency anemia	-0.36	0.42	0.70	[0.31, 1.58]	0.74	0.39
Hypertension	-0.03	0.30	0.97	[0.55, 1.73]	0.01	0.92
RA	1.20	0.52	3.33	[1.20, 9.25]	5.30	0.02**
Current smoker	-0.06	0.35	0.94	[0.47, 1.87]	0.03	0.86
Previous smoker	-0.21	0.32	0.81	[0.43, 1.52]	0.42	0.51

*$p < .10$ **$p < .05$ ***$p < .01$

Gender. Gender was not found to have a statistically significant association with SSI risk in the regression model. Despite a negative coefficient associated with female gender, the *OR* was not found to be statistically significant (*OR* = 0.70, $p = .21$).

BMI. A significant was found by BMI, with associations between smoking and SSI found for patients with BMI in the overweight range (25.0 < BMI < 30.0). Compared with patients who had a normal BMI (18.5 < BMI < 25.0), overweight patients had a 41% chance of having SSI (*OR* = 0.41, $p = .03$). The coefficient for BMI below the normal range (BMI < 18.5) was positive; however, the association was not significantly different from zero (*OR* = 1.61, $p = .71$). BMI categorized as obese (BMI > 30.0) suggested a negative association between obesity and increased SSI risk; however, the *OR* was not found to be statistically significant (*OR* = 1.33, $p = .87$).

Age. Age was not found to have a statistically significant association with SSI risk in the regression model. The positive coefficient for age suggested a positive relationship between age and SSI risk, but the *OR* was not found to be statistically significant (*OR* = 1.02, *p* = .21).

Health diagnoses. A significant association was found for one of the four comorbid conditions included in the present model. Patients who presented with RA were more than 3 times more likely to have SSI (*OR* = 3.33, *p* = .02). The coefficient for diabetes suggested a positive association between diabetes diagnosis and SSI risk; however, this association was not statistically significant (*OR* = 1.17, *p* = .70). Coefficients for deficiency anemia and hypertension suggested a negative relationship between diagnoses and SSI risk; however, neither association was found to be statistically significant (OR_{anemia} = 0.70, *p* = .39; OR_{htn} = 0.97, *p* = .92).

Insurance coverage. None of the four insurance types was found to have an association with SSI risk. The coefficients for all four insurance types were positive; however, the *p* values for all four types were greater than *p* = .05 ($\text{OR}_{\text{Medicare}}$ = 1.33, *p* = .67; OR_{Medicaid} = 1.73, *p* = .75, OR_{comm} = 4.57, *p* = .26; $OR_{\text{self-pay}}$ = 1.35, *p* = .66).

Summary

Included in Chapter 4 were the analyses of the results of this quantitative, cross-sectional study. Chi-square tests for independence were used to determine the association of patients' smoking histories, demographic data, and health diagnoses to SSI. Based on the chi-square analyses, there was no statistically significant association between smoking and SSI. However, RA were found to have a statistically significant association with SSI. Chapter 5 presents the interpretation of the findings, the limitations of the study, recommendations, implication of social change and conclusion.

Chapter 5: Discussion, Recommendations, and Conclusion

Chapter 5 presents the results of the study, offers recommendations, explains the implications for social change, and ends with a conclusion. In this study, patients who smoked and had initial SSI complications were readmitted to hospital for TKR revisions. When examining the relationship between smoking and the development of SSI among orthopedic patients, the results showed that patients who smoked did not have an increased risk of developing SSI. In addition, the results indicated that patients who smoked and had a BMI greater than 30 had a heightened risk for SSI. Each year presents an increase in the number of patients who develop infections resulting from different risk factors (D. J. Anderson et al., 2014). By helping patients to understand the consequences of smoking, health care professionals can facilitate a reduction in SSI. The findings relevant to the association between cigarette smoking and the development of lower extremity SSI, particularly in TKR procedures, are discussed in Chapter 5.

The purpose of this nonexperimental study was to ascertain the association between smoking status and the development of lower extremity SSI, particularly in TKR procedures, among orthopedic patients postsurgery. This quantitative study followed a cross-sectional design. The data extracted from the three groups in the data set displayed the possible association among smoking status; SSI; and Andersen’s (1995) BM categories and their variables (predisposing variables of age, gender, and BMI; enabling variable of health care insurance; and need variables of health diagnoses, diabetes, hypertension, deficiency anemia, and RA).

Interpretation of the Findings

This study was conducted to examine the effects of smoking behavior on the risk of SSI among patients who had undergone surgery of the lower extremities, particularly TKR. The purpose of the study was to focus on identifying the risk factors that might help in reducing SSI postprocedure. Jain et al. (2015) cited cigarette use as a significant risk factor for SSI, but other clinical researchers have argued that cigarette smoking does not affect the healing process of patients who have undergone certain procedures (F. A. Anderson & Spencer, 2003; Durand et al., 2013; Olsen, Møller, Brorson, Hasselager, & Sort, 2017). The question of whether smoking affects the health status of patients was addressed by using three categories of Andersen's (1995) BM: predisposing, enabling, and need. The variables associated with each category were as follows: predisposing (variables of age, gender, and BMI); enabling (variable of health care insurance status); and need (variables of health diagnoses, diabetes, hypertension, deficiency anemia, and RA).

