2017

Assessment of Postoperative and Postdischarge Wound Infection After Abdominal Hysterectomy

Jinni J. Amin
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Jinni J. Amin

has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

Review Committee
Dr. James Rohrer, Committee Chairperson, Public Health Faculty
Dr. Adebowale Awosika-Olumo, Committee Member, Public Health Faculty
Dr. Jagdish Khubchandani, University Reviewer, Public Health Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2017

Abstract

Assessment of Postoperative and Postdischarge Wound Infection After Abdominal Hysterectomy

by

Jinni J. Amin

MPH, Walden University, 2011

BS, Towson University, 2009

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

August 2017

Abstract

Surgical site infection (SSI) is the most common healthcare-associated infection. Approximately 2% to 14% of surgical patients are diagnosed with SSI, which may extend length of stay in the hospital or lead to readmission and may necessitate another surgical procedure. Patient readmission due to SSI costs health care industries about $3,000 to $29,000 per case and a total of $10 billion per year. The purpose of this quantitative cross-sectional retrospective study was to examine the association between SSI and teaching status, hospital ownership, and number of beds in the hospital. The epidemiological triad was used as a framework to describe the relationship between the person (hospital is the unit of analysis), place (regional location), and time (one year of data). The dataset used in this study was retrieved from Centers for Medicare & Medicaid Services. A hospital was classified as having a high SSI rate if its rate was in the highest third. Contingency tables were used to test the relationships. The chi-square tests revealed that teaching hospitals were more likely to have high SSI rates than were nonteaching hospitals. Forty percent of teaching hospitals had high SSI rates compared to 26% of nonteaching hospitals ($p < 0.001$). Hospital ownership, bed size, and region were not significant predictors of high SSI rates. Findings from this study may lead toward further reductions in SSI by guiding infection control efforts toward hospitals with higher rates.

Assessment of Postoperative and Postdischarge Wound Infection After Abdominal Hysterectomy

by

Jinni J. Amin

MPH, Walden University, 2011

BS, Towson University, 2009

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

August 2017

Dedication

I wish to dedicate this dissertation to my parents Jatin and Pravina Amin for their constant encouragement, help, support, and special prayers while I pursued my educational endeavors. They have worked so hard to set the ground work for their children and provided unlimited opportunities and success.

Acknowledgments

I am appreciative to my committee chair, Dr. James Rohrer, for continued encouragement, motivation, and support. He always made himself available to assist in achieving my academic goals. I would also like to thank my committee member Dr. Debo Awosika-Olumo.

Thanks to God and my wonderful parents, Jatin and Pravina Amin, for their unconditional love and support throughout my academic career. Without their support I may not have the courage to fulfill my dreams. I would also like to thank my sister, Ranna and brother, Hitesh for their support and encouragement throughout this process. I am also grateful to friends and colleagues I fail to mention, but contributed to the successful completion of this dissertation.

.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Background

Healthcare-associated infections (HAI) are the type of infections that patients acquire while receiving healthcare treatment at a medical facility including inpatient and outpatient care (Centers for Disease Control and Prevention [CDC], 2016). It is possible to develop HAI while being treated at home as well. These infections are caused by various bacteria, fungi, and viruses. It is estimated that one out of every 25 patients who are hospitalized in United States has acquired HAI. In other words, annually 650,000 patients have been diagnosed with HAI (Agency for Healthcare Research and Quality, 2016). The most common HAI is the surgical site infection (SSI). Thirty-one percent of hospitalized individuals are diagnosed with SSI (CDC, 2016). According to CDC (2016), in 2011, about 157,500 SSIs were related to inpatient surgeries. On August 18, 2011, the Center for Medicare and Medicaid Services (CMS) announced all SSIs should be reported to the CDC’s National Healthcare Safety Network (NHSN) in the CMS Hospital Inpatient Quality Reporting (IQR) Program requirements for 2012. The rule of reporting inpatient data starting from January 1, 2012, particularly emphasized abdominal hysterectomy and colon procedures (CDC, 2012).

Patients who have acquired SSI are expected to extend their length of stay in the hospital, require additional care from the medical staff, and consume extra bandage dressings. Also, SSI patients may need readmission and the infection may require another procedure as well. The research reported so far has yielded estimates of both direct and indirect costs of treating SSI. Chapter 2 provides discussion on the financial impact of

SSI on the states and on medical insurance companies. Further research included 46 independent risk factors based on substantial evidence (i.e. obesity, longer operating time, diabetes mellitus, smoking, history of previous SSI, and type of surgery procedure), moderate evidence (i.e. spinal level of surgery, previous surgery, larger operative blood loss, blood transfusion, and American Society of Anesthesiologists [ASA] classification), limited evidence (hypertension, invasive index, renal disease, drain duration, trauma, disseminated cancer, and presence of comorbidities), conflicting evidence (i.e. age, alcohol abuse, dural tear, postoperative incontinence, steroids, neurological surgery, tumor surgery, prolonged hospital stay, and the number of residents who participated in the surgery) and complications are presented as well (Xing et. al., 2013). There is very limited evidence regarding the relationship between SSI and academic institution, hospital ownership, number of beds, and geographical locations, and how these variables impact patient outcomes. Risk factors for which there is conflicting or weak evidence that will serve as the primary focus for this study are academic institution, hospital ownership, number of beds, and regional location of the hospitals (Northeast, Midwest, South, and West).

Problem Statement

SSI is a major public health problem that is increasing morbidity and mortality after a surgical procedure (Koek, Willie, Isken, Voss, and Benthdme, 2015). Every year, approximately 500,000 to 750,000 cases of SSIs occur in the United States (Kitembo and Chugulu, 2013). Between 2% and 14% of SSI cases are diagnosed after the patient is discharged from the hospital (Graves et al., 2006). Nearly 4% to 25% of patients are readmitted, and some require another surgery due to initial surgical complications, which increase the length of stay at the hospital (Tevis, Kohlnhofer, Weber, and Kennedy, 2014). Patient readmission due to SSI costs health care industries about $3,000 to $29,000 per case and a total of $10 billion per year (Anderson et al., 2014). Abdominal hysterectomy is considered to be the highest volume surgery in the United States with SSIs increasing morbidity incidence rates by 15-25% (Azoury et al., 2015).

Purpose of the Study

The design of this study was a quantitative, cross-sectional retrospective analysis of observational data. The purpose of the study was threefold: (a) to evaluate the overall rate of abdominal hysterectomy surgical site infection following postoperative procedures, (b) to distinguish relationship between academic institution, hospital ownership, number of beds and SSI rates, and (c) to examine the correlation between surgical site infection rate for the hospital and the region (Northeast, Midwest, South, and West).

Research Questions/Hypotheses

RQ1: Is there an independent association between SSI rate and the teaching status institution, hospital ownership, number of beds, and region (Northeast, Midwest, South and West)?

$H_0$1: There is an association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

H_a1: There is no association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

H_02: There is an association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_a2: There is no association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_03: There is an association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

H_a3: There is no association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

Theoretical Base

For the proposed topic, the epidemiological triad of the person, place, and time was an ideal framework (Foxman, 2017). The framework provides an overview of person (who was affected), place (where the condition occurred), and time (time period the condition occurred). The suggested model was developed to provide descriptive epidemiological information to prevent disease occurrence, implement interventional programs, and conduct additional research. For SSI, person and personal characteristics did not apply because the hospital was the unit of analysis. Place was determined by the regional location (Northeast, Midwest, South, and West). Finally, the time was held constant by using a single year of data. Researchers who are strong supporters of the epidemiological triad have claimed that the model is beneficial in order to observe and assess investigational trends and also to initiate complicated research (Friss, 2012).

Nature of the Study

The nature of this study was quantitative, cross-sectional, retrospective, and observational. Quantitative research was indicated when the research question demanded a quantitative answer such as the rate of postoperative wound infection. The proposed approach was employed to examine the association between the SSI rates for the hospital ownership, academic institution, and number of beds. Also, this method was used to assess some related issues causing SSI, as well as geographic locations. Additionally, the study demonstrated cause and effect relationships to answer research questions.

Conceptual Definitions

Terms used in this study are defined as follows:

Healthcare associated infection (HAI): Infections individuals acquire while being treating for another health condition. It can be acquired from the hospitals and are caused by various bacteria, fungi, viruses, or pathogens (Office of Disease Prevention and Health Promotion, 2016).

Surgical site infection (SSI) or surgical wound infection: An infection that develops at the site where surgical procedure was performed (CDC, 2012).

Abdominal hysterectomy: Removal of a uterus via a surgical procedure though an incision in an individual's lower abdomen (Mayo Clinic, 2016).

Hospital type: A medical treatment facility where patients are treated with specialized healthcare professionals and proper medical equipment that are funded by various stakeholders, including public sector, health organizations (i.e. for-profit or nonprofit), healthcare insurance companies, or by charities and donations.

Hospital ownership: The physicians, investors, organizations, corporations, or religious groups that own a hospital.

For-profit hospital: Private hospital that is not owned by state and/or local governments.

Not for profit hospital: A medical facility or a clinic that does not need to pay to taxes to either state or to federal governments that is mainly supported by charity and community.

Government hospital: Hospitals owned and funded by government .

Military hospital: Hospitals that are mainly used by the military personnel and their beneficiaries.

Veterans Affairs hospital: Hospital funded and operated by the U.S. Department of Veterans Affairs for veterans.

Physician owned hospital: Hospital fully or partially owned by the physician(s) or that may have a partnership with a larger local hospital and a group of other physicians.

Academic hospital: A hospital that also includes a medical school that is affiliated with a university.

Teaching hospital: A medical center that offers medical/clinical education to train the future healthcare providers. Teaching hospitals are associated with medical schools at universities.

Region: One of several areas defined by law in the United States, including Northeast, Midwest, South, and West.

Northeast region: Region includingConnecticut, Maine, Massachusetts, New Hampshire, Rhode Island, New Jersey, New York, and Pennsylvania.

Midwest: Region including Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

South: Region including Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, District of Columbia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas.

West: Region including Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, and Washington.

Number of beds: The maximum number of beds a hospital holds license to physically set up and have available to utilize.

Assumptions and Limitations

In conducting this study, I presumed that the size of the population included in the data would be large. The main advantage of this study is that the data was available from CMS and included all the hospitals in the United States that reported SSI incidence. A second advantage of the data was that the measures included in the dataset were developed by CDC and the data was collected by NHSN. Lastly, the data used was most recent, FY 2015, which provided the latest estimates on SSIs.

This study also had limitations. First, the collected data was not primary data; therefore, there were limitations on inclusion/exclusion criteria. Also, the data only included the hospitals that had provided the data to NHSN.

Delimitations

Because this study involved the SSI after an abdominal hysterectomy, only infection-related data were included in the study. In addition, only subjects who had been diagnosed with SSI after an abdominal hysterectomy were included. More details on the study population and variables are described in Chapter 3.

Significance of the Study

The literature revealed that individuals who experience postoperative SSI are at greater risk for increased morbidity and mortality. Each unique SSI is associated with around 7-10 extra days spent at the hospital, which enhances the risk of postoperative complications (Anderson et al., 2014). Treating SSI costs healthcare insurance companies approximately $3,000 to $29,000 per case and a total of $10 billion per year (Anderson et al., 2014). Such costs to individuals and the healthcare industry could be alleviated by improving strategies to prevent SSI. This study was quantitative, using CMS data on SSI.

Gap in the Literature

My expectation in conducting this study was to identify specific causes of postsurgical infections. Chapter 2 provides risk factors correlated with SSI where strong, moderate, low, and conflicting evidence are presented, such as hypertension, invasive index, trauma, insufficient intraoperative irrigation, disseminated cancer, age, alcohol abuse, dural tear, postoperative incontinence, prolonged hospital stay, and the number of residents who participated in the surgery (Xing et al., 2013). This research presented in addressing the low evidence and conflicting evidence to fill in a gap of uncertainty, specifically hospital type has shown to be important for other quality indicators, however not for SSI (Flood, Scott, and Ewy, 1984). For example, a study conducted by Flood et al. (1984) indicated a strong relationship between high volume hospitals and better outcomes for patients. Since for-profit hospitals are operated by investors and numerous stakeholders, their primary goal is making profit. Therefore, hospitals for profit are a risk factor for quality (Herrera, Rada, Kuhn-Barrientos, and Barrios, 2014). In this study, I have attempted to investigate limited evidence to very low evidence on postoperative wound infection in order to fill in the gap in research. This study added evidence to current research to prove that the presented independent variables were risk factors for SSI, which includes hospital type, hospital ownership, and number of beds.

Implications for Social Change

The proposed study was conducted to examine the relationship between the SSI rate per hospital and academic institution, hospital ownership, number of beds, and geographical location, which has shed light on the specific risk factors. The identified risk factors may allow various hospitals to prevent SSI. The analysis presented from the study was conducted to assist and evaluate various preventions that are already taking place and also help implement new prevention programs through different hospitals. This study may impact positive social change by decreasing preventable SSIs.

Summary

One of the objectives of Healthy People 2020 (2016) was to reduce the amount of cases of SSI by measuring the incidence of infections, expanding on implementation strategies, and developing various prevention tools. The present study was intended to examine the risk factors associated with SSI after an abdominal hysterectomy. Finding new risk factors for SSI promotes social change by aiding in the prevention of the infection. Chapter 2 provides an overview of SSI, the risk factors, and financial impact of SSI. Chapter 3 describes the design and methodology of this study. This study used one year of publicly available data from the CMS. Chapter 4 will include outcomes from analyses, and Chapter 5 will present discussion of findings and recommendations.

Chapter 2: Literature Review

Introduction

Healthcare-associated infections occur when an individual gets infected while being treated for a medical procedure; however, many of these infections are treatable. The source of infections from surgical procedures may have been the devices that were used during the proces or from the surgical team (Healthy People 2020, 2016). The most common HAI is the surgical site infection (SSI). Thirty-one percent of hospitalized individuals are diagnosed with SSI (CDC, 2016). According to CDC (2016), in 2011, about 157,500 SSIs were related to inpatient surgeries. Anderson and Sexton (2016) stated that 2% to 5% of the surgical patient population would develop SSI (i.e.,one in 24 patients) (Anderson & Sexton, 2016). Nearly all SSI cases are diagnosed within inpatient settings, and more than half of those patients require readmission (Min, Chen, Miller, Sexton, & Anderson, 2012). Literature indicates several risk factors that play a significant role in postoperative SSI. SSI is considered a public health problem, increasing morbidity and mortality rates and costing millions of dollars in treatment. For example, North Carolina ranks 10th for the most populated state in the United States with 9.6 million residents, which includes both urban and rural areas and contains well-known manufacturing companies, universities, and other recognized areas (Anderson, Pyatt, Webber, and Rutala, 2013). According to Anderson and colleagues (2013), every year, the cost of the infection is $100 million for the state of North Carolina.

The focus of this study was on patients who have had an abdominal hysterectomy and were diagnosed with SSI. It is very common for a patient to develop SSI after an abdominal hysterectomy (Lachiewicz, Moulton, & Jaiyeoba, 2015). Every year, more than 600,000 abdominal hysterectomies are performed in the United Sates. An approximately 10.55% infections rate is reported after an abdominal hysterectomy. The primary factors that increase the risk of SSI are obesity, diabetes, compromised immune system, a large amount of blood loss, longer operative time, poor nutritional habits, and comorbidities (i.e. diabetes and drinking; Clarke-Pearson & Geller, 2013).

Literature Search Strategy

The articles reviewed were researched using Google Scholar, Google search engine, Walden Library, PubMed, CINAHL, Medline and other databases provided by Walden Library. The articles were located via searching various key terms, such as *surgical site infections, surgical wound infection, postoperative surgical site infections, postoperative readmissions, nosocomial infection, healthcare-associated, infection, surgical readmission, hysterectomies and abdominal hysterectomies*, and *cellulitis.* Only studies written between 2011 and2016 were included. Reviewed articles included meta-analyses, observation studies, randomized controlled studies, nonrandomized studies, retrospective studies, and quasi-experimental studies, as well as patients' records reviewed both prospectively and retrospectively from the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) databases.

