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Association of Surgical Site Infections with Hospital Size and Urban and Rural Locations in California

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This is to certify that the doctoral study by

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Walden University
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Abstract

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by

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MBA/MHA, University of Phoenix, 2009

BS, University of Benin, 2003

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Healthcare Administration

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Abstract

Approximately 20% of health care-associated infections (HAIs) result from surgical site infections (SSIs), increasing health costs, morbidity, and mortality. The mandates of public reporting of HAIs through the Centers of Medicare and Medicaid Services can have consequential effects on hospitals' reimbursement, a significant concern to health care administrators. The primary purpose of this quantitative study was to determine if urban and rural locations and the size of hospitals affect the rate of SSIs in California. The two research questions addressed whether there is an association between the rate of SSIs in urban and rural locations and the size of hospitals in California. The Donabedian model was used as the conceptual framework to examine quality of care by focusing on implementation, physical facility, and processes. Data from the California Department of Public Health was analyzed using Mann-Whitney U and Kruskal-Wallis tests to determine the association between the rate of SSIs in rural and urban locations and the size of hospitals. The 2019 data set contained 28 types of surgical procedures from 336 rural and urban hospitals in 52 California counties. A higher rate of SSIs was evident in urban than rural hospitals. The rate of SSIs was also higher in large-sized hospitals than in medium and small hospitals. Research recommendations include exploring the rate of SSIs in different regions using data obtained from hospitals. This study may serve as a guide for health care administrators to understand the interplay of the size and location of hospitals and prevalence of SSIs. This understanding may also highlight community disparities leading to positive social change through the development of programs to improve quality care, reduce financial burden, and attain patient satisfaction.

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Dedication

This study is dedicated to the memories of my parents, Chief Oshevire Victor Omaraye and Mrs. Emuakpoyere Victoria Omaraye, whom implicit love and discipline have sustained me in my academic pursuit. Although both have gone to join the Lord, their principles and trust in my ability to do what is right have charted the course of my life. I want to thank my lovely and understanding wife, Mrs. Izobea Omaraye. Without her support, this program would not have been possible. My utmost gratitude goes to my son, Oghenetega Jesse Omaraye, my three daughters, Oserukeme Serena Omaraye, Okeroghene Sabina Omaraye, and Ogheneruno Salome Omaraye, for their love, support, and encouragement.

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Section 1: Foundation of the Study and Literature Review

The risk associated with surgical site infections (SSIs) is significant, occurring in different surgical procedures and accounting for a high percentage of nosocomial conditions. SSIs make up about 20% of nosocomial infections occurring in hospitals and contribute to increased health costs, morbidity, and mortality arising in various procedures and specialties (Cheng et al., 2017). The problems associated with SSIs in hospitals are severely affecting many patients in the United States each year. The prevalence of SSIs is a common occurrence in hospitalization, arising in 2% to 5% of surgical patients and equaling about 160,000 to 300,000 SSIs in the United States every year (Garner & Anderson, 2016). Health care administrators' implementation of appropriate mitigation measures could minimize the rate of SSIs in health care organizations to improve patient satisfaction, reduce costs associated with treatment, and deliver quality care.

The effects of SSIs pose a severe challenge in the health care industry, and the need for policymakers to explore associated factors, such as locations and sizes of hospitals, is critical. Evaluation of the influence of urban and rural areas on the rate of SSIs using high-high and low-low clusters can provide policymakers with the knowledge necessary to address the problems of disparities by targeting the right places and people, leading to positive social change (Bagheri et al., 2017). Examining the association between the size and location of the hospitals with SSIs could provide researchers with the necessary information to identify any gaps in infection control practices among different hospitals.

Problem Statement

Health care-associated infections (HAIs) acquired during treatment are a significant concern for health care administrators and clinical staff. SSI, a segment of HAIs, affects many patients, significantly impacting costs to health organizations, patients, and government-funded programs. HAIs that occur 48 hours after hospital admission or within 30 days of receiving treatment in a health care facility account for nearly 1.7 million hospitalized patients, with more than 98,000 deaths annually (Haque et al., 2018). For example, the rate of SSIs in colorectal surgery accounts for 30% of SSIs and costing between $3.5 and $10 billion in the United States annually (Losh et al., 2017). Leaders of health services organizations should create initiatives to reduce the incidence of SSIs. Over 20% of all HAIs are attributed to SSI, affecting 4% of hospitalizations annually (Oriel et al., 2017).

The consequences of SSIs include an extended length of hospital stay for affected patients, increased costs associated with treatment, and the possibility of death for about 1.9% of patients out of a total of 850,000 surgeries performed in the United States (Haque et al., 2018; Rodrigues de Carvalho, 2017). The associated costs for SSIs amount to more than $1 billion a year (Russell et al., 2018; Sodhi et al., 2019). The focus of this study was to determine the association between the size of hospitals and hospitals in rural and urban locations in California with the rate of SSIs.

Purpose of the Study

The primary purpose of this quantitative study was to determine if urban and rural locations and the size of hospitals affect the rate of SSIs in California. In this study, I used secondary data to examine the differences in the rate of SSIs occurring in urban and rural locations. I conducted the current study because while some studies have examined the rate of SSIs in health care facilities, little evidence is available to compare the prevalence of SSIs between hospitals in rural and urban locations in California. The examination of the rate of SSIs in different areas can provide an insight into whether there are differences in the occurrence of SSIs in rural and urban locations that may help in evidence-based interventions within the health care community (Bagheri et al., 2017). The risks associated with SSIs require a systematic approach by health care administrators, government agencies, and policymakers. The dependent variable for this study was the rate of SSIs, while the independent variables were hospitals in rural and urban locations in California and the size of the hospitals categorized into small, medium, and large.