Researchers have reported that smoking status and patients' ages have been used to determine a correlation to SSI (Aquina et al., 2017; Lorio et al., 2008). According to Aquina et al. (2017), older patients have a higher probability of postoperative complications, but the results of this study found that the association between age below or above 55 years and SSI was not significant. However, older patients without health care coverage are more prone to severe medical issues and are costly to insurance providers (Lorio et al., 2008). Results indicated that none of the four insurance types had an association with SSI risk.

The literature reviewed in Chapter 2 provided evidence that regardless of the risks associated with smoking, a significant number of patients continue to smoke following an operative procedure (Cherian & Mont, 2015; Fleisher, 2013). Some of the findings identified in the review of the literature support the null hypothesis, indicating RA showing a statistically significant association with SSI. The null hypothesis was accepted because no significances was found between patients' smoking histories in three groups (i.e., smokers, nonsmokers, previous smokers) and SSI.

The literature reviewed supported the findings of this study. Fisichella et al. (2014) suggested that smoking may expose risk that increases early TKR revisions which might either have no effect on wounds or might be the reason for the revision. Researchers have provided limited information on smoking and the development of SSI in lower extremity TKR (Cherian & Mont, 2015; Fisichella et al., 2014). Therefore, the findings add the current literature base.

Discussion

Although, no association was found between smoking and SSI. The results helped to partially fill the gap in the literature because a statistically significant association was found between the (IV) RA and (DV) SSI. Smoking cigarettes is the most prominent cause of preventable deaths worldwide (Wang, Mamudu, Collins, & Wang, 2017). In more recent literature, X. Li, Nylander, Smith, Han, and Gunnar (2018) identified the relationship between smoking and SSI in 11 specialties 30 days postprocedure: orthopedics, plastic surgery, general surgery, vascular surgery, thoracic surgery, cardiac valve, cardiac artery surgery, neurosurgery, otolaryngology, urology, and podiatry/other surgeries. TKR is considered a successful procedure for orthopedic patients who have arthritis (Malizos & Varitimidis, 2017). Cigarette smoking increases risk factors related to joint infection and also slows improvements in arthritic knees postprocedure.

The literature identified smoking cessation as valuable in some cases (Alexander, Solomkin, & Edwards, 2011). Sørensen (2012) suggested that patients who smoke should attend smoking cessation training to prevent some of the risks associated with SSI. Researchers have asserted that smoking cessation training is useful and can help some patients (Alexander et al., 2011; Durand et al., 2013). X. Li et al. (2018), for example, concluded that the complications of smoking and SSI are difficult and can be costly for surgeons to treat. Sørensen even recommended that patients undergoing surgical procedures attend smoking cessation training to avoid postoperative complications. However, researchers have not established the optimal time period of cessation smoking training that could reduce the occurrence of SSI.

SSI can also be difficult to manage because it involves the occasional interruption of suppressing SSI with medications, along with the determination of whether a TKR revision will be needed using either a Stage 1 or a Stage 2 reimplantation, an exchange of TKR components or polyethylene, and antibiotics (Malizos & Varitimidis, 2017). A Stage 1 reimplantation involves taking tissue and fluid cultures to test for infection, removing all TKR components, debriding the synovium tissue, washing the knee with antibiotic solution, and reimplanting new components or a cement spacer (Malizos & Varitimidis, 2017). Stage 2 follows the same steps as Stage 1, but if the laboratory results test positive for infection, the reimplantation procedure will occur once the patient’s health status is optimized (Malizos & Varitimidis, 2017). Patients who smoke but adhere to the recommendation to quit smoking after the surgical procedure have less chance of SSI and TKR revision. Daines, Dennis, and Amann (2015) examined TKR postoperative exposures leading to infection. Of 60,355 TKR revision cases, 25% of the patients showed a higher risk of infection and complications, and despite the patients' low exposure to modifiable risk factors, the cases were significant enough for surgical revision (Daines et al., 2015).

Theory Integration

The results of this study and previous research might have been different because of behavioral differences. Andersen (1968) developed the BM to examine the impact of the three categories of predisposing, enabling, and need variables on patients' behaviors and a range of other factors that regulate such behaviors (Holford et al., 2014) to understand the effect of human behaviors. Researchers have used Andersen's model to identify the impact of patients' smoking behaviors within community clinics, hospitals, centers, private practices, and outreach programs (Babitsch et al., 2012; Gelberg et al., 2000). Researchers have also used the model to predict health outcomes and understand the effect of smoking on health status (Fertman & Allensworth, 2010; Glanz & Bishop, 2010; Holford et al., 2014; Jain et al., 2015). Andersen's BM gave this study a strong foundation to focus on patients' smoking behaviors and determine how such behaviors affect the healing process.