Theoretical Foundation

Epidemiological triad of the person, place, and time was an ideal framework for this study (Foxman, 2017). Descriptive epidemiological triad model provides an overview of person (who was affected), place (where the condition occurred), and time (time period the condition occurred). Another epidemiological triad is used for infectious disease, chronic illness, and injury resulting from accident. The pathogen (agent), the environment, and the host (receptive patient) are the three essential components of the epidemiological triad (Nelson & Williams, 2007).

The suggested model, descriptive epidemiology, was developed to provide constructive information to prevent disease occurrence, implement interventional programs, and conduct additional research. For SSI in this study, person and personal characteristics did not apply because the hospital was the unit of analysis. Place was determined by the regional location (Northeast, Midwest, South, and West). Finally, the time was held constant by using a single year of data. Researchers who are strong supporters of descriptive epidemiology have claimed that the model is beneficial in order to observe and assess investigational trends and initiate complicated research (Friis, 2012).

Origin of the Theory

The epidemiological triad model was initiated to illustrate an epidemiological event, which can be instances such as an epidemic of influenza or increased rates of motor vehicle crashes that are taking place locally or nationally. However, epidemiologists tend to use the 5W's of descriptive epidemiology: what (health issue), who (person), where (place), when (time), and why/how (causes, risk factors). Therefore, the descriptive epidemiology comprises person, place, and time (CDC, 2012).

Descriptive epidemiological triad delivers a path of examining and evaluating the data in order to understand distinctions in disease frequency geographically and over time. Also, based on the personal characteristics (person, place, and time), epidemiologists are able to analyze how the disease differs amongst individuals. Additionally, it is imperative to generate theories about the causes of a specific health condition or disease, which helps researchers present preliminary ideas for analytic epidemiology to form an association between potential risk factors and health outcome (Boston University, n.d.).

Example: Epidemiological Triad

The descriptive epidemiological triad model has been used for decades to understand the risk factors for an acute disease. Person variables include age, sex, race/ethnicity, and socioeconomic status. Place variables contain international, local, urban/rural areas, and within country. Lastly, time includes seasonality, point epidemic, gradual changes over long time periods, and clustering. For example, based on a study of children who are being breastfed, researchers are able to conclude that infants in the United States are mostly breastfed from birth to three months of age. Also, the researchers observed that non-Hispanic black mothers breastfed less compared to other ethnic groups. Also, women did not breastfeed their child often if they were younger, unmarried, and had a lower level of education or socioeconomic status (Friis, 2012).

Rationale for the Choice of Theory

Since the descriptive epidemiological triad is used mainly to concentrate on the person, place, and time, the framework fits well with the current study. For the SSI rate, the time is held constant by using only one year of data. Place includes hospital type and geographical location (Northeast, Midwest, South, and West). Finally, personal characteristics do not apply in the presented study because the hospital is the unit of analysis. The framework was ideal to answer the research questions.

Within the last decades, there has been an extraordinary change in healthcare settings and the way healthcare is being delivered to the patient population. Also, technology within the health system is expanding. For prevention purposes, there is now a higher demand for reporting of HAIs. Based on the reporting of HAIs, public health experts are focusing more on the prevention and surveillance of these infections through different databases (Greene, 2015).

Epidemiological triad has been a long-established framework that is used to understand differences in disease incidence occurring geographically and over a period of time, also how the disease differs with each individual (Boston Universtiy, n.d.). Based on population, location, and time, it also identifies risk of developing an infection, such as SSI. Therefore, it is easy to identify hospitals where patients are at risk for developing SSI in order to take preventative steps. Based on the theoretical model, more risk factors can be determined in order to prevent postoperative wound infections. As technical innovation progresses and changes in data reporting occur, infection preventionists can concentrate more on the data analysis and collaborate with local stakeholders (i.e. policy makers, hospital leaders, and hospital staff) to implement prevention strategies to decrease the rate of SSIs (Greene, 2015).

Researchers who are strong supporters of the epidemiological triad model have claimed that the model is beneficial in order to limit and prevent the infections (Cohen & Shang, 2015). Many epidemiological studies are using the triad to assess the relationship between person, place, and time. Epidemiologists use numerous designs, for instance, ecological, surveillance, cohort, and randomized clinical trials where the epidemiological triad is used. The epidemiological triad helps heath care professionals to test their hypotheses or merely describe the correlation between risk factors and SSI. The model will benefit the health care providers and researchers to enhance healthcare delivery and implement advanced technology into the medical facilities (Nelson & Williams, 2007).

Historical Perspectives

The ancient Egyptians were the first to develop training for clinicians to heal physical wounds. In 1600 BCE, Edwin Smith provided specific knowledge on how to manage wound infection and different remedies to help individuals heal faster. A Greek surgeon, Hippocrates, who is also known as the father of medicine. Circa 460-377 BCE, he utilized vinegar on open wounds to assist with the healing process. In the late 1800s, Joseph Lister (Professor of Surgery) and Louis Pasteur (Bacteriologist) updated the entire theory of contamination for wounds. Around 1867, Lister was able to determine that an antiseptic may prevent an infection. He used carbolic acid in open fractures to disinfect lesions and avoid infection which otherwise would lead to amputation. By 1871, Lister started using a carbolic spray in operational areas to decrease infection. By 1880, sterilization of surgical instruments began, and surgical staff started wearing gowns, masks, and gloves. Around 1940, antibiotics such as Penicillin were first introduced to control wound infections in surgical procedures. The total reduction of infection in surgical wounds has not happened surprisingly, because of the resistance of bacteria strains and because of more exciting surgical interventions are being presented in immunocompromised patients in surgeries that require implants (Singhal & Kaur, 2015).

Epidemiology of Surgical Site Infections

Since the 1960s, epidemiological evidence of SSIs has been collected, and the characterization of infections and classification of wounds were implemented (Cooper, 2013). Diagnosis of SSIs varies among the US population, hospitals, and surgeons/providers. In general, teaching hospitals may have the highest rates of SSI compared to nonteaching hospitals (4.6 percent vs. 6.4 percent). Numerous studies have shown that individuals with cancer are at an increased risk of SSI (Anderson & Sexton, 2015).

Different types of surgical procedures are correlated with the rates of SSIs. According to Anderson and Sexton. (2015), after abdominal surgery, an individual is at higher risk of SSI. For example, small bowel surgery (5.3% to 10.6%), colon surgery (4.3% to 10.5%), gastric surgery (2.8% to 12.3%), liver pancreas surgery (2.8% to 10.2%), exploratory laparotomy (1.9% to 6.9%), and appendectomy (1.3% to 3.1%). The most common infections that are linked to high-volume procedures include coronary bypass surgery (3.3% to 3.7%), cesarean section (3.4% to 4.4%), vascular surgery (1.3% to 5.2%), joint prosthesis (0.7% to 1.7%), and spinal fusion (1.3% to 3.1%). On the other hand, eye surgeries have a very low rate of SSI (0.14%). For ambulatory surgeries SSI rates are fairly low (3% per 1000 surgeries) (Anderson & Sexton, 2015).

Surgical Wound Classification

1. Class I/Clean: An uninfected surgical wound in which no aggravation is experienced, and the respiratory, wholesome, genital, or uninfected urinary tracts are not entered. Furthermore, clean lesions are sealed and, if needed, removed with closed drainage. Nonpenetrating (blunt) trauma incisional wounds ought to be included in this category if they meets the necessary criteria (CDC, 2016).
2. Class II/ Clean-Contaminated: Surgery of entering respiratory, alimentary, genital or urinary tracts, mostly involving biliary tract, appendix, vagina, and orpharyx. In this category, there is no indication of contamination or any disruptions in the technique used (CDC, 2016).
3. Class III/Contaminated: In this category, fresh, open and accidental wounds are seen. In addition, surgeries involving open cardiac massage or gross spillage from gastrointestinal tract, and incision entry points in which intense, no purulent aggravation is experienced including necrotic tissue without evidence of purulent drainage (i.e. dry gangrene) are included in this category (CDC, 2016).
4. Class IV/Dirty or Infected: This category involves old traumatic injuries that contain destroyed tissue and that contains existing clinical infection or perforated viscera. This category suggests that the bacterium affecting

postoperative infection was already present before the surgery took place (CDC, 2016).

Criteria for Defining Surgical Site Infection

The term SSI refers to an infection that has been acquired after a surgical procedure affecting the opening of the wound, soft tissue, and/or organ of an individual (CDC, 2016).

Based on CDC/NHSN standards, SSIs are defined as following:

Superficial Incisional Surgical Site Infection

- Infection appears within 30 days after surgery (Day 1 = day of the procedure/surgery), and it affects only skin and subcutaneous tissue of the surgical incision. To meet these criteria, a patient must have one of the following:
    - Infected drainage from the incisional surface;
    - Bacterium detached from an aseptically-acquired sample or tissue
    - A superficial incision that is intentionally accessed by a specialist or provider and specimen-based testing is not executed. Also, patient presents one of the following indications of infection: pain, tenderness of the surgical site, inflammation around the site, redness, erythema, and/or heat; or
    - A surgeon and/or a provider identifies a superficial incisional SSI.

Deep Incisional Surgical Site Infection

- Infection appears within 30-90 days after a surgical procedure involving deep soft tissues of the incision such as fascial and muscle layers. To meet the criteria in this category, a patient must have one the following:
    - Purulent drainage from the deep incision;
    - A deep incision suddenly dehisces or is intentionally opened by a specialist when the patient has one of the symptoms: fever of greater than 38 degrees Celsius and pain around the surgical site; or
    - An abscess or another indication of infection implicating the deep incision is found on physical examination or pathological test, or imaging exam.

Organ Space Surgical Site Infection

- Infection appears within 30-90 days after the procedure, involving the part of the body which is deeper than the fascial/muscle layers that have been manipulated during surgery. In order to meet the criteria, a patient must present one of the following:
    - Infected drainage from a drain placed via a stab wound into the organ;
    - Organisms that are classified from an aseptically acquired specimen of fluid or tissue in the organ/space;
    - An abscess or a sign of infection on examination of the site or pathological test, or radiological test; or
    - Diagnosed by a provider or a surgeon as an organ/space SSI.

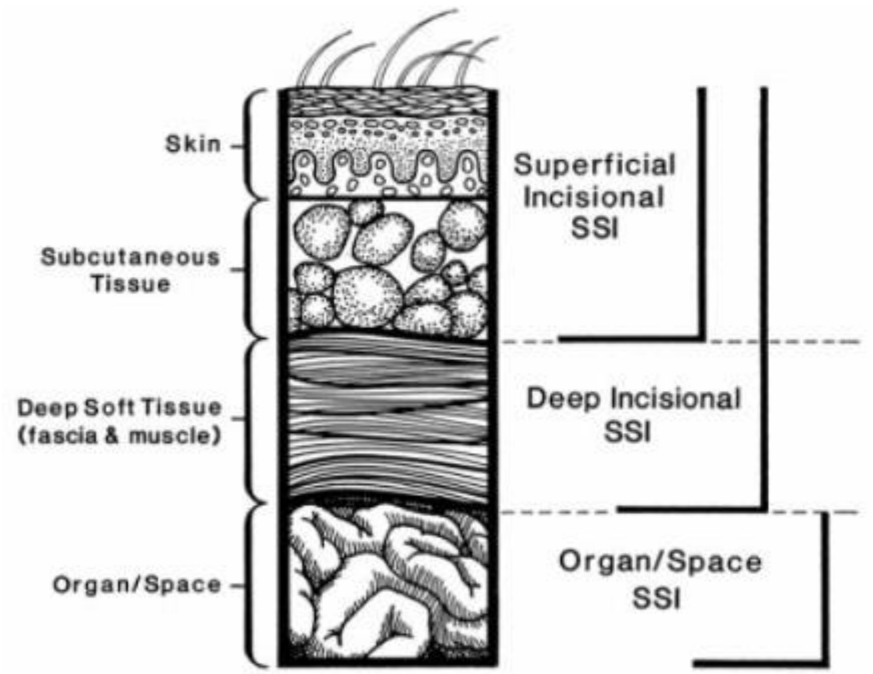

Figure 1: Three categories of surgical site infection (SSI; CDC, 2016)

Microbiology

The bacteria on an individual's skin are the primary cause of SSI, along with streptococcal species, staphylococcus aureus, and coagulase-negative staphylococci. In clean-polluted strategies, the transcendent creatures incorporate gram-negative poles and enterococci notwithstanding skin verdure. At the point when the surgical methodology includes a viscus, the pathogens mirror the endogenous vegetation of the viscus or adjacent mucosal surface; such diseases are ordinarily polymicrobial. Between 1986 and 2003, gram-positive bacilli were known as the contributing pathogen correlated with SSI in the United States; however, it has decreased from 56 to 33%. *S.aureus* accounted for 22% of pathogens causing SSI, which increased to 30% between 2006 and 2007 (Anderson & Sexton, 2015).

There are numerous other external sources to contract infection including the environment of an operating room or the surgical team itself. Also, a team member carrying group A streptococci (anal, vaginal, or nasopharyngeal) in the operating room, as well as artificial nails, are a cause for SSI. Once in a while, infected bandages and dressings may carry pathogens that may cause an outbreak of SSI (Anderson & Sexton, 2015).

Pathogenesis of Surgical Site Infection

Staphylococcus aureus is bacteria related with SSI, which is commonly reported as a contributing agent. But, the scope of pathogens connected with SSIs differs with the area, with a low frequency of antibiotic-resistant microorganism. In a Swiss clinic, the distinguished pathogens triggering SSIs resulted from standard methods to culture pathogens that are routinely utilized as a part of laboratories all through the world yet the use of present day molecular strategies to portray the different bacterial qualities in chronic SSIs has started to modify observations. Approximately 23 constant pathogens were associated with SSIs, and it was shown that two previously obscure bacteroidales were available in the greater part of the SSIs researched, six genera were distinguished in a significant portion of the injuries, and anaerobic bacilli instead of vigorous cocci prevailed. These proposed unculturable microscopic organisms are available in SSIs and that different species are available (Cooper, 2013).

Antibiotic-resistant strains have increasingly been associated with nosocomial infections; methicillin-resistant *S. aureus* (MRSA), Methicillin-resistant coagulase-negative staphylococci, vancomycin-resistant enterococci and extended spectrum betalactamase gram-negative bacteria have caused particular concern. In recent combat injuries, the microbial flora lesions have appeared to particularly broad. Besides *S. aureus*, soldiers have recovered from trauma wounds from the beta-haemolytic streptococci and clostridia, *Aeromonas*, *Acinetobacter Achromobacter*, *Comomonas*, coliforms, enterococci, *Pseudomonas* and *Bacillus*. Also, some combatants were sent back from the Green Zone in Afghanistan with lacerations that were severely contaminated with debris from the war zone environment which may have infected fungal soft-tissue caused by *Rhizopus*, *Apophysomyces, Mucor, Saksenaea, Absidia* and *Chaetomium*. Numerous diseases in the battle zone workforce now include antibiotic-resistant bacterium, and living beings creating augmented beta-lactamases are a particular issue (Cooper, 2013)

Antimicrobial Prophylaxis

The adequacy of antibiotic prophylaxis is primarily used to prevent SSI and to decrease the bacteria at the surgical site throughout the surgical procedure. If known before surgery that an individual is at high risk of an infection, antibiotics are warranted in order to decrease the chances of developing an infection at the surgical site (for example, cardiac surgery or medical device implantation). If the surgical wound is already infected and antimicrobial therapy has been ordered, then it is not considered prophylactic. However, at this point, antimicrobial therapy is much needed and has been prescribed by the provider. Studies have shown that those who have received prophylactic antibiotics, one to two hours prior to the surgery have lower rates of SSI compared to those who did not receive the dose of antibiotics within this timeframe. It is common to make errors while selecting a specific dose of antimicrobial prophylactic. According to Anderson & Sexton (2015), there are approximately 34,133 individuals in the United States that are going through a surgical procedure; about 56% received a dose of antimicrobial prophylactic, one to two hours prior to their surgery, and the antimicrobial was discontinued for 41% after 24 hours of surgery (Anderson & Sexton, 2015).