Research Questions and Hypotheses

Research Question 1: Is there an association between hospital location (i.e., urban or rural) and the rate of SSIs in California?

$H_1$1: There is no association between hospital location (i.e., urban or rural) and the rate of SSIs in California.

$H_0$1: There is an association between hospital location (i.e., urban or rural) and the rate of SSIs in California.

Research Question 2: Is there an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California?

$H_1$2: There is no association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California.

$H_0$2: There is an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California.

Theoretical Foundation for the Study

I selected the Donabedian model as the theoretical framework for this study to highlight the association between the location of hospitals in urban and rural areas and the size of the hospitals with the rate of SSIs. The ability of health care administrators to implement policies that would ensure clinical adherence to best practices is critical to the delivery of quality health care. The Donabedian model provides the foundation for quality, implementation, and evaluation of processes through assessment of structural framework of clinical leadership, including physical facility, equipment, and human resources, leading to positive health outcomes (Talsma et al., 2014). The Donabedian model has been previously used to examine the relationship between hospital-level structure and quality arising from the processes of care in emergent general surgery, which confirmed a correlation between length of stay in the hospitals and the number of quality improvement practices (Heena et al., 2020).

The Donabedian model is the most commonly used conceptual framework to assess the quality of care measured by structure, process, and outcome, resulting in significant differences in emergency and elective surgery (Russell & Chen, 2020). As the United States moves toward reimbursement based on the outcome of care, health care administrators making efforts to reduce the rate of SSIs through the implementation of adequate policies could help improve the quality of care delivered to patients and reduce the cost associated with treatment. Providing surgeons and other health care personnel with a stratification of the rate of SSIs dependent on the risk factors and timely feedback comprising accurate data can reduce the risks associated with SSIs (Ling et al., 2019).

Nature of the Study

In this study, I used the quantitative approach with a descriptive design to evaluate the association between hospitals located in urban and rural regions and the size of the hospitals with the rate of SSIs. Secondary data were used to determine the differences in the rate of SSIs between hospitals in urban and rural locations and the size of the hospitals. This quantitative analysis may help determine the effect that the size and location of hospitals have on the prevalence of SSIs. The findings of this study may also enable health care administrators to allocate resources appropriately and implement relevant clinical practices to reduce the rate of SSIs, leading to improved delivery of quality care, cost savings, and patient satisfaction.

Introduction – Literature Review

The annual costs associated with SSIs in the health care industry are approximately $3.5 billion to $10 billion, attributed to readmissions, increased length of hospital stays, and visits to the emergency department (Ban et al., 2017). In this study, I examined the impact of SSIs in various hospitals in California. To ascertain the association of SSIs and hospitals in different geographical locations, highlighting some of the factors attributed to the prevalence of SSIs is essential. The mandates for the public reporting of HAIs required by hospitals in the United States were used to highlight the disparities in the rate of SSIs between rural and urban hospitals, showing the impact of effective infection control practices in the reduction of SSIs in various hospitals.

Search Strategy

This literature review contains several studies that examined the correlation between multiple factors and SSIs. The keyword search terms used to locate literature for this review were *hospital policies related to SSIs, surgical site infections, SSI, hospital-acquired infections, surgical site infections in California, surgical site infection prevention, surgical wound infection, hospital-acquired prevention,* and *hospital-acquired conditions*. I conducted the searches for literature in the following databases accessible through the Walden University Library: PubMed, BMC Public Health, National Center for Biotechnology Information, and Science Direct. The literature review is focused on the variables of SSIs obtained from various surgical procedures; SSIs in rural and urban hospitals; and the rate of SSIs in small, medium, and large hospitals. These variables were chosen to determine the consequential effects of a high rate of SSIs on hospitals. Hospitals could be penalized by government agencies for a high rate of SSIs; therefore, the need for health care administrators to implement quality control programs that would minimize the rate of SSIs is imperative. The Centers for Medicaid and Medicare Services (CMS), as mandated by the Affordable Care Act, stipulates that, hospitals could lose 1% of reimbursement if their Hospital-Acquired Condition score is in the top quartile (Çelik et al., 2017).

Literature Review of Key Variables

Rate of SSIs

The rate of SSIs varies depending on the type of surgery; therefore, health care administrators need to examine appropriate data to identify surgical specialties with the highest rate. Exploring the risk factors through various surgical procedures can reduce the rate of SSIs (Hamza et al., 2018). SSIs could migrate from one site to another, posing multiple challenges for the surgical team and patients. SSIs can extend from the skin and superficial subcutaneous tissues of incision sites of the patients to deep subcutaneous tissues and organ spaces with an attendant clinical and financial burden on patients (Fisha et al., 2019). The process of identification could enable policymakers to allocate adequate resources and implement programs to decrease SSIs. The rate of SSIs is more prevalent in abdominal surgery, with an incidence of between 15% and 25% in the overall SSIs, causing a significant increase in postoperative stay and higher cost of treatment (Alkaaki et al., 2019).

The need to identify the bacteria that is more prevalent in SSIs is also critical due to various types of infections that occur in surgeries. According to Mohamed and Haja (2018), the most frequent bacteria identified in SSIs is *Staphylococcus aureus*, accounting for about 27% more prevalent in diabetic patients in emergency operations.