Andersen's (1995) BM was appropriate for use in this study to examine the variables in three categories of the BM (i.e., predisposing, enabling, and need) and their association between smoking habits and SSI outcomes (Jain et al., 2015). Researchers have used Andersen's BM to understand patients' behaviors and the effects of changing such behaviors on SSI (Stokols, 1996). When compared to nonsmokers, patients who smoke have been affected disproportionately by SSI because of the ways that tobacco consumption affects the healing process negatively. Andersen's BM was used to examine the association between smoking status and the development of lower extremity SSI. The effectiveness of treatment depends on the ability of patients to make behavioral changes that can help to reduce the risk of SSI.

Limitations of the Study

One limitation of the study was the use of archival data. The data collection process of any study warrants that the measurements be precise, even though several issues can affect the test; reliability tests the stability of the measurements (Kimberlin & Winterstein, 2008).

Every database holds sensitive information. Deidentifying the data reduced any potential risk to the hospital or to the patient cases. One error that could have occurred before analyzing the data involved inconsistencies in patients' information. For example, some patients might have self-identified as being smokers at the baseline of surgery but might have reported postoperatively having never smoked, thus threatening the findings. If this occurred before data analysis took place, baseline data were used to reduce the threat of errors in the statistical findings.

Case selection criteria ensured that the data were from patients who were at least 18 years of age between 2007 and 2014. The study was limited to gathering enough cases therefore by using consecutive sampling was appropriate until all inclusion criteria was met. Secondary data of previously identified TKA revised for infection and any new cases were confirmed through EPIC chart review. The electronic medical information database was used to collect patients' self-reported information to determine if an association existed between patients' smoking habits and orthopedic outcomes postsurgery. Because of limited access to data on employment, marital status, and number of hospital readmissions, smoking on the day of surgery was misclassified. In addition, the collection of data from one hospital limited the sample size and weakened the statistical findings.

Recommendations for Future Research

There is a need for further research on this topic to identify other factors that might produce results different from those of this study. Most SSIs occur for a variety of reasons, so tailoring treatment plans or surgical revision to meet the needs of patients appropriately also might reduce the risk of SSI. Tobacco use accounts for more than 6 million deaths annually in the United States, and 50% of health complications are linked to chronic diseases (Laniado-Laborín, 2009).

The sample for this study was small because of the lack of TKR revision cases. It might be beneficial to conduct a qualitative or a mixed methods study on participants' perception of cigarette smoking and the development of lower extremity SSI, particularly in TKR procedures, among orthopedic patients postsurgery. Franklin (2017) noted that some surgeons have suggested that patients use mobile cell accelerometers to engage in activity postprocedure. Orthopedic patients who are willing to reduce smoking prior to surgery can avoid SSI and be more satisfied with the outcomes of surgery. Further research is recommended to investigate the significance of identified risk factors and SSI.

Implications for Social Change

Results of this study have implications for positive social change. The findings may encourage future researchers to examine the association of SSI to smoking status, age, gender, BMI, insurance coverage, RA, and comorbid conditions. The goal of the study was to identify a possible link between smoking and SSI in the lower extremities of orthopedic patients, and then use the findings to discuss the implications for positive social change by understanding patients' behavioral risk factors. Based on the results RA was found to be a contributing factor to SSI, so providing the orthopedic community with education that lead to insight into ways to reduce the risk factors of RA and SSI could simulate social change. One of many ways to help patients obtain knowledge about the link between RA and SSI would be to use cost-effective mobile technology. Advances in technology, such as the use of mobile cell phone applications to track and measure RA, are facilitating the education of patients regarding ways that they can make behavioral changes to improve health outcome (Griffiths et al. 2018). These advances are another way to support positive social change. Day et al. (2018) reported that the orthopedic patients in their study who smoked tobacco agreed to receive mobile text messages to help them to refrain from smoking. The approach allowed health care providers to educate patients on pre- and postoperative instructions, exercises, and ways to reduce smoking habits postsurgery and the financial ramifications of caring for patients with SSI. Day et al. (2018) stated that 92% of the 34 orthopedic patients in their study were men and women between the ages of 51 and 75 years. Receiving text messages from health care providers made the patients feel more comfortable with and more able to understand information on postsurgical instructions and pain control. The patients also were more prepared for surgery and more informed following the TKR procedures.

RA is a complex condition that requires immediate and long-term medical treatment (Carpenter et al.,2017). This study is significant to the practice of orthopedic surgery because examining the ways that RA can contributes to SSI the results can provide valuable information that may benefit health care professionals, patients, and researchers. Results also could lead to new insight to help doctors and nurses reduce orthopedic complications resulting from the increased in the risk factors associated with smoking.

Conclusion

The results met the goal of the study to examine the association between smoking status and the development of lower extremity SSI, particularly in TKR. Results showed no significant relationship between patients' smoking histories, demographic data, health diagnoses, and SSI. The results also identified a significant relationship among RA and SSI. Dissemination of the results connected to orthopedic patients who smoked at the baseline of surgery, nonsmokers, and previous smokers might lead to positive social change for the health wellness of the three groups. Further research on orthopedic patients who smoked on the same day as a TKA procedure and SSI postsurgery is warranted to build the knowledge base relevant to smoking and the risk factors related to SSI following TKR procedures.

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