Risk Factors

Xing et al., (2013) conducted a systematic review of independent risk factors for SSI. The systematic review included 36 observational studies which involved approximately 2,439 patients. The result of the study indicated 46 independent factors (described below) which were assessed as a risk factor for SSI. The data presented from this review provided facts to guide providers/surgeons choosing an optimal antibiotic prophylaxis therapy strategy prior to surgery. Further research and reports are needed to evaluate the effects and recommendations to these independent risk factors. The table below describes strong, moderate, conflicting, and limited evidence which identifies the risk factors that are associated with SSI (Xing et al., 2013).

Table 1

Risk Factors Associated with SSI

Substantial Evidence:

- obesity/BMI
- longer operating time
- diabetes mellitus
- smoking
- history of previous SSI, and
- type of surgery procedure

Moderate Evidence:

- spinal level of surgery
- number of spinal levels operated
- surgery involving the sacrum or pelvis
- larger operative blood loss
- surgery with spinal instrumentation
- previous surgery
- blood transfusion, and
- ASA classification

Limited Evidence:

- hypertension
- invasive index
- renal disease
- bony or connective tissue neoplasm
- skin to lamina distance
- thickness of subcutaneous fat
- surgical case order
- drain duration
- male gender
- hemodialysis
- albumin count
- trauma
- insufficient intraoperative irrigation
- dependent functional status
- disseminated cancer
- presence of comorbidities
- preoperative irradiation
- exposure to razor shaving
- intraoperative administration of FiO_2 less than 50%
- pre/post-operative elevated serum glucose level, and
- poor timing of prophylactic antibiotic therapy

(table continues)

Conflicting Evidence:

- age
- alcohol abuse
- dural tear
- postoperative incontinence
- tumor surgery
- neurological surgery
- steroids
- prolonged hospital stay, and
- the number of residents who participated in the surgery

Note. Xing et al., (2013)

Table 2

Evidence Table

Evidence table above provides sources of evidence that corresponds with the proposed study.

Author	Methods/design	Source of data	Measures	Findings
Olsen, M. A., Higham-Kessler, J., Yokoe, D. S., Butler, A. M., Vostok, J., Stevenson, K. B., … the CDC Prevention Epicenter Program. (2009)	Retrospective case-control study	Multi-hospital data analysis	IV: height, weight, smoker, diabetes, congestive heart failure, preoperative glucose level, creatinine, postoperative glucose level, creatinine, blood transfusion during surgery and after, length of surgery, and type of surgery DV: SSI after abdominal hysterectomy	Obesity, blood transfusion, longer surgical time and lack of health insurance were identified as primary independent risk factors were identified that are associated SSI.
Lake, A. G., McPencow, A. M., Dick-Biascoechea, M. A., Martin, D. K., & Erekson, E. A. (2013)	Secondary database analysis	American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP)	IV: age, race, ethnicity, ASA classification preoperative comorbidities, and intraoperative factors. DV: SSI after hysterectomy	A total incidence of postoperative SSI occurred in 1.6% of the population enrolled in the study.
Kassin, M. T., Owen, R. M., Perez, S., Leeds, I., Cox, J. C., Schnier, K., … Sweeney, J. F. (2012)	Retrospective study using secondary data	ACS NSQIP	IV: demographic factors, preoperative comorbidities, and postoperative complications. DV: 30-Day Hospital Readmission	Results from the study indicate that postoperative complications increases readmission rates in patients who went through a surgical procedure.
Yokoe, D. S., Khan, Y., Olsen, M. A., Hooper, D. C., Greenbaum, M., Vostok, J., . . . Stevenson, K. B. (2012)	Retrospective cohort study	5 hospitals affiliated with CDC	IV: pharmacy data, administrative data DV: SSI following abdominal hysterectomy	82 SSI were confirmed through the surveillance. Of 82 cases, 43 superficial, 11 deep, and 28 organ-space SSI were identified.

Merkow RP, Ju MH, Chung JW, Hall, B., Cohen, M., Williams, M., Tsai, T., Ko, C., & Bilimora K. (2015)	Prospective study	ACS NSQIP	IV: demographic factors, preoperative risk factors, laboratory values, operative variables, postoperative complications, and readmission variables. DV: unplanned postoperative readmissions.	Post discharge complications increase the risk of readmission. 5.7% patients were readmitted to the hospital, unplanned.
Lawson EH, Hall BL, Ko CY. (2013)	Retrospective cohort study	ACS NSQIP	IV: demographics, preoperative risk factors, comorbidities, hospitalization, and procedure variables. DV: superficial vs. deep/organ space SSIs	Approximately 27,011 patients from 305 different hospitals were enrolled in the study. A total of 6.2% of superficial and 4.7% of deep/organ space SSIs were developed after a surgery.
Korol, E., Johnston, K., Waser, N., Sifakis, F., Jafri, H. S., Lo, M., & Kyaw, M. H. (2013)	Systematic Review	MEDLINE, EMBASE, the Database of Abstracts of Reviews of Effects and Cochrane Database of Systematic Reviews.	IV: demographics, post-surgical time until onset of SSI, odds ratios, and all factors that correlated to SSI DV: SSI	Results from this systematic review reported and average rate of SSI is 3.7%, varying from 0.1% to 50.4%. An average of 17.0days of SSI onset.
Namba, R., Inacio, M., & Paxton, E. (2013)	Retrospective review	Total joint replacement registry	IV: Patient, surgical, surgeon, and hospital factors DV: Deep surgical site infections	The results of the study reveal that the patient's weight and diabetes increase rate of deep SSI. The results also indicate that the lower volume hospital had higher rates of deep SSI following total knee arthroplasty.

Gibson, A., Tevis, S., & Kennedy, G. (2014).	Retrospective analysis of data	ACS NSQIP	IV: demographic, comorbidities, length of stay, and postoperative variables DV: post discharge SSI	The study indicates 55.1%o f of males was diagnosed with SSIs. Majority of the readmissions associated to SSIs occurred within the first week after patient was discharged.
Xing, D., Ma, J.-X., Ma, X.-L., Song, D.-H., Wang, J., Chen, Y., … Feng, R. (2013)	Systematic Review	MEDLINE, EMASE, Science Direct, and OVID	IV: patient factors, pre, intra and postoperative factors, DV: developing SSI	An overall of 46 independent risk factors were assessed for possibility of SSI. However, there were six convincing risk factors associated with SSI including obesity, longer operation time, diabetes, smoking, history of prior diagnosis of SSI, and type of surgery.
Ming, D. Y., Chen, L. F., Miller, B. A., Sexton, D. J., & Anderson, D. J. (2012)	Retrospective cohort study	37 community hospitals affiliated with the Duke Infection Control Outreach Network (DICON)	IV: type of surgery, date of surgery, patient demographics, NHSN risk score, health care location at time of diagnosis of SSI, and microbiological data. DV: depth of SSI	1,919 SSI were diagnosed. 64% were complex SSIs, 87%of the complex cases were diagnosed within hospital inpatient settings. 58% of cases were identified after being discharged from the hospital.
Durkin, M. J., Dicks, K. V., Baker, A. W., Lewis, S. S., Moehring,	Retrospective cohort study	20 hospitals affiliated with Duke Infection Control Outreach	IV: microbiological data, hospital readmissions, and postdischarge	Majority of the SSI cases were observed during the months of summer.

R. W., Chen, L. F., … Anderson, D. J. (2015)		Network	questionnaires, demographics, clinical, and surgical data DV: seasonal impact on SSI	
Khavanin, N., Lovecchio, F. C., Hanwright, P. J., Brill, E., Milad, M., Bilimoria, K. Y., & Kim, J. Y. (2013).	Retrospective Study	ACS NSQIP	IV: demographics, comorbidities, preoperative lab values, details, postoperative outcomes DV: 30 day perioperative morbidity following abdominal hysterectomy	Out of 9,917 patients, 2,219 were at a standard weight, 2,765 were overweight, and 4,933 patients were obese. Patients with higher BMI were at higher risk of surgical complications, including wound infections, and wound disruption.

Lawson, Hall, and Ko, (2013) conducted a retrospective cohort study to distinguish the possible factors relating to superficial vs. deep/organ-space SSIs. The ACS NSQIP database was developed to identify risk factors and 30-day postoperative complications. Since colectomy procedures are common, authors decided to include those who underwent colectomy in 2011. The rates of superficial SSI were compared to deep/organ-space perioperative variables, which included demographics; risk factors, comorbidities, hospitalization variables; and variables relating to procedure. Three hundred and five hospitals were identified in the database search; including 27,011 patients were included in the study. About 6.2% of individuals developed superficial, and 4.7% were diagnosed with deep/organ-space SSI. Among both of these groups, common risk factors included open surgery was at higher risk compared to laparoscopic. Also those that were smoker had a greater risk of developing SSI. Other particular postoperative risk factors included diagnosis of cancer and radiation therapy. Obesity seemed to stand out the most amongst those who developed superficial SSI. The study also represented limitations as well which could include not coding superficial SSI appropriately based on the severity level of the SSI. Another limitation includes the authors combined patients who may have developed deep and organ-space SSI. Instead of two categories, there should have been three types (superficial, deep and organ-space SSIs) (Lawson et al., 2013).

Kassin et al., (2012) conducted a retrospective study using the NSQIP database between October 2009 and July 2011 to include inpatient general surgery. About 135 variables included those who underwent general surgery, but not limited to pre/postoperative risk factors, morbidity, and mortality outcomes. Between October 2009 and July 2011, approximately 1,442 individuals underwent a general surgical procedure, which was noted in NSQIP. Among those, about 163 (11.3%) patients returned to the hospital within 30 days after being discharged. About 22% of readmissions accounted for SSI, which contained the following comorbidities: the spread of cancer, dyspnea, open wound before the procedure, blood transfusion, pulmonary problems after the surgery, sepsis/shock, urinary tract infection, and cardiac complications. Multivariable analysis was performed to detect the most significant independent risk factor for those returning to the hospital related to postoperative complications. One of the main limitations of the study is that the data was collected only from one institutional hospital, which means recruiting small sample size leading to weak statistical power (Kassin et al., 2012).

"A Systematic Review of Risk Factors Associated with Surgical Site Infections Among Surgical Patients" (Korol. et al., 2013) was a systematic review that was directed to portray specific risk factors correlating to SSI. In this wide-ranging systematic review, various risk factors for SSI, *S. aureus* SSI, and MRSA SSI were distinguished; these included variables portraying decreased patient wellness, comorbidities, propelled age, risk indicators (ASA), expanded BMI, and patient requirement. Other critical markers included an expanded length of preoperative care at a hospital and complicated surgery, which increase surgical time. Based on the review, SSI developed at an average of the seventeenth day with 13 different studies conducting multivariable analysis concluding diabetes mellitus as the primary factor of developing SSI. The strength of this study was that it included all the studies that reported risk factors associated with SSI. Various stratified examinations were performed to think about results against particular study qualities, including types of surgical procedures, geography, and populace attributes; but, expansive patterns stayed reliable in these stratified investigations, and further understanding was constrained because of smaller study-numbers (Korol et al., 2013).

There are various SSI risk models that have been created specifically for surgeries. Walvran and Musselman (2013) used a multivariate logistic regression method to establish the self-regulating relationship of patient and surgical covariates with the threat of any infection (such as superficial, deep, and organ space) inside the 30-day period window. Authors created an operational risk score model to gather factors for specific surgeries by using the first three number of the Current Procedural Terminology (CPT) code. During the first stage of developing this model, authors used binomial logistic regression to isolate the covariates that correlated with 30-day SSI. During the second stage of the model, authors again used the binomial logistic regression to distinguish variables that are strongly related to 30-day SSI. The results showed approximately 181,146 patients that had standard variables such as demographics, previous history, and surgical dynamics. The overall risk of SSI was 3.9%. The study clearly states the risk of SSI increased with the following: smoking, increased BMI, cancer, using steroids, sepsis prior to the surgery, settings of an operating room, contaminated equipment, ASA scores of three or more, and an increase in surgery time. Numerous strengths were presented in this model. First of all, it included a large group of surgeons and wide-ranging procedures and facilities. Second, the model was extremely precise with both outstanding separation and alignment. Finally, the model had practical significance to clinicians and patients since it allows the SSI risk for a specific patient to be computed through the web or the SSI Risk Index (van Walraven et al., 2013).

An interesting study conducted by Durkin et al., (2015) measured the correlation between seasons and the impact of SSI rates. The data was collected from 20 different hospitals that are affiliated with Duke Infection Control Outreach Network (DICON), where the authors detected 4,543 SSI after a surgical procedure. Multivariable regression analysis was performed to indicate that the SSI rates increased during the months of summer (July-September). Based on the results, authors suggest examining alleviating risk factors during these months and preventing rising rates of SSI (Durkin et al., 2015).

Surveillance

Reconnaissance is similarly necessary for standard definitions. The CDC's definition requires observation for contamination is attempted for 30 days for disease in soft tissues and up to a year for orthopedic and vascular prosthetic surgery. Because of the approval of same-day surgery and accelerated postoperative recovery, the surveillance has been inaccurate based on the inpatient data. A monitoring system that tracks specific rates of SSIs data is the National Healthcare Safety Network (NHSN) operated by the CDC. The CDC requires reporting at least one month to sustain NHSN requirement by collecting SSI (numerator) and operative procedure (denominator) data on all surgeries. All of these that are reported based on NHSN requirements are followed for superficial, deep, organ/space SSIs (CDC, 2016). SSI surveillance requires dynamic, patient- based and forthcoming reconnaissance. Following surgical procedures, post-discharge measures should be collected for both inpatient and outpatient. The following steps should be considered: 1) a complete assessment of the surgical wound during the follow-up visit; 2) patients' medical records to be reviewed; 3) providers send surveys by mail or email to follow-up; and 4) patients' surveys collected by mail or email to evaluate patients' infections (CDC, 2016). A quasi-experiment led by Cannon et al., (2016) suggests that the rates of SSI may decrease by adequately addressing definitions created by NHSN and improving communication channels between patients/caregivers and providers (Cannon et al., 2016).

In 2010-2011 the Virginia Department of Health (VDH) received a grant under the American Reinvestment and Recovery Act (AARA) for collaboration with 18 different hospitals to perform an SSI pilot. The primary objective of this pilot was to: a) to be able to easily transform data into NHSN based on the data collected on SSI; b) to evaluate the time and exertion related with monitoring after a procedure and particular antibiotic therapy based on Surgical Care Improvement Project (SCIP) measures; and c) to be able to make HAI surveillance in Virginia attainable and valuable by adding one or SSI standards or antibiotic therapy from SCIP measures. Hospitals that took part in this pilot expressed that the pilot was amazingly useful to get ready for future reporting necessities by increasing more involvement in NHSN data section, encouraging the procedure expected to meet the requests of future reporting, exhibiting the amount of time was connected with reconnaissance to discover approaches to diminish the weight on the contamination anticipation group's workload, and/or computerizing information transfer forms and expanding electronic abilities (Alvarez & Burnshell, 2012).

30-Day Postoperative Complications and Readmission

Close to one in seven patients are going through a surgical procedure and are likely to experience hospital readmission within 30-days after being discharged from the hospital due to SSI (Kazaure et al., 2012). There are numerous reasons behind why the patient was readmitted to a hospital after a surgical procedure such as scheduled chemotherapy or elective surgery. On the other hand, there are those incidences that are escapable from readmitting the patient that may have been a result of comorbidity (i.e. diabetes) causing postoperative complications (Lawson et al., 2013). Readmission is concerning for medical facilities, providers and policy makers, especially those evaluating quality and hospital expenditures. The Centers for Medicare and Medicaid Services were focused on three broad categories (myocardial infarction, heart failure, and pneumonia); however, more categories are essential to be added such as total hip and knee arthroplasty. Further data on leading causes of readmission is being collected by ACS NSQIP, which also assists policy makers and clinicians to be able to make accurate decisions, in order to prevent readmissions after a surgical procedure (Merkow et al., 2015). Many research studies have been conducted to identify the reasons and risk factors that are associated with postoperative complications leading to hospital readmissions.