Government Mandate on Hospitals

The efforts of the government requiring hospitals to publish the report of infection rate accessible to the public could be used to help improve the performances of hospitals leading to a reduction in SSIs. The National Healthcare Safety Network (NHSN), a database and HAI tracking platform developed by The Centers for Disease Control and Prevention (CDC), has records of SSIs for 39 various surgical procedures divided by patient, hospital risk factors, and procedures (Reese et al., 2017). The NHSN could provide the hospitals with the prospect of comparing their performance with that of other health care facilities and implementing quality measures to reduce SSIs. Several government agencies and consumer organizations, such as The Joint Commission, CMS, and the Leapfrog Group, are championing the efforts to reduce the rate of SSIs (Qi et al., 2019). Making the public reporting of SSIs by hospitals accessible to consumers is essential to minimize the rate of SSIs as hospitals develop programs to mitigate against SSIs.

Another measure to reduce the rate of SSIs in hospitals is the pay-for-performance program on infections, penalizing 1% of hospitals with the worst performances on their total Medicare payments, which amounted to about $1 billion in the first year (Qi et al., 2019). Reese et al. (2017) explored the risk adjustment model of NHSN for SSI after surgical procedures of open reduction and internal fixation. Reese et al. relied on risk factors, such as wound classification, body mass index (BMI), duration of surgery, open fracture, diabetes, fracture location, and correct perioperative antibiotic, and used highly validated data lacking in the NHSN model data to reveal that identifying the risks inherent in infection after open reduction and internal fixation can enable infection prevention personnel to examine valuable data with the surgeons. Early identification of risk factors in patients seeking surgical intervention can help decide if the patient is at risk of complications, whether the surgery is necessary, and the need for patient medical optimization and planning for perioperative care (Florschutz et al., 2015). However, Reese et al. failed to examine all the NHSN risk factors and could not ascertain the association between hospital bed size and the rate of SSIs. They were unable to establish the correlation between the duration of surgery and surgical volume and the rate of SSIs.

Risk Factors

The need to understand the factors that contribute to the rate of SSIs is critical to enable heath care administrators to explore programs that could minimize the rate of SSIs. The risk factors for SSIs spread across all surgical specialties, including labor and delivery, where SSIs can result from infections in the pelvic organs occurring when normal flora of the female genital or gastrointestinal tract contaminate the uterus (Mamo et al., 2017).

Alfonso-Sanchez et al. (2017) examined the association of age, sex, nutrition, interventional measures, and length of hospital stay after surgery as factors for deep organ/space SSIs. Their study relied on a longitudinal perspective to examine the prevalence of SSI in patients with various surgeries in 2014, such as general, neurology, orthopedic, cardiac, trauma, and vascular surgery. They used eight hospitals on the Mediterranean coast with similar sizes of between 350 and 600 beds. They found that several environmental control measures are critical to minimizing the rate of SSIs. Interventional measures can promote compliance with guidelines, such as the World Health Organization’s (WHO) initiative, the Core Components of Infection Prevention and Control Programs, to reduce infections (Tomsic et al., 2020). Alfonso-Sanchez et al. also highlighted the need to examine and monitor the temperature and humidity of the operating room. Although they extensively highlighted several risk factors, the authors failed to explore the variances in different hospitals regarding bed size or environmental settings.

Najjar et al. (2018) studied the risk factors for orthopedic SSIs to determine the correlation between length of hospital stay and the rate of SSIs. They gathered data about patients that had orthopedic surgery between May 11, 2016, and August 15, 2016, in government, private, and university teaching hospitals, using a cluster, multistage sampling method comprising of different regions in Jordan. Najjar et al. highlighted factors such as obesity and diabetes, sex, operation room traffic, the use of prophylactic antibiotics, and more extended hospitalization as significant contributors to the high rate of SSIs due to patients' vulnerability affected by exposure to microorganisms. Length of postoperative stay and longer surgeries contribute to an increase in the rate of orthopedic SSIs, as evident in total knee arthroplasty surgeries that are longer than 100 minutes (Najjar et al., 2018: Ravi et al., 2019). The national records comprising of six registries monitored in 6 years revealed an increase in the burden of SSI arising from total knee arthroplasty with a follow-up decline due to a rise in antibiotic prophylaxis adequacy, electric hair removal instead of shaving, preoperative skin preparation, and different infection control practices among other measures (Hijas-Gómez et al., 2018). Najjar et al. further posited that the presence of microorganisms on a patient's skin before disinfection and the duration of surgery could increase the risks of wound contamination leading to infections.

SSIs are significant threats to patients and are associated with a prolonged hospital stay, leading to increased health care costs (Mujagic et al., 2018). Although Najjar et al. (2018) established the correlation between LOS, wound contamination, and SSIs in orthopedic surgery, the authors failed to highlight the impact of bed size of hospitals or the locations of the hospitals. The sample of 286 used in the study is relatively small, which may have affected the overall results.

Control Measures

The health care industry could prevent SSIs through the implementation of various control measures. Allegranzi et al. (2016) posited that the complexity of SSI, which results in a significant financial burden on the health care system and patient morbidity and mortality, is preventable through interventional measures utilized before, during, and after surgery. Implementation of standardized measures during presurgery, intraoperative, and postoperative can minimize the rate of SSIs (Deng et al., 2019). Allegranzi et al. emphasized that due to the epidemiological importance of SSIs, the WHO developed evidence-based recommendations to prevent their occurrence. According to Allegranzi et al., the WHO reported in 2010 that SSIs were 20 times higher in low- and medium-income countries than in higher income countries, with SSI being the second most common cause of health care infections in the United States and Europe.