A retrospective analysis demonstrates that the rates of readmissions are increasing from 3.8% to 41.0% related to patients, clinicians, and facilities elements. The main intent of this study was to evaluate not only patient but the surgeon and surgical subspecialty in order to predict the 30-day readmission results. The data was collected from the Department of Surgery at Johns Hopkins Hospital (JHH) from January 1, 2009, through December 13, 2013. Pearson X^2 was utilized to measure the categorical variables. The Kruskal-Wallis test was conducted to evaluate the continuous variables. A Multivariable logistic regression model was performed in order to prove if there's any relationship between 30-day readmission rates and the patient and surgeon-level factors. The model was utilized where there was an interception at the surgeon and the surgical subspecialty altitude. Approximately 22,259 patients participated in this study, 56 surgeons performed these major surgeries, including eight different surgical subspecialties. Nearly 2,975 (13.2%) patients were readmitted to the hospital within 30-days of surgery. About 82.8% of the variation in readmission was contributed by the patient-related factors, whereas only 14.5% represented surgical subspecialty and 2.8% was characterized by patients' surgeon level variables. (Gani, Lucas, Kim, Schneider, & Pawlik 2015). Another retrospective analysis of NSQIP data collected from January 1, 2006 to June 30, 2011 showed that about 58.1% of patients were diagnosed with SSI after they were discharged, while 54% of those patients were readmitted due to SSI (Gibson, Tevis & Kennedy, 2014). Tevis, Kohlnhofer, Weber, and Kennedy (2014) indicates that the reasons for majority of the readmissions are due to laparoscopic case, short stay at the hospital after surgery, dyspnea before the surgery, and GI complications. Lastly, another retrospective cohort study involving about 551,510 patients that went through a surgical procedure. About 16.7% of the total population experienced complications following the surgery and about 41.5% experienced complications after being discharged. Approximately 75% of patients faced these complications within 14 days after being released. The following procedures accounted for the most complications: 14.5% of proctectomy, 13% of enteric fistula repair, and 11% of pancreatic procedures. A multivariate regression model was used to conclude factors that are related to post-discharge complications (Kazaure et al., 2012).

A multivariate regression model was employed by Lawson et al., (2013) to estimate the effect of preventing complications after a surgical procedure has been performed and the cost associated with the readmission rates. The authors included the following procedures that were at higher risk for SSI: cardiac, pulmonary, neurologic, and renal. The results of the study concluded 12.8% individuals are being readmitted within 30-days after the surgery. The likelihood of readmitting a patient is higher for those who had complications after the surgery compared to those who did not face any difficulties. The study presented some limitations which included the following issues: medical records were interrelated between ACS-NSQIP and Medicare records showing hospital admissions; the accuracy of matching this data may not have been accurate enough; and instead of using 100% population-based method, ACS-NSQIP uses the methodological sampling (Lawson et al., 2013). Merkow et al., (2015) gathered data from 346 different hospitals for readmission and factors that are associated with readmissions after being discharged from the hospital. The authors presented that about 19.5% individuals are being readmitted due to surgical site infection, including 25.8% colectomy, 26.5% ventral hernia repair, 28.8% hysterectomy, 18.8% arthroplasty, and 36.4% after lower extremity vascular bypass (Merkow et al., 2015).

A retrospective cohort study conducted at the VA including colorectal, arthroplasty, vascular, and gynecologic procedures that were operated during January 2005 to August 2009. Complications, after a procedure were the primary independent variable and readmission within 30 days, was used as the dependent variable. Patient's demographic information, habits (alcohol consumption and smoking), style of living, and other variables were utilized as covariate variables. Approximately 59,273 surgeries directed at 112 different VA hospitals, where 71.9% complications occurred prior to discharge and 28.1% medical problems appeared after the patient was discharged from the hospital. The results displayed men and patients that were older were more likely to have complications and were readmitted after the procedure. Also, both males and the more elderly population had stayed longer at the hospital after the surgery. Those who had congestive heart failure, diabetes, chronic obstructive pulmonary disease, chronic kidney disease, and loss of weight were at higher risk for complication and readmission. Also, ASA class, necessary procedure, lengthy procedure time, accumulative case complexity as measured in relative value units (RVU) were accounted for postoperative complications and readmission within 30-days. The study had some limitations. First of all, authors were only able to identify those who were readmitted to the VA hospitals; therefore those individuals that went to civilian hospitals were not included in the study. Second, the majority of the population including in the study were white men and older population, so other demographics did not appear in the study (Morris, Deierhoi, Richman, Altom, & Hawn, 2014).

According to Kripalani, Theobal, Anctil, and Vasilevskis (2014), in order to reduce the readmission rates due to SSI, the following items should be implemented in hospitals: 1) enhancing safety of patient's health before discharging; 2) improving medication plans, such as antibiotics; and 3) developing better strategies before patient is being "handover" from one staff member to another, as well as from hospital to outpatient clinic. There are numerous ways to implement interventions before discharging and once the patient leaves the hospital. The interventions may focus on 1) educating patients on how to take care of themselves at home; 2) antibiotics usage; and 3) making sure the patient has a follow-up appointment scheduled before he/she is discharged (Kriplani et al., 2013)

Financial Impact of Surgical Site Infections

The cost associated with SSI and readmission is significant that is associated with morbidity and mortality, also has an effect on hospital's performance as well. The rate of hospital readmission is highly expensive for the medical care insurances and Medicare beneficiaries (Lawson et al., 2013). Several studies have been led to demonstrate the financial impact of SSI on hospitals and healthcare. Each year many patients are being diagnosed with SSI that is associated with costs, morbidity and mortality. According to Zimlichman et al., (2013), "recent estimates of the national morbidity and mortality burden of HAIs have made it clear that HAIs represent a major public health problem."

A retrospective data was collected from four of the Johns Hopkins Health System from January 1, 2007, to December 31, 2010, for those individuals who were diagnosed with SSI. Daily total charges, the length of stay (LOS), and readmission within 30days were measured as main outcomes. Based on the results the total expenses for the day was $7,924 for those patients with SSI, compared to $7,493 for those who didn’t have SSI. The length of stay for those who had SSI was longer (10.56 vs. 5.64 days) than those who didn’t. The readmission rate was 51.94 for individuals diagnosed with SSI, while only 8.19 readmission rate per 100 procedures (Shepard et al., 2013).

Schweizer, Cullen, Perencevich, and Vaughan Sarazin (2014) conducted a study which included 129 patients from Veterans Affairs (VA) Hospital to define costs that are related to the total, deep, and superficial wound infections for those high-volume surgeries. In order to analyze the total amount spent on the patients from 2010, linear mixed-effects models were utilized, while risk factors were controlled. Based on the results, about 54,233 individuals had the surgical procedure completed at the VA hospital, where 3.2% of patients were diagnosed with SSI. Of that 3.2%, 0.8% was identified as deep SSI, and 2.4% were diagnosed with superficial SSI. An average cost of treating these patients cost $52,620 compared to $31,580 for those who didn’t experience SSI after a procedure. Deep SSIs cost about $25,721 while only $7,003 were charged for superficial SSIs. The authors indicated Veterans Health Administration might be able to save about $6.7 million every year if the hospitals that aren’t doing so well and are in the highest 10th percentile decrease the rates of SSI to those facilities that are in the 50th percentile (Schweizer, Cullen, Perencevich, &Vaughan Sarazin, 2014).

Preventing Surgical Site Infection

In 1970, Centers for Disease Control and Prevention started National Nosocomial Infections Surveillance (NNIS) system to observe the rates and trends of nosocomial infections. Numerous medical facilities are not yet holding fast enough to national norms of perioperative preparation demonstrated to lessen surgical morbidity, including proper choice, timing, and end of antimicrobial prophylactic. This was uncovered by a review investigation of 34,133 Medicare patients experiencing surgery at 2,965 facilities. Three principle result measures were assessed, to be specific, the rate of patients who got prophylactic antibiotic agents within one hour preceding surgery, who got an antibiotic chosen as per current rules, and who had the antimicrobial suspended inside 24 hours after surgery. The outcomes were unacceptable, with just 55.7% of patients accepting antibiotic agents on time and just 40.7% having antibiotics agents ceased after 24 hours. Then again, the determination of antibiotic was reliable with current measures 92.6% of the time. In 2002, the Centers for Medicare & Medicaid Services (CMS) joined forces with the CDC in regards to Surgical Infection Prevention (SIP) project, in light of conflicting consistency to prevent surgical infection (Rosenberger, Politano, & Sawyer, 2011).

In 2006, the Surgical Care Improvement Project (SCIP) was executed with the objective of decreasing surgical entanglements by 25% (Hawn et al., 2011). There is ample amount of evidence-based research has been taken place between September 2013 and September 2014 to decrease the risk developing SSIs. Along with evidence-based interventions, the following measures can be included in a surgical care bundle to enhance positive surgical outcomes incorporated to SSIs: surgical team’s clothing, hand cleanliness, antimicrobial sutures, showers before the procedure, and weight-based dosing (Edmiston et al., 2014). Table 3 below describes different phases and recommendations that should be considered to reduce SSIs.

Table 3

Prevention of SSI

Preoperative Phase	Preoperative showering	Ask patients to shower on the procedure day, using soap
	Hair removal	Use clippers instead of shaving
	Patient & Surgical personnel	All personnel and patient should wear sterile attire
	Jewelry, acrylic nails, and nail polish	Staff members should remove acrylic nails, nail polish and jewelry prior to procedure
	Staff movement	Restrict staff members from going in and out of the OR, which increase the risk of SSI
	Antibiotic prophylaxis	Administer it prior to the surgery, especially to those that are having procedure on an infected wound
Intraoperative Phase	Hand decontamination	Surgical team must wash their hands per protocol using an alcoholic hand rub or an antiseptic surgical solution before touching a patient, after an interaction with bodily fluids and a patient
	Drapes	Use an iodophor-impregnanted drapes, unless patient is allergic to iodine
	Antiseptic skin preparation	Sterilizing surgical site with antiseptic solution such as Chloraprep , DuraPrep, or Betadine
	Sustaining patient's temperature	In order to decrease SSI rates, keeping perioperative normothermia to fight the infection
	Antiseptic-coated sutures	Antiseptic triclosan has been proved to reduce the infection, especially in neurosurgical cases
	Wound Irrigation	The most important step in decreasing SSI to remove loose, dead tissue, waste, germs from the surgical site
Postoperative Phase	Dressing Change	Use an sterile method to change or remove surgical wound bandages
	Wound cleaning	Keep the surgical site clean and sterile at all times to reduce infection Advise patient to shower 48 hours after the surgery
	Antibiotic regimen (in case of SSI)	If there are symptoms of infection, prescribe patients an antibiotics

(Agency for Healthcare Research and Quality, 2011)
(Tsai & Caterson, 2014)

Infection Control Personnel in a Hospital Setting

Several studies have showed that the SSIs are considerably increasing morbidity and mortality during the postoperative length of stay at the hospital. However, these incidences may decrease if the hospitals are focusing on hiring infection-control staff (Poggio, 2013). The state of New York identified the need of infection prevention personnel, and hospital epidemiologists. The Hospital for Special Surgery (HSS), NY has a significant lower rate of an infection for the fourth time in a row. At the HSS, infection prevention is nurse is dedicated full-time and the nurse supervises the operating area, standardization of each room, also improving surgical time, quality, and patient safety. Also, after a surgical procedure, an operating room is accurately cleaned by the staff, which is precisely monitored by the infection prevention nurse. This decreases the incidence of contamination and infections (Hospital for Special Surgery, 2012).

As surgical care increases, it is essential for hospitals to include an infection control personnel, especially infection preventionists (IP) or hospital epidemiologists (HE) for 1) to review surveillance data and preparing intervention plans; 2) preparing and executing infection control policies; and 3) providing sufficient information to the medical and senior administration staff of the facility on infection control. Having an IP and HE at a medical facility increases quality and safety of patient care, prevent infection, control any outbreaks in the hospital, implement new infection control programs, and new innovations are introduced to control infections. (Sydnor & Perl, 2011).

Surgical Site Infection in an Academic Hospital

An SSI incidence rate varies from different geographical location of the hospital, higher vs. lower volume hospital, and academic versus nonacademic hospitals. A prospective study conducted to recognize risk factors for SSI in a teaching hospital. Approximately 1138 patients were enrolled in the study, where 36 patients ended up with SSI. The chi-square test was performed to test for categorical variable to identify significant relationship. Multivariate logistic regression model was also used to determine independent risk factors associated with SSI. The results of the study revealed 38 patients in total were diagnosed with SSI and 36 of them were diagnosed while they were hospitalized. There were six independent risk factors including diabetes, cancer, preporcedural white blood cell count more than $10x10^9$, wound classification, contaminated, dirty, operative procedure more than 120 minutes., and postoperative drainage. Xing et al., indicates in their systematic review, that the number of resident surgeons participating in the operative procedure is conflicting evidence. Another retrospective study of 172,344 patients who were diagnosed with leiomyomata and underwent abdominal hysterectomy. The study was conducted to establish if the volume of the hospital and academic facility affect surgical outcomes. The comparison was made between academic vs. nonacademic hospitals and annual volume was compared as well. The study observed 37 total deaths. Mortality was not fundamentally identified with doctor's facility volume or academic center. Conversely, morbidity was found to have a positive relationship with teaching center (odds ratio1.34; 95% CI, 1.23 to 1.45), in spite of the fact that a reverse relationship amongst volume and morbidity was monitored for prolonged length of stay (3 days) and blood transfusion results in the initial 3 (least) volume quintiles and for pulmonary embolism in the most noteworthy volume quintile. The authors suggest conducting additional research to portray a relationship between volume, teaching hospitals, and outcomes by using large national databases (Juillard et al., 2009).

Surgical Site Infection After an Abdominal Hysterectomy

According to National Women's Health Network, the second most common surgical procedure is hysterectomy in the United States including women that are at reproductive age. Abdominal hysterectomy is considered as a usual method of removing the uterus and additional reproductive organs. The old-fashioned approach of an abdominal hysterectomy was by laparotomy (Wiser, Holcroft, Tulandi, & Haim, 2013). In 1989, the very first case of total laparoscopic hysterectomy took place, which allowed patients to recover faster, shorter length of stay at the hospital, fewer complications after the procedure(Wiser, Holcroft, Tulandi, & Haim, 2013). National Women's Health Network states, "When performing an abdominal hysterectomy, surgeons can either use a vertical incision or a "bikini cut" incision depending on the scope of the surgery. The vertical incision cuts vertically from the navel to the pubic hairline, while the "bikini cut" is a horizontal incision made directly above the pubic hairline." (National Women's Health Network, 2016)

Major risk factors associated with SSI after an abdominal hysterectomy includes age, smoking, medications prior to the procedure (i.e. insulin, steroids, antimicrobial agents or chemotherapy). A study conducted at the University of Iowa Hospitals and Clinics (UIHC) comprised of including 590 women who had an abdominal hysterectomy. Out of 590 women, 66 developed SSI after a hysterectomy. Logistics regression was used to analyze the data collected. The data analysis revealed several risk factors contributing to the SSI after a hysterectomy such as preoperative showers, antimicrobial prophylaxis, an environmental factor within an operating room (Savage, Pottinger, Chiang, Yohnke, Bowdler, & Herwaldt, 2013). *The Influence of BMI on perioperative morbidity following abdominal hysterectomy* observed about 240 variables from the ACS NSQIP database from 2006-2010. Khavanin et al., (2013) used a logistic regression model to evaluate the relationship between BMI and complications encountered after an abdominal hysterectomy. The results from the study disclosed 11.3% of those complications were discovered in patients that were obese. Patients with higher BMI were at greater risk of surgical complications, including wound infections, and wound disruption.