According to Allegranzi et al. (2016), the WHO's recommendations to reduce the rate of SSIs focused on nurses, anesthetists, surgeons, technical support staff, infection prevention personnel, hospital administrators, and other medical personnel involved in direct surgical care. Collaboration, teamwork, and effective communication in the operating room can improve patient safety and attain positive outcomes with an attendant reduction in SSIs (Dellinger, 2016). Allegranzi et al. also listed the following recommendations: appropriate surgical site skin preparation techniques, perioperative discontinuation of immunosuppressive agents, engaging in whole body preoperative bathing, enhanced nutritional support, suitable hair removal techniques, and optimal timing for administration of surgical antibiotic prophylaxis. The differences in international and national guidelines and standards in preventing SSI programs are due to lack of adequate data, independent interpretation of existing data, and varieties of target audiences (Ban et al., 2017). Although Allegranzi et al. critically examined the recommendations of the WHO to prevent SSIs, they made no effort to highlight the influence of the volume of surgical cases and the physical location of hospitals on the prevalence of SSIs.

Çelik et al. (2017) examined various categories of SSIs, emphasizing the need for hospitals to implement programs to minimize the rate of SSIs due to the penalty imposed by government agencies. The bundled care in preoperative decolonization procedures for *Staphylococcus aureus* in colorectal surgery has successfully reduced the rate of SSIs (Ban et al., 2017). The financial penalties imposed by CMS on health care organizations for poor delivery of care have yet to achieve their desired goals due to a lack of accountability and compliance among health care facilities (Iskandar et al., 2019). The current reimbursement system based on performance, including financial penalties, carries some setbacks arising from the unwillingness of some hospitals to share publicly or their underreporting of incidences of SSIs (Iskandar et al., 2019). A more robust system of rewarding quality care, innovation, and transparency are needed to improve quality care.

According to Çelik et al. (2017), the most common surgery performed by gynecologists is the hysterectomy. Their study relied on data obtained from a tertiary referral center using 840 patients with a hysterectomy and who reported SSIs after surgeries between April 2014 and April 2015. Çelik et al. highlighted the importance of a controlled operating room environment, proper technique in hair clipping, administration of antibiotics prophylactically less than 30 minutes before the beginning of the surgical procedure, and good hand hygiene to reduce the rate of SSIs.

Çelik et al. (2017) further stated that SSIs include superficial, deep, and organ space, per CDC guidelines. Deep organ infections can lead to purulent drainage and abscess formation attributed to an epidural abscess, septic discitis, and vertebral osteomyelitis (Li et al., 2019). According to Li et al. (2019), effective management of risk factors can help reduce mortality and morbidity, length of hospital stays, and cost saving associated with care. Çelik et al. also highlighted the importance of hospitals implementing programs to reduce SSIs in deep/organ space to avoid penalties. However, Çelik et al. noted that a single interventional approach is not adequate to decrease the rate of SSIs. Although Çelik et al. attempted to establish a correlation between SSI and several factors mentioned previously, including the surgeons’ competency, an attempt to examine the correlation between the geographical locations of the hospitals and SSIs or the size of the hospitals was missing.

Rural and Urban Hospitals

Seasonality

Anthony et al. (2018) conducted a mixed-methods study to determine the seasonality of SSIs in hospitals in different regions. The infection prevention programs in hospitals located in urban and rural locations vary because small hospitals face challenges due to multiple job responsibilities of infection prevention personnel and a lack of expertise in the field (Reese et al., 2014). Anthony et al. utilized SSI data categorized into type of health care institutions, sex, locations of hospitals (i.e., urban or rural), and age. They found that seasonal changes affect the rate of SSIs occurring in all age groups, women, men, and all geographical regions, with higher temperatures being associated with a higher rate of SSIs (Anthony et al., 2018). Using a multivariate model to analyze patient demographics, the location of hospitals, and severity of patient conditions, Anthony et al. (2018) discovered that the odds of an SSI admission increased more during the warm weather of August than the cold season in January by a rate of 55.6%. The rate of SSIs is higher during the summer months than in winter, and the variability can provide clinicians with the understanding to implement strategies to modify the risk factors (Roof et al., 2020). Anthony et al. examining SSI data of multiple surgical specialties, highlighted a significant difference in the rate of SSIs in teaching and nonteaching hospitals due to seasonality.

The results indicated that the incidence of SSIs differs in teaching hospitals and other hospitals at different times of the year. The rate of SSIs is associated with seasonality, and complications of hip fracture surgeries occur more in spring and summer than in winter (Ogawa et al., 2020). Anthony et al. (2018) concluded that SSI risk is associated with warmer weather depending on the season. The need to schedule elective surgical procedures in other months besides summer is critical to reducing infections and healthcare costs. Despite the efforts of the authors to establish the correlation between seasonal changes and the rate of SSIs, the attempt to determine the influence of seasonal differences in various locations was lacking.