A retrospective case-control study conducted by Olsen et al., (2013) analyzes the risk factors for SSI after an abdominal hysterectomy. The study was performed from July 1, 2003 through June 30, 2005 at four different CDC Prevention Epicenter facilities. A total of 84 patients were recognized with SSI after an abdominal hysterectomy. Out of 84 patients, 53 patients developed SSI after abdominal hysterectomy, where 63.1%were superficial incision; 15.5% were deep incisional; and 21.4% were an organ-space SSI. Multivariable logistic regression was used to identify independent risk factors for incisional SSI. Demographics, primary comorbidities, and operative risk factors were correlated via univariate analysis. The analysis displayed the primary independent risk factors that were associated with the SSI includes obesity, blood transfusion, longer surgical time and lack of health insurance. Some of the limitations of the study include that it is a retrospective observational study, which prevented from including additional risk factors for SSI, (i.e. preoperative skin antisepsis, or operative hemostasis). Also, it only includes four facilities which prevents from having a larger population from other facilities. Along with limitations, study also includes strengths as well which is that it was multicenter study. Therefore, it allowed authors of the study to look at different dynamics of the facilities and they were all teaching hospitals. Additionally, the authors utilized regulated definitions of different types of SSI. Lastly, the analysis was primarily focused on risk factors only for incisional SSI after abdominal hysterectomy because the risk factors vary for organ-space SSI. The authors suggest there is a need to verify the relationship of perioperative hyperglycemia with SSI after abdominal hysterectomy (Olsen et al., 2013).

Yokoe et al., (2012) reviewed medical records from 2003 to 2005 from five different hospitals that are affiliated with CDC. This study is unique because the authors of the study are evaluating inpatient pharmacy and administrative data to discover SSI after a hysterectomy. The results indicated confirmed diagnosis of 82 SSI, of which 43 were superficial, 11 deep, and 28 organ-space. Four of the five hospitals accounted for 59% of the SSIs after hysterectomy. Based on the results of the study, authors suggest that it might be beneficial to improve diagnosis codes of SSI surveillance. For example, the findings from the study states, after a hysterectomy only 14% of the patients were identifies for antimicrobial and diagnosis-codes, while 92% of SSI appeared.

State-Based Study

A survey was collected from health departments from 10 various states, including California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New Mexico, New York, Oregon, and Tennessee in two different phases between 2009-2011. The surveys were distributed while collaborating with Emerging Infections Programs (EIP). The hospitals were randomly selected, if the hospital refused to participate, alternative hospitals were used. Regression modeling was used to measure the age of the participant and an estimate of the length of stay in the hospital. The study included about 183 hospitals, where 51% (93) facilities were small, 37% (63) were medium-sized facilities, and about 12% (22) were larger hospitals. The most common SSI was after colon surgeries, accounting for 14.5%. About 10% after hip arthroplasties, 6.4% after small-bowl surgeries, and 9.1% SSI were recognized as other, unspecified procedures. A multivariable regression analysis resulted that those older in age were at higher risk of developing an infection (Magill et al., 2014).

Another survey-based study was conducted in the state of North Carolina across 117 acute care hospitals. The collected variables on surveillance data included licensed bed size, patient-days, ventilator-days, central-line days, urinary catheter days, the number of surgical procedures, the number of intensive care units (ICU), type of ICU, and the number of infection preventionists. In addition, hospitals were also asked to distinguish between procedures completed at either inpatient or outpatient sites.

Descriptive statistics, Wilcoxon ran-sums test were used to analyze to compute means, medians, and interquartile range. The result shows that most common HAI in the state of NC is SSI, accounting for 73% of all HAIs. Approximately $985,000 and $2.7 million is an average cost of all HAIs; SSI, reports 87%-91% of total cost. One of the major weaknesses of this study is that the response rate was only 53%, Therefore the assessment may not be as accurate. Overall, the study stipulates an average annual cost of HAIs across NC (Anderson et al., 2013).

Hospital Type and Surgical Site Infection

There is limited evidence on relationship between hospital type and SSI. Historically, a study was conducted to examine the outcomes for approximately 500,000 patients that were treated both medically and surgically, in over 1,200 nonfederal medical facilities in United States. Authors of this study discovered the correlation between high volume hospitals and better outcomes for surgical patients. Based on the findings, some evidence revealed that hospitals with low-volume are associated with poor outcomes for the patients who received surgical care (Flood et al., 1984).

Geographic Location and Healthcare Outcomes

Rosenberg et al., (2016) conducted a study to evaluate differences in US wellbeing results in an all-payer populace before and after risk-adjustment. The study combined data from 16 different sources; it also included 22 million all-payer-inpatient admissions retrieved from the Healthcare Cost and Utilization Projects. The Healthcare Cost and Utilization Project involves covers regions containing 50% of the U.S. population. The study concludes that the geographic changeability in medicinal services results has suggestions for all healthcare participants including patients, healthcare providers, medical facilities, policymakers, pharmaceutical companies, and medical technology companies (Rosenberg et al., 2016).

Hospital Ownership and Quality of Care

According to Halpin et al., (2011), in 2008, California started reporting HAIs in their acute care hospitals publicly, to encourage quality of care and patient safety (Halpin, Milstein, Shortell, Vanneman, and Rosenberg, 2011). Another study conducted by Herrar, Rada, Kuhn-Barrientos, and Barrios (2014) led a systematic review to deliver an outline and health related outcomes of different type of facilities, including provider- namely public, private non-for-profit (PNFP), and private for-profit (PFP). The authors concluded that there is an effect on healthcare outcomes based on the hospital ownership. The authors of this study states that providers from PFP seems to have negative outcomes compared to PNFP, however more research needs to be conducted in order to fill the evidence gap in the literature (Herrera et al., 2014).

Angelici (2010) demonstrates how quality of care is affected by hospital ownership. The review shows that public facilities have a negative influence on mortality rate, in spite of the fact when hospital size is being compared, large public hospitals offer better quality of care (Angelici, 2010). Another systematic review presented relationship between ownership of the hospital and quality of services, which included approximately thirty-one studies from 1981to 2001. The review results revealed correlation between hospital ownership and healthcare results. When studies were examined for the entire nation of the US, it was verified that the for-profit hospitals had worse outcomes, compared to non-profit hospitals (Eggleston, Shen, Lau, Schmid, and Chan, 2008).

Proposed Variables for Surgical Site Infection

Hospital Ownership

Based on the literature, there is minimal evidence on relationship between hospital ownership and SSI. Therefore this study will assign in identifying the association between hospital ownership and SSI. According to Herrera et al., (2014) private for-profit hospitals may have limited resources to spend on care; also, the primary goal for the investors is making profit, which may have negative impact on healthcare outcome. It is essential to observe this variable to fill the gap in research evidence. Overall, it is important for healthcare providers to constantly monitor and evaluate the effort of ownership to be able to comprehend the effect of different types of ownership. Therefore, the presented study will add more evidence into the current research. For the proposed study, the following hospitals are expected to report: profit vs. nonprofit, government, physician owned, and academic hospitals (Juillard et al.,2009).

Number of Beds

After reviewing in literature, there is very minimal evidence that shows that the relationship with number of beds in the hospital and surgical outcomes. Mostly, this evidence is drawn from the studies that are conducted for high volume hospitals and surgical outcomes. Therefore, this variable will add valuable information to the research showing if the number of beds in the hospital is associated with surgical outcomes or not.

Teaching Hospital

The literature suggests that there is an additional research needs to be conducted to reveal a correlation between volume, teaching hospitals, and patient outcomes (Juillard et al., 2009). Consequently, the variable presented in this is teaching status, which will add value to the research by presenting if the teaching hospitals have better or worst outcomes.

Region

In spite of various investigations of geographic differences in healthcare expenditure and use at the regional, local, state, and national levels across the United States, a far reaching portrayal of geographic differences in healthcare outcomes has not been distributed. This variable will add beneficial evidence to the limited research.

Summary

Surgical site infection is an infection which develops within a specific part of the body where the procedure was performed. CDC reports that approximately 1 to 3 out of every 100 patients undergoing surgery will develop an SSI (CDC, 2012). The literature reveals that individuals who experience postoperative SSI after the surgical procedure is at greater risk for increased morbidity and mortality (Anderson et al., 2014). SSI also extends the length of stay by 7-10 additional days in the hospital, which costs healthcare insurance companies and states approximately $3,000 to $29,000 per case and a total of $10 billion per year (Anderson et al., 2014) SSI is an unplanned and preventable result of surgery. There is ample amount of evidence associated with risk factors (see Table 2) leading to SSIs; it is essential for healthcare personnel in each health facility to review the literature and implement SSI prevention measures (Spruce, 2014).

The proposed study used the CMS data on SSI. The expectation of this study was to identify specific causes of postoperative SSI. In this study, I will attempt to investigate specific risk factors in the intraoperative period and the effects on postoperative wound infection. The identified risk factors may allow various hospitals in the United States to prevent SSI. The proposed approach will be able to examine the risk factors which predict the outcome of a surgical procedure. Also, this method will be able to assess some related issues causing SSI. Table 1 above demonstrates the conflicting evidence, which means that the approximation of effect is unclear based on the evidence. Conflicting evidence has been reported about correlation between trauma and surgical site infection (Xing et al., 2013). Also, there is limited evidence found in the literature about academic hospitals having higher incidence rates of infection than community hospitals (Juillard et al. 2009). Therefore, this research provided strong evidence in order to fill in an important knowledge gap. This research was conducted to fill the gap of indefinite risk factors causing SSI after an abdominal hysterectomy.

The next section, Chapter 3, is where the methodology, data source, participants, data collection approach, data analysis will be discussed in details. Chapter 4 will be followed by where the results of the study will be presented. Finally, Chapter 5 will include the interpretation of the data, finding of the study, and the recommendations, and limitations of the study.

Chapter 3: Research Method

Introduction

In Chapter 3, I describe the research design and methodology with a rationale for the approach used in this research. This section includes the study methodology and an outline of the study design and approach, the setting and sample, and the study's instrumentation and materials. Also, I specify justifications of data collection and data analysis for each research question and hypotheses. Lastly, I provide ethical concerns regarding protection of human subjects engaged in this study. The purpose of the study was threefold: (a) to evaluate the overall rate of abdominal hysterectomy SSI following postoperative procedures, (b) to distinguish relationships between teaching status, hospital ownership, number of beds and SSI rates , and (c) to examine the correlation between surgical site infection rate for the hospital and the region (Northeast, Midwest, South, and West).

Research Design and Rationale

This was a cross-sectional retrospective study of the CMS data. The dataset consisted of the data on SSI after an abdominal hysterectomy that had already occurred in the past. The data used in this study came from year 2015 and was de-identified with no identifiers linked to any patients' names or records.

The presented quantitative research methodology incorporated the use of nonexperimental design. A nonexperimental design was suitable for this study because the research goal was to analyze numerous variables by collecting statistical data to generate information about SSI and associated risk factors. For the study, I utilized the linear regression model to explain the relationship between SSI rate and the quality indicators such as academic institution, hospital ownership, number of beds, and region.

In Chapter 2, the researchers of several studies reviewed used multiple logistic regression methods to identify risk factors. Several studies have proved and presented the anticipated analyses appear to appropriate to determine the statistical relationship between SSI and risk factors among targeted population. The following research questions were used in this study to analyze the data:

Research Questions/Hypotheses

RQ1: Is there an independent association between SSI rate and the teaching status institution, hospital ownership, number of beds, and region (Northeast, Midwest, South and West)?

$H_0$1*:* There is an association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

H_a1: There is no association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

$H_0$2: There is an association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_a2: There is no association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_03: There is an association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

H_a3: There is no association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

Study Population and Sample Size

The target population in this study was all the hospitals who collected data on SSI after an abdominal hysterectomy was performed. The database only contained the data from the year 2015, which included 755 hospitals reporting SSI rates. Various variables were collected, which are outlined below in the variables section. A power analysis was performed using OpenEpi, version 3.0, in order to determine the estimated sample size required for the study. In order to prevent making a type I error (false positive), the accepted alpha level of 0.05 and power of 0.80 were used to determine the sample size. A power of 0.80 used to set the power of 80% chance of correctly or incorrectly rejecting the null hypothesis. It is essential to estimate an appropriate sample size in order to obtain accurate results for the selected population.

Table 4 shows the percentage of exposed (teaching hospitals; 59%) and unexposed (non-teaching hospitals; 40%) hospitals entered in the calculator for the academic institution. Two-sided significance level (1-alpha) of 95% and Power (1-beta) of 80% was already prepopulated into the calculator. Based on the calculation, the preferred sample size for this variable was 182 total and 91 cases for each group and a ratio of 1.47:1.00. Table 5 shows the percentage of exposed (for profit) and unexposed (nonprofit) institutions entered in the calculator for the hospital ownership. Two-sided significance level (1-alpha) of 95% and Power (1-beta) of 80% was already prepopulated into the calculator. Based on the calculation, the preferred sample size for this variable was 354 total and 177 cases for each group and a ratio of 1.76:1.00.

Table 4

Sample Size: Power for Cross-Sectional Study (Estimated) Academic Institution

Two-sided significance level(1-alpha):	95%
Power	80
Ratio of Sample Size	1
Ratio of Exposed (Academic)	1.47
Mean – Exposed	1.409
Standard Deviation – Exposed	1.409
Ratio of Unexposed (Non-academic)	1.0%
Mean – Unexposed	0.9
Standard Deviation – Unexposed	1

	Total
Sample Size – Exposed	91
Sample Size-Nonexposed	91
Total sample size:	182

Table 5

Sample Size: Power for Cross-Sectional Study (Estimated) Hospital Ownership

Two-sided significance level(1-alpha):	95%
Power	80
Ratio of Sample Size	1
Ratio of Exposed (Profit)	1.176
Mean – Exposed	2.98
Standard Deviation – Exposed	0.12
Ratio of Unexposed (Non-Profit)	1.0
Mean – Unexposed	3.44
Standard Deviation – Unexposed	1.1

	Total
Sample Size – Exposed	177
Sample Size-Nonexposed	177
Total sample size:	354

Data Collection

The dataset used in this study was archival data from the CMS. The data included the following fields: hospital name, address, city, state, phone number, measure name, score, and start and end date (1/1/2015 – 12/31/2015). The reported data on CMS was from acute care hospitals, and the CDC was responsible for tracking all HAIs. Calculations for the HAI measures were adjusted for variations in the characteristic of hospitals and patients using a standardized infection ration (SIR). For SSI from abdominal hysterectomy, the following variables were included in the risk adjustment: patient diabetes status, age, body mass index, ASA score on the physical stats of the individual prior surgery and type of hospital (acute care hospital). Additional fields were added such as hospital ownership, teaching hospital (Yes/No) and the number of beds in the hospital. The data for additional fields were collected from the American Hospital Directory.

Once the IRB approval was received, the data was analyzed using SPSS. Paperwork for IRB approval was submitted to Walden University to gain access and conduct analysis. The archived dataset is available to the public, and the data is de-identified with no personal identification to any patients. The acquired nonconfidential data was stored on my personal computer.

Variables

Three independent variables and one dependent variable were being examined in this study. The surgical site infection rate for the hospital was the dependent variable, whereas hospital type, hospital ownership, and number of beds in the hospital are the independent variables. Also, additional independent variables were being used for this observational study as covariates are regional location of the hospital (Northeast, Midwest, South, and West) The primary goal of this evaluation was to identify risk factors associated with abdominal hysterectomy SSI following postoperative in the United States.

Operational Definitions

Hospital type. A medical treatment facility where patients are treated with specialized healthcare professionals and proper medical equipment. There are different types of hospitals which are funded by various stakeholders, including public sector, health organizations (i.e. for profit or non-profit), healthcare insurance companies, or by charities and donations.

Hospital ownership. hospital that is operated by physicians, investors, organizations, corporations, or by religious group.

For Profit Hospital. Private hospitals that is owned by state and local governments.

Not for Profit. A medical facility or a clinic that does need to pay to taxes to either state or to federal. It is mainly supported by charity and community.

Government. Hospitals that are owned by government and funded by the government as well.

Military. Hospitals that are mainly used by the military personnel and their beneficiaries.

Veterans Affairs. Ran on federal government's funding and operated by the U.S. Veterans Administration for the veterans.