Disparities in Geographical Locations

The geographical locations and the size of hospitals could have an impact on the rate of SSIs. Bagheri et al. (2019) conducted a study to determine the disparities of SSIs in various geographical locations. The research adopted a mixed-method to identify the hotspots of SSIs in colorectal surgical procedures across different communities. The study examined homogeneity in the pattern of SSIs in urban and rural settings showing disparities between communities. The low-income communities have a higher rate of SSIs in colectomy, and the need for policymakers to implement programs that target low-income groups can help reduce disparities (Qi et al., 2019). Bagheri et al. used data of admitted patients aged 18 years and above engaged in 58,096 colorectal surgeries spanning between 2002 and 2013 in public and private hospitals. The study results revealed that the highest number of patients with SSIs were from medium or high-volume hospitals compared to few infections in low-volume hospitals.

The study confirmed the homogeneity between communities in urban locations compared to the communities in rural settings. According to Qi et al. (2019), living in low-income zip codes is associated with a higher rate of SSIs as surgical bundles, optimization of diabetes management, and effective postoperative surveillance can help reduce SSIs. The study, however, failed to establish a delineation between urban and rural settings. The primary focus of the study was on colorectal surgical procedures, which may not have reflected the overall rate of SSIs in various communities. Bagheri et al. (2019) highlighted the need for healthcare administrators, policymakers, and clinicians to identify the rate of SSIs in different communities to address the problems associated with disparities and geographical variations of SSIs.

Mekhla and Firoz (2019) conducted a study to determine an association between the rate of SSIs in public and private hospitals located in rural areas. The study examined 100 patients in an Indian rural teaching hospital with 700 beds with abdominal surgeries between April 2016 and May 2017, focusing on superficial SSIs and associated risk factors. The result of the study showed a higher rate of SSIs in rural hospitals. The rate of SSIs in public hospitals was higher than in private hospitals, attributed to the engagement of senior surgeons in private hospitals operating under a cleaner environment, in contrast to the surgeons operating in public hospitals (Fisha et al., 2019). Mekhla and Firoz recommended that a larger data source that included additional rural and urban hospitals may have been more reliable.

According to Tariq et al. (2018), the occurrence of SSIs varies due to several factors such as geographical locations, the health status of the patients, surgeons, types of procedures, and hospitals. Tariq et al. emphasized that SSIs are the third most reported nosocomial infections that result in more extended hospitalization and higher cost in patients and the economic and social impact on the patients and family members. SSIs in spinal fusion surgery vary depending on the instrumentations used, patient demography, and type of surgery performed, with the infections ranging between 1% and 20%, accounting for approximately 20% of all hospital admission in 30 days after surgery (Li et al., 2019). This cross-sectional study occurred between May 2016 and April 2017 with 554 patients that had various general surgeries in tertiary care settings of Karachi, Pakistan.

Tariq et al. (2018) attributed the prevalence of SSIs to the quality of care in the facility, duration of operation, intraoperative blood transfusion, emergency procedure, type of anesthesia, age, gender, and BMI, among other factors. According to Tariq et al., the highest rate of SSI occurred in wound debridement, incision, cholecystectomy, appendectomy, laparotomy, abdominal hysterectomy, hernia repair, and cesarean section. The critical part of the article is the assertion by Tariq et al. that insufficiency of data coupled with limited resources can significantly affect the burden of SSIs. The two primary ingredients of the research, the geographical locations and the conditions of the hospitals, lacked a detailed analysis.

Small, Medium, and Large Hospitals

Surgical Volume in Hospitals

The ability to establish a relationship between the rate of SSIs and surgical volume in hospitals could assist policymakers in adopting the necessary strategies focused on allocating adequate resources for surgical procedures. Several factors such as volume of surgeries performed in the hospital, the working environment in the operating room, and seasons are attributed to the prevalence of SSIs, having WHO and other studies recommending consistent surveillance and feedback as crucial to the reduction of SSIs in hospitals (Fisha et al., 2019).

Calderwood et al. (2017) conducted a study to examine the relationship between surgical volume and the rate of SSIs. The research used a quantitative method to evaluate the correlation between the prevalence of SSIs and the volume of surgical procedures in hospitals. The study utilized data from patients that underwent Coronary Artery Bypass Graft (CABG) or hip arthroplasty from 2005 to 2011 in the United States. The study employed logistic regression to evaluate the fluctuations in hospitals' performances regarding financial penalties due to the rate of SSIs. The result of the study revealed that the rate of SSIs is highest among hospitals with a low annual volume of procedures. Hip arthroplasties performed at low-volume healthcare facilities attracted significantly higher SSIs, complications, and mortality rates than hospitals with high-volume surgical procedures (Mufarrih et al., 2019). According to Calderwood et al., the research revealed an aggregate SSI risk annually in hospitals with low surgical volumes, although the hospitals were excluded from quality reporting. According to Calderwood et al., quality measurements are used by CMS through value-based service to determine reimbursement in hospitals, a strategy that assists consumers to make choices.

According to Calderwood et al. (2017), hospitals could lose over $1.9 billion annually in payments through sanctions in reimbursement for failure to meet the delivery of quality care to patients. The study revealed that surgical volume in hospitals is a strong predictor of outcome after undergoing CABG and hip arthroplasty with a higher rate of SSIs in hospitals with lower surgical volumes due to longer operative time. According to

Cheng et al. (2017), prolonged operating time in all surgical procedures can lead to SSIs. Patients with surgical procedures of 30 minutes longer develop SSIs more than patients who have fewer surgical procedures time. Although the study results could help determine the relationship between surgical volume and the rate of SSIs in CABG and hip arthroplasty, the effect of surgical volume on the overall rate of SSIs in hospitals is lacking in the research.

Hospital Bed Size

Hospital bed capacity is one of the essential parts of management planning in meeting patient care needs depending on staffing and overall cost factors. The planning of hospital capacity regarding beds, according to Ravaghi et al. (2020), is critical due to the rising cost of inpatient care, growing demand for hospital care, and limited resources, as the number of beds relies on the impact of hospital needs, policies, staffing design, and existing services.

Buchanan et al. (2018) examined the factors that can predict SSIs after craniotomy. The study examined the Nationwide Readmissions Database (NRD) of patients 18 and older that underwent nonemergent craniotomy between 2010 and 2014. The study also relied on all hospital discharges that attained the quality assurance standards in 20–27 member states, including an estimated 50% of discharges in the United States. Buchanan et al. posited that although SSIs are relatively rare in cranial neurosurgery, the risk inherent in the incidence of SSIs in neurosurgery can be severe due to the proximity of the wound to the central nervous system.

Buchanan et al. (2018) further highlighted that when SSIs occur in neurosurgery, the consequential effect in morbidity and mortality is high, resulting in LOS and hospital costs estimated at $3 billion yearly with no standardized remedial cause the administration of antibiotic prophylaxis. Factors such as larger hospital bed size, type of insurance, diabetes, age, and length of hospitalization, among other factors, can predict the rate of SSIs (Buchanan et al., 2018). Other factors enumerated by Buchanan et al. are teaching status and the annual procedural volume of the hospitals. Apart from the hospital bed size and surgical volume, the authors did not discuss the effect of the locations of the hospitals regarding the incidence of SSIs. According to Ravaghi et al. (2020), no identified model is suitable to ascertain an optimal number of hospital beds, and the decision lies on health care leaders and policymakers depending on the goals to align with demographic and epidemiological changes, political and socio-economic factors, available data, and geographical characteristics.

Gaps in the Literature

The literature review was based on the rate of SSIs, urban and rural hospitals, and the size of the hospitals identified as small, medium, and large as significant variables. The variations in the rate of SSIs among surgical specialties could pose some challenges for health care administrators to have a standardized method of addressing the problems associated with the prevalence of infections in surgeries. The rate of SSIs in spinal surgeries could differ from those in general surgeries, with the differences extending among hospitals engaging in the same types of surgeries. Associated risks of SSIs vary depending on the type of procedure, with a higher rate of SSIs in spinal surgery than orthopedic procedures due to the complexity in spinal surgical cases (Peng et al., 2019). Nearly all the literature used in this study recognized the financial burden and other effects on hospitals, patients, and family members.

The lack of uniformity among the rate of SSIs in various surgical procedures could lead to misinterpretation of overall results. The rate of SSIs could be skewed among hospitals due to a lack of a standardized method of monitoring infections. Some small healthcare facilities do not report the occurrences of SSIs. According to Calderwood et al. (2017), the data of SSIs in low volume hospitals are neglected, raising concerns of instability as the rate of SSIs in health care facilities with low surgical volumes are excluded from the public assessment.

Some of the articles emphasized the dichotomy between the sites affected by SSIs, which are deep organ space and superficial subcutaneous, posing a challenge to health care professionals to identify the best strategies to reduce SSIs in hospitals. SSIs are categorized into two groups by CDC-NHSN, the superficial incisional and the deep incisional, otherwise known as organ/space infection, with the formal affecting the skin or subcutaneous tissue as the organ/space affects fascia and muscle layer (Çelik et al., 2017). Despite the emphasis on the knowledge to differentiate between deep organ space and skin infection, none of the articles highlighted the requirement for some hospitals to report only SSIs affecting the deep organ space. In contrast, other hospitals are required to report the incidences of SSIs in both deep organ space and superficial.

Some of the articles examined the government mandate to sanction any hospitals with penalties in Medicare reimbursement due to high rate of SSIs. Other articles, however, argued that the requirement by the government for hospitals to publish the rate of SSIs for consumers assessment has led to an improvement in the quality of patient care. While some authors examined certain measures recommended by government agencies and organizations such as proper hair shaving techniques and environmental control in the operating room, other authors examined the risk factors such as age, sex, obesity and diabetes, length of hospital stay, BMI, lower hematocrit, and interventional control, among others. According to Çelik et al. (2017), BMI, lower hematocrit, lower hemoglobin levels in patients, and more prolonged operation are associated with risk factors of SSIs. Despite the several recommendations as witnessed in the articles, no standardized approach to reducing SSIs in hospitals was identified in all the articles reviewed. No ideal method of surveillance and generalizability is known to minimize the rate of SSIs globally, and the incidences of antimicrobial-resistant pathogens will continue to threaten any achievement if no alliance research collaboration is established (Iskandar et al., 2019). Although some articles highlighted the association between SSIs and hospitals in rural and urban areas and the sizes, an in-depth review to support the correlation between the variables is conspicuously missing.

Definitions

Deep/organ space SSIs: Infections that affect the deep soft tissues such as muscle layers and fascial around the surgery area opened or worked on during a surgical procedure (Fadayomi et al., 2018).

HAIs: Infections acquired during treatment, such as surgical procedures and the use of catheters or ventilators in the health care facility, can lead to morbidity and mortality with an attendant burden of increased costs of care (Heathypeople.gov, 2020). HAI, also known as nosocomial, is an infection that occurs during a patient's stay in a hospital or other health care facility while receiving treatment, which may arise after the patient's discharge or manifest 48 hours after admission to the hospital (Monegro et al., 2020).