Physician Owned. Fully or partially owned by the physician or may have a partnership with a larger local hospital and a group of other physicians.

Teaching. a medical center that offers medical/clinical education to train the future healthcare providers.

Region. different regions that are defined by law in the United States, including Northeast, Midwest, South, and West.

Northeast Region. States that are included in this region are Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont New Jersey, New York, and Pennsylvania.

Midwest. States that are included in this region are Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota.

South. States that are included in this region are Delaware, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, District of Columbia, West Virginia, Alabama, Kentucky, Mississippi, and Tennessee, Arkansas, Louisiana, Oklahoma and Texas.

West. States that are included in this region are Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, and Washington.

Government Hospitals (Federal, Hospital District or Authority, Local, and State). Hospital that is operated and funded by government.

Proprietary Hospital. Hospital is that operated by a large corporation for profit-making business.

Voluntary Non-profit (Church, private, and other). Hospital that is operated by the church, which funded by charity and donations.

Number of beds. the maximum number of beds hospital holds license to operate, physically set up, and available to utilize.

Table 6

Dependent and Independent Variables Used in This Study

Dependent Variable	Independent Variables	Covariates
Surgical Site Infection Rate for the Hospital	Teaching Status Hospital Ownership Number of beds	Region (Northeast, Midwest, South, and West)

Data Analysis Plan

To retrieve access to the dataset, approval from Walden University's IRB was required. The IRB approval granted access to the deidentified data from the CMS, which did not have any personal information or link to the patient's record. Once the approval from Walden IRB was approved, the data was transferred from excel file into the Statistical Package for the Social Sciences (SPSS) to perform the analysis. The file was saved on a personal laptop, which was password protected. Once the data was transferred into SPSS, descriptive statistics were performed to review missing data and to clean the data. Using random sampling function in SPSS, 755 random cases were selected.

To test the hypothesis, multiple linear regression modeling was utilized to be able to deliver the significant results. Descriptive statistics was performed for all variables to report mean and standard deviation. Linear regression model is a good fit to test the association between dependent and independent variables are linear. One-way ANOVA will be carried out to verify the significance for dependent and independent variable.

Lastly, to identify factors that are significantly related with SSI, linear regression test was executed to test the hypotheses that the commands are independently correlated with of SSI when adjusting for covariates. Linear regression is the standard method utilized in epidemiology to examine the relationship between dependent variable and independent variable. If the assumptions of linear regression analysis are not met, logistic regression will be conducted. The research variables, measures, and codes are described below in Table 6.

Table 7

Research Variables, Measures and Coding

Variable	Variable Type	Name	Codes
SSI Rate for the Hospital (Score)	Dependent Continuous	SSI Rate for the Hospital	
Hospital Ownership	Independent Categorical	Hospital Ownership	Government Hospital District or Authority, Local and State= 1 Physician Owned = 2 Proprietary =3 Voluntary non-profit church, private and other = 4
Number of Beds	Independent	Number of Beds	25^{th} Percentile – 268 50^{th} Percentile – 370 75^{th} Percentile – 546 95^{th} Percentile – 881.60
Teaching Status	Independent Categorical	Teaching	No = 0 Yes = 1
Region	Covariate Categorical	Region	Northeast = 1 Midwest = 2 South = 3 West = 4

Data cleaning. Collected data was assessed for any discrepancies, and missing data, in order to detect out of range values to determine whether interpolation of missing cases was necessary prior to data analysis. Individuals that were readmitted to the hospital due to any complications were handled as separate cases. Using SPSS, descriptive statistical analysis was performed on every variable to clarify any outliers or data, such as age of 200 years.

Threats to Validity

Threats to External Validity

The hospitals used in this study were originated from a secondary dataset. Every hospital has unique process, policies, and procedures in identifying patients that are diagnosed with SSI. Physicians, nurses and other clinicians involved have different approaches in evaluating patients; therefore, one method may work well in one hospital, which may not work well with another hospital.

Threats to Internal Validity

One possible threat to internal validity was the type of error occurring when the participants are selected based on the diagnosis, where a patient may or may not have serious complications regarding SSI. Therefore, there were certain limitations associated with analyzing the data including the information being limited to the participants. Also, both surgical procedure and outcome information may or may not be reported appropriately.

Threats to Statistical Conclusion Validity

Inaccuracy of the data impact the statistical validity. For the proposed study, I will be depending on the VDH for the data. It is expected that all the data received is not accurate. For example, the calculated BMI may differ among patients. BMI is important in assessing if the patient is obese or not obese. However, data cleaning will be conducted to avoid the type of error.

Protection of Participants' Rights

The proposed study used a secondary dataset from CMS. CMS extracted data and de-identified all the personal information of the participants. Since the data is de-identified, there were no additional risks of disclosure of confidential or private information of the subjects included in the dataset. The dataset was stored on a personal laptop and once the analyses were completed, the dataset was permanently deleted from the personal laptop to avoid an accidental breach of the data.

Summary

This chapter described using a secondary dataset to conduct a quantitative cross-sectional retrospective study. It portrayed study design containing the source of data, data collection, identifying sample size, data analysis strategies, and protecting participants' rights. Chapter 4 describes the results of the study.

Chapter 4: Results

Purpose of the Study

The design of this study was a quantitative, cross-sectional retrospective analysis of observational data. The purpose of the study was threefold: (a) to evaluate the overall rate of abdominal hysterectomy SSI following postoperative procedures, (b) to distinguish relationships between academic institution, hospital ownership, number of beds, and SSI rates, and (c) to examine the correlation between surgical site infection rate for the hospital and the region (Northeast, Midwest, South, and West).

Research Questions and Hypotheses

The objective of this study was to examine the following research questions:

RQ1: Is there an independent association between SSI rate and the teaching status institution, hospital ownership, number of beds, and region (Northeast, Midwest, South and West)?

$H_0$1: There is an association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

H_a1: There is no association between SSI rate and the teaching status when controlling for hospital ownership, number of beds, and region (Northeast, Midwest, South and West).

$H_0$2: There is an association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_a2: There is no association between SSI rate and the hospital ownership when controlling for teaching status, number of beds, and region (Northeast, Midwest, South and West).

H_03: There is an association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

H_a3: There is no association between SSI rate and the number of beds when controlling for teaching status, hospital ownership, and region (Northeast, Midwest, South and West).

Data Collection

As mentioned in Chapter 3, the dataset used in this study was archival data from the CMS. The data included the following fields: hospital name, address, city, state, phone number, measure name, score, and start and end date (1/1/2015 – 12/31/2015). The reported data on CMS was from acute care hospitals, and the CDC was responsible for tracking all HAIs. The database only contained the data from the year 2015, which included 755 hospitals reporting the SSI rates. Data analysis on the CMS data was conducted after the IRB approval was obtained on March 22, 2017.

Descriptive Statistics

There are 6 tables presented in this chapter. Table 8 shows the results of descriptive statistics for the dependent variable, SSI rate for the hospital. A total of 755 hospitals reported SSI rates occurring at their specific facility. Table 9 presents the frequency table for both the dependent variable and independent variables. The dependent variable in this table includes high score SSI rate (top third of all cases) (*N* = 256, 33.9%) and other scores (*N* = 500, 66.1%). Table 8 demonstrates the one-way ANOVA for the independent variables. Table 11 presents results of the multiple linear regression of all cases, testing for the association between SSI rate (DV) and teaching status, hospital ownership, the number of beds, and region. Table 12 displays the results of two-way tests of association between each independent variable and score. Table 13 is the results of logistic regression analysis among dependent variable and independent variables.

Table 8 presents the descriptive statistical analysis conducted using the sample of 755 cases. The analysis included the dependent variable of all 755 hospitals reporting SSI rate: mean (.96202), standard deviation (.897858), variance (.806), skewness (1.703), kurtosis (1.139), minimum (0.000) and maximum (4.668).

Table 8

Descriptive Statistics: Dependent Variable

SSI Rate for the Hospital (Score)	
Mean	.96202
Standard Deviation	.897858
Variance	.806
Skewness	1.073
Kurtosis	1.139
Minimum	0.000
Maximum	4.668
Percentiles	
25th Percentiles (≤ 268 beds)	.00000
50th Percentiles (269-370 beds)	.76200
75th Percentiles (371-546 beds)	1.54900
95th Percentiles (547- 881 beds)	2.71240

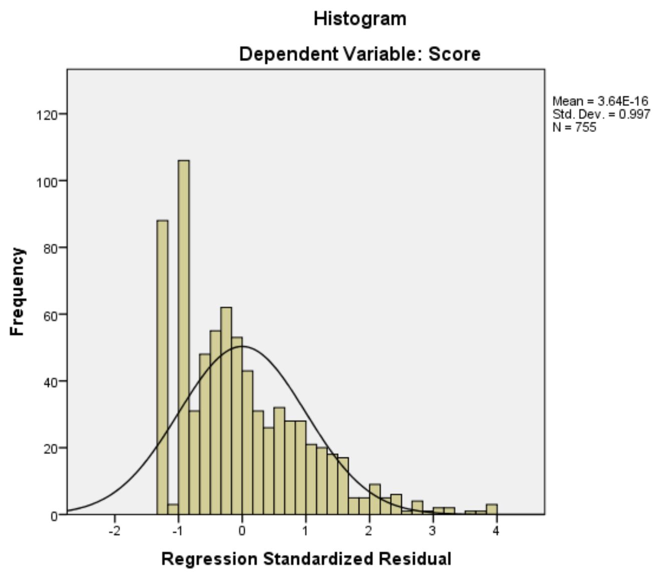

Figure 2: Histogram chart: Dependent Variable

The histogram in figure 1 shows that the bell curve distribution of the data is skewed to the right. Table 9 presents the frequency table for the dependent and independent variables. The dependent variable is split between the top third (33.9% of the cases) high score cases and other score (66%) cases. The analysis also included the following independent variables: teaching status, hospital ownership, number of beds, and region (Northeast, Midwest, South, and West). In the teaching variable, there were 446 (59%) teaching hospitals and 309 (41%) nonteaching hospitals. Within the hospital ownership category, there were 100 hospitals that were local or state government hospitals; 120 that were physicians owned and proprietary, and a total of 535 voluntary nonprofit church, private, and other hospitals. The number of the variable number of beds was analyzed based on the percentiles. The 25th percentile accounts for less than or equal to 268 beds in the hospital (*N* = 164); 50th percentile includes 269 to 370 number of beds in the hospital (*N* = 161); 75th percentile reports 371 to 546 number of beds in the hospital (*N* = 161); 95th percentile accounts for 547 to 881 number of beds in the hospital (*N* = 129); 100th percentile included 882 to 1,672 number of beds in the hospital (*N* = 31), which are the largest hospitals. There were 110 cases that occurred in a hospital that didn't report number of beds. Lastly, the region variables were divided into four different categories, including Northeast (*N* = 122), Midwest (*N* = 171), South (*N* = 318), and West (*N* = 144).

Table 9

Frequency Table: Dependent and Independent Variables

Dependent Variable	*f*	%
High Score	256	33.9%
Other Score	500	66.1%
Total	755	100%
Independent Variable		
Teaching Status		
Yes	446	59.1%
No	309	40.9%
Total	755	100%
Hospital Ownership		
Government Hospital District or Authority, Local and State	100	13.2%
Physician Owned and Proprietary	120	15.6%
Voluntary non-profit church, private and other	535	70.9%
Total	755	100%
Number of Beds		
25th Percentile	164	21.7%
50th Percentile	161	21.3%
75th Percentile	161	21.3%
95th Percentile	129	17.1%
100th Percentile	31	4.1%
Missing	110	14.6%
Total	755	100%
Region		
Northeast	122	16.2%
Midwest	171	22.6%
South	318	42.1%
West	144	19.1%
Total	755	100%

One-Way ANOVA

Table 10 presents one-way ANOVA to test the assumption of independence between the variables. The categories with higher means for the SSI rate were as follows: teaching hospitals, government or state hospitals, 75th and 95th percentile number of beds (larger hospital), Northeast and West region. For the teaching status (Yes & No) variable, the *F* value for Levene's test is 7.582 with a Sig. (*p*) value of .006, which indicates ANOVA is inappropriate. Also, for the 25th percentile ($\leq$ 268 number of beds in the hospital), the *F* value for Levene's test is 9.609 with a Sig. (*p*) value of .002, which also indicates ANOVA is inappropriate. Therefore, the ANOVA results were disregarded and two-way tables were used to test for univariate associations.

Table 10

One-Way ANOVA: Independent Variables

	Total *N*	Mean	Standard Error	Sig.
Teaching Status				
Yes	446	1.085	.042	.006
No	309	.784	.050	.006
Total	755			
Hospital Ownership				
Government Hospital District or Authority, Local and State	100	1.020	.090	.750
Physician Owned and Proprietary	120	.775	.082	.162
Voluntary non-profit church, private and other	535	.993	.039	.302
Total	755			
Number of Beds				
25th Percentile	162	.910	.071	.002
50th Percentile	161	.842	.071	.315
75th Percentile	162	1.079	.070	.855
95th Percentile	129	1.027	.079	.881
100th Percentile	32	1.066	.159	.240
Missing	110	.936	.086	.053
Total	755			
Region				
Northeast	122	1.063	.081	.707
Midwest	171	.911	.069	.800
South	318	.914	.050	.722
West	144	1.044	.075	.395
Total	755			

Multiple Linear Regression

Table 11 demonstrates multiple linear regression model, where the assumptions of the linear relationship were not met; therefore, multiple logistic regression analysis (Table 13) was conducted to show the relationship between variables. The total number of cases that were included in the analyses was 755 and the R^2 was .028, which means that the linear regression explains only 2.8% of the variance in the data. There is approximately 2% or less than a variation of the variation of a dependent variable (score) is explained by the independent variable (teaching status, hospital ownership, the number of beds, and region). The Durbin-Watson values show the critical values between 1.5 and 2.5; therefore, it is assumed that there is no linear autocorrelation in this multiple linear regression model. Based on the linear regression below, the overall model was not significant.

Table 11

Multiple Linear Regression: Independent Variables Total Number – 755; R Square - .028

Independent Variable	B Unstandardized Coefficients	Beta Standardized Coefficients	R Square	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound	Durbin Watson
<u>Teaching Status</u>							
Yes	.301	.165	.027	.000	.172	.429	1.942
No			Reference				
<u>Hospital Ownership</u>							
Government Hospital District or Authority, Local and State			Reference				
Physician Owned and Proprietary	-.222	-.091	.008	.013	-.397	-.047	1.937
Voluntary non-profit church, private and other	.106	.054	.003	.139	-.035	.248	1.936
<u>Number of Beds</u>							
25th Percentile	-.067	-.030	.001	.403	-.223	.090	1.950
50th Percentile	-.152	-.069	.005	.057	-.308	.004	1.954
75th Percentile	.148	.068	.005	.062	-.008	.304	1.956
95th Percentile	.078	.033	.001	.367	-.092	.249	1.949
100th Percentile			Reference				
Missing	-.030	-.012	.000	.744	-.213	.152	1.948
<u>Region</u>							
Northeast	.120	.049	.002	.177	-.054	.294	1.943
Midwest	-.066	-.031	.001	.396	-.220	.087	1.949
South	-.083	-.046	.002	.211	-.213	.047	1.936
West			Reference				

Two-Way Tests of Association

Table 10 was performed to present relationship between each independent variable and both high score (third of a total number of cases) and other scores. The total sample analyzed in Table 10 included 755 cases. The teaching status variable ranged from 40% for high score for the teaching hospital and 26% for nonteaching hospital (*p* = .000). Therefore, teaching hospitals have 40% high rate compared to 26% for nonteaching hospital.

The government, state, and local hospitals accounted 39% for high score and 61%. The physician owned and proprietary hospitals included 27% of high score and 73% of other score. Voluntary non-profit church, private and other hospitals contained 35% of the high score and 65% of other score. The overall *p value* for the hospital ownership was .123, which is not statistically significant.