Hospital Bed Size: Hospital bed capacity can be used to determine the availability of inpatient care by assessing the ratio of beds to population, which is critically arising from the increasing cost of health care and limited resources (Ravaghi et al., 2020).

The Leapfrog Group: A nonprofit organization that acts as a watchdog by collecting, analyzing, and publishing hospital data showing value-based purchasing to consumers (Cornett, 2017).

LOS: LOS is an essential guide used to appraise the performances, efficiency, and patient quality of care in hospitals regarding the length of hospitalization (Baek et al., 2018).

NHSN: A surveillance that assists public health professionals and the health care sector to identify the occurrence of HAIs in health care facilities utilizing data obtained to implement strategies to prevent infections (Dick et al., 2019).

The Nationwide Readmissions Database: The NRD was developed by the Healthcare Cost and Utilization Project to address a gap in health care and assist in appraising the national readmission rate for all patients irrespective of payer for a hospital stay or ages of the patients (Agency for Healthcare Research and Quality, 2019).

Pay-for-Performance: A form of payment that payers commercially or publicly use to improve the quality of care delivered by physicians to patients common in the United States and other countries worldwide (Bond et al., 2019).

Rural: The rural areas are known for the high prevalence of agricultural economic activities, behavior, and system of values different from that of urban, as well as a resident in dispersed space (Popescu et al., 2018).

Size of Hospital: The size of a hospital is determined by the number of beds, teaching status, and the workforce (Statista (n.d).

Superficial Fungal Infections: Infections that affect the epidermis, mucosa, and human hair, which, although may not be life-threatening but can potentially spread from person to person that may result in morbidity (Kelly, 2012; Shena et al., 2020).

SSI: is an infection that occurs within 30 days after a surgical procedure within the periphery of the surgical incision or 90 days from implants in prosthetics as defined by CDC (Agency for Healthcare Research and Quality, 2019).

Types of Surgery: Types of surgical specialties are identified as general surgery, gynecology, orthopedic surgery, neurological surgery, and cardiothoracic surgery, among others (American College of Surgeons, n.d.).

Urban: No universal definition is known for urban as countries use criteria such as economic advancement, settlement size, and population density where nonagricultural economic activities are present to categorize areas as urban (Wineman et al., 2020).

Assumptions

The assumption that licensed bed size is critical to categorize hospitals as small, medium, and large is evident in this study. According to Fortaleza et al. (2017), hospitals are categorized as large, medium, and small with greater or equal to 200 beds, 50–199 beds, and less than 50 beds, respectively. The decision for bed capacity could be dependent on available resources and adequate planning. Hospitals are either for-profit or not-for-profit and owned by individuals, states, or integration, which can execute planning decisions based on the number of beds (Jones, 2020).

Another assumption in this study is the standardization of the SSIs rate of surgical specialties measured as a unit. The rate of SSIs could vary depending on the specialties, as seen in the literature review section, and treating the rate as a unit is assumed in this study. The comparisons between hospitals on performance resulting from SSIs outcomes are considered standardized with variability in surveillance methodologies of SSI rate prevalent in the self-reporting to NHSN (Pop-Vicas et al., 2021).

Limitations

The limitations of this study included the need to obtain an accurate tool to measure the size of the hospitals in the category of small, medium, and large. Another limitation is the distribution of hospitals in different geographical locations, as some hospitals are in areas identified as rural or suburban. The delineation between urban and rural areas could be challenging to ascertain sometimes due to the conflicting indices in the application of measurement if people living in the urban areas have a higher standard of living than the people in the rural locations. According to United Nations Statistics

Division (n.d.), no single definition exists to describe rural and urban that applies to all countries or regions within the same country, and the distinction between rural and urban even in developed economies is marred with uncertainties.

Another challenge is the varying degree of reporting incidences of SSIs to government agencies. Some hospitals that operate under the integrated system report SSIs for superficial and deep or organ surgeries. Other hospitals operating under different health models are only required to report SSIs arising from only deep or organ surgeries. The differences in reporting methods could affect the overall rate of SSIs in hospitals in the same province, with some missing values identified in the government data.

Scope and Delimitations

The scope of the study was limited to the examination of data to establish the association between the rate of SSIs and urban and rural hospitals, and the size of the hospitals divided into small, medium, and large as the variables. The incidence of SSIs results in an increase in clinical and financial burden due to costs associated with a prolonged hospital stay, diagnostic tests, and treatment (Badia et al., 2017). The results of this study could help to highlight the rate of SSIs as influenced by the size and locations of hospitals. Secondary data were obtained from HealthData.gov, a publicly available dataset containing SSIs for surgical procedures in hospitals within the United States. The dataset was obtained and analyzed without modification.

Generalizability

The generalizability of the study was tapered to the rate of SSIs in rural and urban hospitals and exploring the association between the prevalence of SSIs and small, medium, and large hospitals. The type of procedures and locations could have a significant effect on the rate of SSIs. Geographical regions can influence the rate of SSIs as the Sub-Saharan region between 2008 and 2013 had an SSIs rate of an average of 7.3% in contrast to the rate of SSIs in European countries that were between 1.75 to 4.78%, while a higher proportion of SSIs is reported for emergency procedures against procedures that are elective (Alfouzan et al., 2019). The need for health care administrators to understand the interplay of different surgical procedures and practical solutions to minimize the rate of SSIs is critical.