As mentioned above, the number of beds is divided into 25th, 50th, 75th, 95th, and 100th percentiles. The 25th percentile category included 29% of the high score and 71% of The 50th percentile category included 31% of the high score and 69% of other score. The 75th percentile category included 43% of the high score and 57% of other score. The 95th percentile category included 36% of the high score and 64% of other score. The 100th percentile category included 31% of the high score and 69% of other score. The missing category included 31% of the high score and 69% of other scores. The overall *p value* for the number of beds was .096, which is not statistically significant.

The Northeast region category included 34% of the high score and 66% of other score. The Midwest region included accounted for 36% of the high score and 64% of other score. The South category included 30% of high score and 70% of other score. The West region included 41% of high score and 59% of other score. The overall *p value* for the region is .168, which is not statistically significant.

Table 12

Chi-Square - Total Number = 755

	High Score	***Other Score***	**Total %**	**Value**	**Asymptotic Significance (2-Sided)**
Teaching Status					
Yes	40%	60%	100%	15.951	.000
No	26%	74%	100%		
Hospital Ownership					
Government Hospital District or Authority, Local and State	39%	61%	100%	4.186	.123
Physician Owned and Proprietary	27%	73%	100%		
Voluntary non-profit church, private and other	35%	65%	100%		
Number of Beds					
25th Percentile	29%	71%	100%	9.340	.096
50th Percentile	31%	69%	100%		
75th Percentile	43%	57%	100%		
95th Percentile	36%	64%	100%		
100th Percentile	31%	69%	100%		
Missing	31%	69%	100%		
Region					
Northeast	34%	66%	100%	5.052	.168
Midwest	36%	64%	100%		
South	30%	70%	100%		
West	41%	59%	100%		

Multiple Logistic Regression Analysis

Table 11 presents a multiple logistic regression analysis of all cases (*N*=755), testing for the association of high score and various independent variables (teaching status, hospital ownership, the number of beds and region). Overall -2 Log Likelihood for the model was 941.753 which have increased significantly, showing a poor fit of the model. Overall 66% value was predicted which means it did not improve the model. The result of this analysis presents an adjusted odds ratio and 95% confidence interval (CI) for each independent variable. The dependent variable in this analysis was a dichotomous measure high score (third of all cases) and other scores. The following variables were not significant: physician owned and proprietary hospitals, non-profit hospitals, number of beds, and region (Northeast, Midwest, and South.

The odds ratio for the teaching hospital was .589 (p = .001, 1.278 -2.0 CI), which means that the odds of high SSI in teaching hospitals were 50% higher than in nonteaching hospitals. The reference categories are non-teaching hospitals, government/local/state hospitals, 882-1672 (100^{th} percentile) number of beds, and West region. Based on the logistic regression model below, we can conclude that the overall logistic regression model was not significant (*-2Log Likelihood = 935.398)*. Lastly, the bar charts below (Figures 2-5) show all the independent variables and correlated high score vs. other score.

Table 13

Logistic Regression; Total Number = 755

Independent Variable	*B*	*S.E.*	Wald	P Value	Exp (B)	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Teaching Status							
Yes	.589	.175	11.285	.001	1.802	1.278	2.
No				Reference			
Hospital Ownership							
Government Hospital District or Authority, Local and State				Reference			
Physician Owned and Proprietary	-.478	.300	2.536	-.478	.300	2.536	-.478
Voluntary non-profit church, private and other	-.194	.236	.673	-.194	.236	.673	-.194
Number of Beds							
25^{th} Percentile	.158	.436	.131	.717	1.171	.498	2.751
50^{th} Percentile	.155	.429	.131	.718	1.168	.504	2.709
75^{th} Percentile	.536	.420	1.623	.203	1.708	.749	3.895
95^{th} Percentile	.237	.428	.307	.579	1.268	.548	2.934
100^{th} Percentile				Reference			
Missing	.132	.443	.089	.765	1.141	.479	2.719
Region							
Northeast	-.423	.267	2.508	.113	.655	.388	1.106
Midwest	-.250	.239	1.089	.297	.779	.488	1.245
South	-.357	.216	2.724	.099	.700	.458	1.069
West				Reference			

Summary of Findings

In this quantitative, cross-sectional retrospective study, retrospective analysis of observational data was performed. The results of the descriptive statistics showed the largest number of hospitals in the study were the voluntary non-profit church, private and other at approximately 71% (n = 535), the majority of hospitals had 25th percentile number of beds ($\leq$ 268) at 21.7% (n = 164), lastly the highest region was South at 42% (n = 318).

The hypothesis tests did not control for the covariates because both multivariate models were weak. TheANOVA results were disregarded because of unequal variances. Instead, the results relied on the two-way tests based on contingency tables. The first hypothesis was that there is an association between SSI rate and the teaching status. The chi-square that teaching hospitals have a significantly higher risk of developing SSI after abdominal hysterectomy. The second hypothesis was that there is an association between SSI rate and the hospital ownership. The chi-square test showed that ownership was not significant. The third hypothesis was that there is an association between SSI rate and the number of beds. As mentioned earlier, the number of beds were divided into four different categories (25th, 50th, 75th, 95th, and 100th percentiles). The chi-square indicated that bed size was not related to SSI. The chi-square also revealed that there are no significant regional differences in SSI. The next chapter of this dissertation will present the interpretation of findings, implications for social change, recommendations for action, and further study.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Every year, approximately 500,000 to 750,000 cases of SSIs occur in the United States (Kitembo and Hugulu, 2013). Between 2% and 14% of SSI cases are diagnosed after the patient is discharged from the hospital (Graves et al., 2006). Nearly 4% to 25% of patients are readmitted, and some require another surgery due to initial surgical complications, which increases the length of stay at the hospital (Tevis, Kohlnhofer, Weber, and Kennedy, 2014). One of the objectives of Healthy People 2020 (2016) is to reduce a number of cases of SSI by measuring the incidence of infections, expanding on implementation strategies and developing various prevention tools.

The purpose of this study was to analyze a cross-sectional retrospective study of the CMS data. The presented study was a nonexperimental design to analyze numerous variables by collecting statistical data to generate information about the SSI. The purpose of this research was to ascertain the relationship between teaching status, hospital ownership, the number of beds, and SSI rates, and to examine the correlation between SSI for the hospital and the region. The target population in this study was utilized from the CMS database which contained 755 hospitals reporting SSI rates from the year 2015.

Interpretation of the Findings

Since neither linear regression nor logistic regression models performed well, conclusions in Chapter 4were based on two-way contingency tables and chi square tests. Two-way tests of association present the relationship between each independent variable and high score (third of a total number of cases) and other score. The chi-square indicated that patients in the teaching hospitals have a significantly higher risk of developing SSI. Hospital ownership, hospital size and region were not significantly related to the risk of contracting SSI after abdominal hysterectomy.

Comparing Findings to Prior Research

This research has provided substantial evidence to fill in a significant knowledge gap of indefinite risk factors causing SSI after an abdominal hysterectomy. I expected this study was to identify specific risk factors for postoperative SSI, targeting hospital characteristics (i.e. teaching status, hospital ownership, the number of beds, and geographical location). I learned that high SSI incidence rates were more common in teaching hospitals than in non-teaching hospitals. Table 1 in Chapter 2 outlines the conflicting evidence and limited evidence on hospital ownership, the size of the hospital, and geographic location. Based on the literature, there is minimal evidence of correlation between hospital ownership and SSI. This study revealed higher risk is not associated with private hospitals for SSI, which contradicts the findings reported by Herrera et al., (2014). After reviewing the literature, there is limited evidence that presents a relationship between number of beds in the hospital and surgical outcome. This research also found no significant association between hospital size and risk of SSI.

Based on the analysis, the results from this study were opposite to Julliard et al., (2009), who demonstrated a correlation between a nonteaching hospitals and contraction of SSI. The authors indicated that the mortality was not fundamentally identified with an academic center. The authors suggested conducting additional research to portray a relationship between volume, teaching hospitals, and outcomes by using large national databases (Juillard et al., 2009). The dissertation study used a national data base to examined those variables, finding that the risk of SSI is higher in teaching hospitals.

The results from the present study revealed no relationship between hospitals located in the Midwest regions and SSI rates. In spite of various investigations of geographic differences in health care expenditure and use at the regional, local, state, and national levels across the United States, a far-reaching portrayal of geographic differences in health care outcomes has not been reported. This study also found no significant regional differences in rates.

Limitations of the Study

The limitations of this study included that the collected data was not primary data; therefore there were limitations on inclusion/exclusion criteria. Also, the data contained in the CMS database contained one year of data. There were also missing data on the number of beds in the hospitals, which may have impacted the results. Most importantly, the findings are not fully adjusted for clinical differences among patients.

Recommendation for Action

The cost associated with SSI and readmission is significant in terms of morbidity and mortality the effect on hospital performance. Hospital readmission is highly expensive for the medical insurance companies and Medicare beneficiaries (Lawson et al., 2013). This study demonstrated a significantly higher risk in the adjusted SSI rate in teaching hospitals compared to nonteaching hospitals. In order to reduce the rates of SSI, policymakers and stakeholders should target teaching hospitals, since they are higher risk for developing SSI . These hospitals should strategize, organize, and execute educational and training programs including subject matter experts in epidemiology, infectious diseases, and infection prevention fields. Medical treatment facilities should evaluate the risk of developing SSI at least annually as the changes occur in the geographical areas, technical innovation, and construction and renovations of the facility.

Currently, CMS only requires hospitals to report SSI data for inpatient abdominal hysterectomy and inpatient colon procedures; however, hospitals should be required to collect SSI data on other surgical procedures as well. It is essential to have hospitals report more variables regarding the SSI incidence, such as the outcomes of the infection and variables relating to the hospital. Presently, there are only 27 states that collaborate with CMS, but there should be a requirement for all states to report their data (Anderson et al., 2014).

Future study is recommended examining additional variables such as hospital staff, such as whether having an infection preventionist impacts the SSI rate in various hospitals. Additional efforts should be made to identify other risk factions for the hospitals in the United States. Along with hospital relating data (i.e. name, address, score rate, and number of beds), further studies should also include patient-level data to implement prevention strategies. Lastly, including about five years of collected and analyzed data would add valuable information to the current research.

Implication for Social Change

The present study was conducted to examine the relationship between the SSI rate per hospital and teaching hospitals, hospital ownership, number of beds, and geographical location, which has shed light on the specific risk factors. The analysis presented from the study was conducted to assist and evaluate various preventions that are already taking place and also help implement new prevention programs through different hospitals. This study may impact positive social change by decreasing preventable surgical site infection.

The results of the study indicate that patients at the teaching hospitals are at higher risk of contracting SSI after an abdominal hysterectomy. Therefore, the identified risk factors may allow various hospitals to implement education and training programs, as well as hiring an infection preventionist to reduce the risk of SSI. This study may add to the current literature on SSI infections and the presented variables including hospital ownership, teaching status, number of beds in the hospital, and the region where the hospital is located. The findings can be broadened to inform insurance companies and public health organizations considering a change in how they approach pre- and postsurgical care.

Conclusion

One of the objectives of Healthy People 2020 (2016) is to reduce the number of cases of SSI by measuring the incidence of infections, expanding on implementation strategies, and developing various prevention tools. This study was intended to examine the risk factors associated with SSI after an abdominal hysterectomy. A key feature of this study is the association between SSI and being a teaching hospital. In the case of this study, the most important finding is the suggestion for further research and prevention strategies aimed at teaching hospitals. The results from this study show patients at academic hospitals and larger hospitals having higher risk of developing SSI after an abdominal hysterectomy. This study has provided evidence to fill in a significant knowledge gap of indefinite risk factors causing SSI after an abdominal hysterectomy. Hopefully, future research will shed more light using more detailed and descriptive primary data in order to generate conclusions on the impact of SSI and various characteristics of a hospital as a unit of analysis.

References

Aehlert, B., & Vroman, R. (2010). *Paramedic practice today: Above and beyond*. St. Louis, MO: Mosby Jems Elsevier.

Agency for Healthcare Research and Quality. (2011). Surgical site infection: Prevention and treatment of surgical site infection. Retrieved from https://www.guideline.gov/summaries/summary/13416/surgical-site-infection-prevention-and-treatment-of-surgical-site-infection

Agency for Healthcare Research and Quality. (2016, July). Health care associated infections. Retrieved from https://psnet.ahrq.gov/primers/primer/7/health-care-associated-infections

Angelici, M. (2010, April 28). Does hospital ownership influence quality of care? Retrieved from http://new.sis-statistica.org/wp-content/uploads/2013/09/RS10-Does-Hospital-ownership-influence-quality-of-care.pdf

Alvarez, A., & Burnshell, D. (2012). *Healthcare-associated infections surgical site infections (SSI) pilot project, data presentation collaborative, and SSI mini-grant program 2010-2011*. Virginia Department of Health, Division of Surveillance and Investigation. Retrieved from http://www.vdh.virginia.gov/content/uploads/sites/3/2016/03/SSI-pilot-report-FINAL.pdf

Anderson, D. J., Podgorny, K., Berríos-Torres, S. I., Bratzler, D. W., Dellinger, E. P., Greene, L., . . . Kaye, K. S. (2014). Strategies to prevent surgical site infections in acute care hospitals: 2014 update. *Infection Control & Hospital Epidemiology*, *35*(06), 605-627.

Anderson, D. J., Pyatt, D. G., Weber, D. J., & Rutala, W. A. (2013). Statewide Costs of Healthcare-Associated Infections: Estimates for Acute Care Hospitals in North Carolina. *American Journal of Infection Control*, *41*(9), 764–768. http://doi.org/10.1016/j.ajic.2012.11.022

Anderson, D. J., & Sexton, D. (2015, September 3). *Epidemiology of surgical site infection in adults*. Wolters Kluwer Health. Retrieved from http://www.uptodate.com/contents/epidemiology-of-surgical-site-infection-in-adults

Association for Professional in Infection Control and Epidemiology. (n.d.). *Infection Prevention and You*. Retrieved from http://apic.org/Resource_/TinyMceFileManager/IP_and_You/IPandYou_SmallFlyer_download_hiq.pdf

Azoury, S., Farrow, N., Hu, Q., Soares, K., Hicks, C., Azar, F., . . . Eckhauser, F. (2015). Postoperative abdominal wound infection—epidemiology, risk factors, identification, and management. *Cronic Would Care Management and Research, 2*, 137-148. https://dx.doi.org/10.2147/CWCMR.S62514

Boston University . (n.d.). *Descriptive Epidemiology*. Retrieved from http://sphweb.bumc.bu.edu/otlt/mph-modules/ep/ep713_descriptiveepi/ep713_descriptiveepi_print.htm l

Cannon, M., Hersey, D., Harrison, S., Joy, B., Naguib, A., Galantowicz, M., & Simsic, J. (2016). Improving surveillance and prevention of surgical site infection in pediatric cardiac Surgery. *American Journal of Critical Care*, 25(2).

http://doi.org/10.4037/ajcc2016531

Centers for Disease Control and Prevention. (2012). *Operational Guidance for Reporting surgical site infection (SSI) data to CDC's NHSN for the purpose of fulfilling CMS's hospital inpatient quality reporting (IQR) program requirements.* Retrieved from http://www.cdc.gov/nhsn/PDFs/FINAL-ACH-SSI-Guidance.pdf

Centers for Disease Control and Prevention. (2012, May 17). *Surgical site infections (SSI)*. Retrieved from https://www.cdc.gov/HAI/ssi/ssi.html

Centers for Disease Control and Prevention. (2012, May 18). *Lesson 1: Introduction to Epidemiology*. Retrieved from https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson1/section6.html

Centers for Disease Control and Prevention. (2016, January). *Surgical site infection (SSI) event*. Retrieved from http://www.cdc.gov/nhsn/pdfs/pscmanual/9pscssicurrent.pdf

Cheng, K., Li, J., Kong, Q., Wang, C., Ye, N., & Xia, G. (2015). Risk factors for surgical site infection in a teaching hospital: A prospective study of 1,138 patients. *Patient Preference and Adherence, 9*, 1171–1177. http://doi.org/10.2147/PPA.S86153

Clarke-Pearson, D. L., & Geller, E. J. (2013). Complications of hysterectomy. *Obstetrics& Gynecology*, *121*(03), 654-673. http://doi.org/10.1097/AOG.0b013e3182841594

Cohen, C., & Shang, J. (2015). Evaluation of conceptual frameworks applicable to the study of isolation precautions effectiveness. *Journal of Advanced Nursing*, *71*(10), 2279–2292. http://doi.org/10.1111/jan.12718

Cooper, R. A. (2013). Surgical site infections: Epidemiology and microbiological aspects in trauma and orthopaedic surgery. *International Wound Journal*, *10*(S1), 3-8. doi:10.1111/iwj.12179

Durkin, M. J., Dicks, K. V., Baker, A. W., Lewis, S. S., Moehring, R. W., Chen, L. F., . . . Anderson, D. J. (2015). Seasonal variation of common surgical site infections: Does Season Matter? *Infection Control and Hospital Epidemiology*, *36*(9), 1011–1016. http://doi.org/10.1017/ice.2015.121

Edmiston, C. E., Lee, C. J., Krepel, C. J., Spencer, M., Leaper, D., Brown, K. R., . . . Seabrook G. R. (2015). Evidence for a standardized preadmission showering regimen to achieve maximal antiseptic skin surface concentrations of chlorhexidine gluconate, 4%, in surgical patients. *JAMA Surgery*, *150*(11), 1027-1033. http://doi.org/10.1001/jamasurg.2015.2210

Eggleston, K., Shen, Y., Lau, J., Schmid, C., & Chan, J. (2008). Hospital ownership and quality of care: What explains the different results? *Health Economics*, *17*, 1345-1362. doi:10.3386/w12241

Flood, A. B., Scott, W. R., & Ewy, W. (1984). Does practice make perfect? *Medical Care*, *22*(2), 115-125. doi:10.1097/00005650-198402000-00003

Foxman, B.. (2017). *Molecular Tools and Infectious Disease Epidemiology* (1st ed.). St. Louis, MO: Elsevier Academic Press.

Friis, R. H. (2012). *Epidemiology 101*. Burlington, MA: Jones & Bartlett Learning.

Gani, F., Lucas, D. J., Kim, Y., Schneider, E. B., & Pawlik, T. M. (2015). Understanding variation in 30-day surgical readmission in the era of accountable care. *JAMA*

Surgery, *150*(11), 1042-1049. http://doi.org/10.1001/jamasurg.2015.2215

Gibson, A., Tevis, S., & Kennedy, G. (2014). Readmission after delayed diagnosis of surgical site infection: a focus on prevention using the American College of Surgeons National Surgical Quality Improvement Program. *American Journal of Surgery*, *207*(6), 832–839. http://doi.org/10.1016/j.amjsurg.2013.05.017

Graves, N., Halton, K., Curtis, M., Doidge, S., Lairson, D., McLaws, M., & Whitby, M. (2006). Costs of surgical site infections that appear after hospital discharge. *Emerging Infectious Diseases, 12*(5), 831–834. http://doi.org/10.3201/eid1205.051321

Greene, L. (2015, December 14). *The surveillance, informatics and epidemiology triangle*. Retrieved from http://www.infectioncontroltoday.com/articles/2015/12/the-surveillance-informatics-and-epidemiology-triangle.aspx

Halpin, H. A., Milstein, A., Shortell, S. M., Vanneman, M., & Rosenberg, J. (2011). Mandatory public reporting of hospital-acquired infection rates: A report from California. *Health Affairs, 30*(4), 723-729. doi:10.1377/hlthaff.2009.0990

Hawn, M. T., Vick, C. C., Richman, J., Holman, W., Deierhoi, R. J., Graham, L. A., . . . Itani, K. M. (2011). Surgical site infection prevention. *Annals of Surgery, 254*(3), 494-501. http://dx.doi.org/10.1097/sla.0b013e31822c6929

Healthy People 2020. (2016). *Healthcare-associated infections*. Retrieved from https://www.healthypeople.gov/2020/topics-objectives/topic/healthcare-associated-infections

Herrera, C. A., Rada, G., Kuhn-Barrientos, L., & Barrios, X. (2014). Does ownership matter? An overview of systematic reviews of the performance of private for-profit, private not-for-profit and public healthcare providers. *PLoS ONE, 9*(12). doi:10.1371/journal.pone.0093456

Hospital for Special Surgery. (2012). Hospital for special surgery has highest volume and significantly lower infection rate for total hip replacement in New York State for fourth year. Retrieved from https://www.hss.edu/newsroom_low-infection-rate-hip-replacement.asp.

Juillard, C., Lashoher, A., Sewell, C. A., Uddin, S., Griffith, J. G., & Chang, D. C. (2009). A national analysis of the relationship between hospital volume, academic center status, and surgical outcomes for abdominal hysterectomy done for leiomyoma. *Journal of the American College of Surgeons, 208*(4), 599-606. doi:10.1016/j.jamcollsurg.2009.01.003

Kazaure, H. S., Roman, S. A., & Sosa, J. A. (2012). Association of postdischarge complications with reoperation and mortality in general surgery. *Archives of Surgery*, 147(11), 1000-1007. http://doi.org/10.1001/2013.jamasurg.114

Kassin, M. T., Owen, R. M., Perez, S., Leeds, I., Cox, J. C., Schnier, K., & Sweeney, J. F. (2012). Risk factors for 30-Day hospital readmission among general surgery patients. *Journal of the American College of Surgeons*, 215(3), 322–330. http://doi.org/10.1016/j.jamcollsurg.2012.05.024

Khavanin, N., Lovecchio, F. C., Hanwright, P. J., Brill, E., Milad, M., Bilimoria, K. Y., & Kim,J. Y. (2013). The influence of BMI on perioperative morbidity following abdominal hysterectomy. *American Journal of Obstetrics and Gynecology*, *208*(6), 449.e1-449.e6. http://doi.org/10.1016/j.ajog.2013.02.029

Kitembo, S., & Chugulu, S. (2013). Incidence of Surgical site infections and microbial pattern at Kilimanjaro Christian Medical Centre. *The Annals of African Surgery* , *10*(1), 26-31.

Koek, M., Wille, J., Isken, M., Voss, A., & Benthem, B. V. (2015). Post-discharge surveillance (PDS) for surgical site infections: a good method is more important than a long duration. *Eurosurveillance*, *20*(8), 21042. doi:10.2807/1560-7917.es2015.20.8.21042

Korol, E., Johnston, K., Waser, N., Sifakis, F., Jafri, H. S., Lo, M., & Kyaw, M. H. (2013). A systematic review of risk factors associated with surgical site infections among surgical patients. *PLoS ONE*, *8*(12), e83743. http://doi.org/10.1371/journal.pone.0083743

Kripalani, S., Theobald, C. N., Anctil, B., & Vasilevskis, E. E. (2014). Reducing hospital readmission: current strategies and future directions. *Annual Review of Medicine*, *65*, 471–485. http://doi.org/10.1146/annurev-med-022613-090415

Lachiewicz, M. P., Moulton, L. J., & Jaiyeoba, O. (2015). Infection Prevention and Evaluation of Fever After Laparoscopic Hysterectomy. *Journal of the Society of Laparoendoscopic Surgeons*, *19*(3). http://doi.org/10.4293/JSLS.2015.00065

Lake, A. G., McPencow, A. M., Dick-Biascoechea, M. A., Martin, D. K., & Erekson, E. A. (2013). Surgical site infection after hysterectomy. *American Journal of Obstetrics and Gynecology*, *209*(5), 10.1016/j.ajog.2013.06.018.

http://doi.org/10.1016/j.ajog.2013.06.018

Lawson E. H., Hall B. L., Ko C. Y. (2013). Risk factors for superficial vs deep/organ-space surgical site Infections implications for quality improvement initiatives. *JAMA Surgery*, *148*(9), 849-858. http://doi.org/10.1001/jamasurg.2013.2925

Magill, S. S., Edwards, J. R., Bamberg, W., Beldavs, Z. G., Dumyati, G., Kainer, M. A., . . . Fridkin, S. K. (2014). Multistate point-prevalence survey of health care–associated infections. *New England Journal of Medicine*, *370*(13), 1198-1208. http://doi.org/10.1056/nejmoa1306801

Mayo Clinic. (2016). *Abdominal hysterectomy*. Retrieved from http://www.mayoclinic.org/tests-procedures/abdominal-hysterectomy/home/ovc-20178788

Merkow RP, Ju MH, Chung JW, Hall, B., Cohen, M., Williams, M., Tsai, T., Ko, C., & Bilimora K. (2015) Underlying reasons associated with hospital readmission following surgery in the United States. *JAMA*, *313*(5):483-495. http://doi.org/10.1001/jama.2014.18614

Ming, D. Y., Chen, L. F., Miller, B. A., Sexton, D. J., & Anderson, D. J. (2012). The impact of depth of Infection and postdischarge surveillance on rate of surgical-site infections in a network of community hospitals. *Infection Control and Hospital Epidemiology : The Official Journal of the Society of Hospital Epidemiologists of America*, *33*(3), 276–282. http://doi.org/10.1086/664053

Merrill, R. M. (2010). *Introduction to epidemiology*. Sudbury, MA: Jones and Bartlett.

Minutolo, M., Blandino, G., Lanteri, R., Puleo, S., & Minutolo, V. (2011).

Surgical site infection in elderly patients. *BMC Geriatr BMC Geriatrics*, *11*(Suppl 1). doi:10.1186/1471-2318-11-s1-a37

Morales, C., Escobar, R., Vilegas, M., Castano, A., & Trujilo, J. (2011). Surgical site infection in abdominal trauma patients: Risk prediction and performance of the NNIS and SENIC indexes. *Canadian Journal of Surgery, 54*(1), 17-24. doi:10.1503/cjs.022109

Morris, M. S., Deierhoi, R. J., Richman, J. S., Altom, L. K., & Hawn, M. T. (2014). The relationship between timing of surgical complications and hospital readmission. *JAMA Surgery JAMA Surg*, 149(4), 348-354 http://doi.org/10.1001/jamasurg.2013.4064

Namba, R., Inacio, M., & Paxton, E. (2013, May). Risk factors associated with deep surgical site infections after primary total knee arthroplasty: An analysis of 56,216 knees. *J Bone Joint Surg Am, 95*(9), 775-782. http://dx.doi.org/10.2106/JBJS.L.00211

National Women's Health Network. (2016). *Hysterectomy*. Retrieved from https://www.nwhn.org/hysterectomy/

Nelson, K. E., & Williams, C. M. (2007). *Infectious disease epidemiology: Theory and practice*. Sudbury, MA: Jones and Bartlett.

Nelson, K. E., Williams, C. M., & Graham, N. M. (2004). *Infectious disease epidemiology: Theory and practice*. Sudbury, MA: Jones and Bartlett.

Office of Disease Prevention and Health Promotion. (2016). *Health care-associated infections*. Retrieved from https://health.gov/hcq/prevent-hai.asp

Olsen, M. A., Higham-Kessler, J., Yokoe, D. S., Butler, A. M., Vostok, J., Stevenson, K. B., . . . the CDC Prevention Epicenter Program. (2009). Developing a risk stratification model for surgical site infection after abdominal hysterectomy. *Infection Control and Hospital Epidemiology : The Official Journal of the Society of Hospital Epidemiologists of America*, *30*(11), 1077–1083. http://doi.org/10.1086/606166

Poggio, J. (2013). Perioperative Strategies to Prevent Surgical-Site Infection. *Clinics in Colon and Rectal Surgery, 26*(03), 168-173. http://dx.doi.org/ 10.1055/s-00331351133

Rosenberger, L. H., Politano, A. D., & Sawyer, R. G. (2011). The surgical care improvement project and prevention of post-operative infection, including surgical site infection. *Surgical Infections*, *12*(3), 163–168. http://doi.org/10.1089/sur.2010.083

Rosenberg, B. L., Kellar, J. A., Labno, A., Matheson, D. H., Ringel, M., Vonachen, P., . . . Moses, H. (2016). Quantifying geographic variation in health care outcomes in the United States before and after risk-adjustment. *Plos One, 11*(12). doi:10.1371/journal.pone.0166762

Savage, M. W., Pottinger, J. M., Chiang, H., Yohnke, K. R., Bowdler, N. C., & Herwaldt, L. A. (2013). Surgical site infections and cellulitis after abdominal hysterectomy. *American Journal of Obstetrics and Gynecology, 209*(2), 108.e1-108.e10. http://doi.org/10.1016/j.ajog.2013.05.043

Schweizer ML, Cullen JJ, Perencevich EN, & Vaughan Sarrazin MS.(2014). Costs associated with surgical site infections in veterans affairs hospitals. *JAMA Surg*, 149(6):575-581. http://dx.doi.org/10.1001/jamasurg.2013.4663

Shepard, J., Ward, W., Milstone, A., Carlson, T., Frederick, J., Hadhazy, E., & Perl, T. (2013). Financial impact of surgical site infections on hospitals. *JAMA Surgery*, 148(10), 907-914. http://dx.doi.org/10.1001/jamasurg.2013.2246

Singhal, H., & Kaur, K. (2015, December 17). Wound Infection. Retrieved from http://emedicine.medscape.com/article/188988-overview

Spruce, L. (2014). Back to Basics: Preventing Surgical Site Infections. *AORN Journal*, *99*(5), 600-611. http://dx.doi.org/10.1016/j.aorn.2014.02.002

Sydnor, E. R. M., & Perl, T. M. (2011). Hospital Epidemiology and Infection Control in Acute-Care Settings. *Clinical Microbiology Reviews*, *24*(1), 141–173. http://doi.org/10.1128/CMR.00027-10

Tevis, S. E., Kohlnhofer, B. M., Weber, S. M., & Kennedy, G. D. (2014). Post-discharge complications are an important predictor of post-operative readmissions. *American Journal of Surgery*, *208*(4), 505–510. http://doi.org/10.1016/j.amjsurg.2014.05.013

Tjeertes, E. E., Hoeks, S. S., Beks, S. S., Valentijn, T. T., Hoofwijk, A. A., & Stolker, R. J. (2015). Obesity – a risk factor for postoperative complications in general surgery? *BMC Anesthesiology*, *15*(1). doi:10.1186/s12871-015-0096-7

Tsai, D. M., & Caterson, E. J. (2014). Current preventive measures for health-care associated surgical site infections: a review. *Patient Safety in Surgery, 8,* 42. http://doi.org/10.1186/s13037-014-0042-5

Van Walraven, C., & Musselman, R. (2013). The Surgical Site Infection Risk Score (SSIRS): A Model to Predict the Risk of Surgical Site Infections. *PLoS ONE*, *8*(6), e67167. http://doi.org/10.1371/journal.pone.0067167

Wiser, A., Holcroft, C. A., Tulandi, T., & Abenhaim, H. A. (2014). Erratum to: Abdominal versus laparoscopic hysterectomies for benign diseases: Evaluation of morbidity and mortality among 465,798 cases. *Gynecological Surgery*, *11*(4), 287-289. http://doi.org/10.1007/s10397-014-0859

Xing, D., Ma, J.-X., Ma, X.-L., Song, D.-H., Wang, J., Chen, Y., . . . Feng, R. (2013). A methodological, systematic review of evidence-based independent risk factors for surgical site infections after spinal surgery. *European Spine Journal*, *22*(3), 605–615. http://doi.org/10.1007/s00586-012-2514-6

Yokoe, D. S., Khan, Y., Olsen, M. A., Hooper, D. C., Greenbaum, M., Vostok, J., . . . Stevenson, K. B. (2012). Enhanced surgical site infection surveillance following hysterectomy, vascular, and colorectal surgery. *Infect Control Hosp Epidemiol Infection Control & Hospital Epidemiology*, *33*(08), 768-773. http://doi.org/10.1086/666626

Zimlichman, E., Henderson, D., Tamir, O., Franz, C., Song, P., Yamin, C. K., . . . Bates, D. W. (2013). Health care–associated infections. *JAMA Internal Medicine,* 173(22), 2039-2046. http://doi.org/10.1001/jamainternmed.2013.9763