The Potential for Positive Social Change

The study results could help health care administrators understand the interplay of rural and urban settings and the effect of size on the ability of health care organizations to manage the incidence of SSIs. Despite the efforts of policymakers, government agencies, and other organizations, SSIs are still prevalent in the healthcare industry, which could be attributed to limited resources and a lack of appropriate measures to deliver quality care. The rate of SSIs in the past two decades is about 20% in the United States and 19.6% in Europe, resulting from a lack of quality care due to inadequate resources in healthcare facilities (Mengesha et al., 2020). This study may be relevant for health care leaders and policymakers to explore various strategies to lessen the financial burden of SSIs on patients and health care organizations, resulting in improved care.

Significance

Large surgical volume facilities could derive a comparative advantage over facilities with lesser volume regarding the availability of resources and infection control practices, leading to a reduction in the SSI rate in the large facilities. As a result of a high rate of SSIs in hospitals with lower surgical volume due to longer periods of surgical procedures, hospitals with higher surgical volume are more likely to have a reduced rate of SSIs, arising from the adoption of standardized infection prevention practices (Calderwood et al., 2017). Determining the correlation between the rate of SSIs for hospitals in urban and rural locations and the size of hospitals may provide policymakers the understanding to identify areas of high risk and adopt the necessary strategies to minimize the rate of SSIs. Several factors such as surgical volume in hospitals, poverty level, climate, and lifestyle could increase SSI rates. The volume of surgical procedures, size of health care facilities, seasonal changes, and environmental-level risk factors can lead to a rise in the rate of SSIs (Anthony et al., 2017). The findings of this study may help health care administrators to determine how the rate of SSIs in California and the association with the geographical locations of hospitals influence the outcomes. Creating policies that focus on patient care could promote quality improvement, drive positive financial results, and attain overall patient satisfaction.

Summary and Conclusion

As the health care industry migrates towards value-based outcomes to improve the quality of care and reduce associated costs of treatment, the need to explore different strategies to minimize the rate of SSIs in health care facilities becomes imperative. The adoption of evidence-based practices in health care facilities can help to improve the quality of care, including sustainable results (Ling et al., 2019). Understanding the role of rural and urban hospitals and the size of hospitals concerning SSIs may assist in implementing programs that are focused on reducing SSIs in health care facilities.

With the lack of unified epidemiological programs in the surveillance of SSIs and inadequate data to compare the prevalence of SSIs, understanding the burden of SSIs can encourage governments to invest in programs that would lead to quality improvement (Iskandar et al., 2019). Although other researchers have attempted to examine the relationship between the rate of SSIs and hospitals in various locations, none is identified to have explored the association between the rate of SSIs for hospitals in rural and urban areas and the association between small, medium, and large hospitals in California. Therefore, this study has addressed this research gap by providing an overview of the importance of exploring SSIs in rural and urban hospitals and determining the relevance of the size of California hospitals and the relationship with the prevalence of SSIs.

Section 2: Research Design and Data Collection

In the previous section of this study, I highlighted the literature to establish an association between the rate of SSIs in urban and rural hospital locations and the size of the hospitals (i.e., small, medium, and large). The dependent variable was the rate of SSIs, and the independent variables were urban, rural, small, medium, and large hospitals. The types of surgery chosen as the covariates for this study were factors associated with the high rate of SSIs. The number of patients seeking surgical procedures could grow by 38% in the next 8 years from the current number of 300 million surgeries yearly, and the consequential effect of mortality and morbidity arising from SSIs demands a surveillance system and accurate data to interpret the rate of SSIs (Atkinson et al., 2021). The Donabedian model is the most commonly used conceptual framework to assess the quality of care measured by structure, process, and outcome (Russell & Chen, 2020). This model provided the foundation for determining the relationship between the rate of SSIs in rural and urban locations and the size of hospitals in California in this study. The primary purpose of this quantitative study was to determine if urban and rural locations and the size of hospitals affect the rate of SSIs in California hospitals. The rate of SSIs will continue to rise due to the increase in the demand for surgeries unless an effort is made to improve the quality of care to lessen the financial burden on health care (Badia et al., 2017).

In this section, I highlight the research design, methodology, and the analysis of the data. The research results could help health care administrators understand the interplay of the size and locations of hospitals regarding the prevalence of SSIs, leading to the implementation of appropriate strategies to reduce the rate of SSIs.

Research Design and Rationale

In this quantitative study, I used an adult data set of patients that underwent surgeries in 2019 from the California Department of Public Health (CDPH) to ascertain the association between independent variables and the dependent variable. A Mann-Whitney U analysis was conducted, followed by the Kruskal-Wallis test. The rationale behind the choice of this type of analysis aligned with the assumption of a nonparametric test. The nonparametric statistical test is used by researchers instead of the parametric test when there is evidence that the assumptions of the parametric test are not met (Nordstokke & Colp, 2018). The data set obtained from CDPH was not normally distributed for the locations (i.e., urban, and rural), for hospital size (i.e., small, medium, and large), and for surgery types (i.e., general, cardiovascular, gynecology, orthopedic, and neurology). The Mann-Whitney U and Kruskal-Wallis tests used in this study provided detailed analyses to determine the association between the rate of SSIs, rural and urban locations, and the size of hospitals in California.

Methodology

Study Population

The focus of this study was on the rate of SSIs in patients that underwent different types of surgeries in California hospitals in 2019. The CDPH adult data set for 2019 used for this study is a segment of the data set published annually by California showing the rate of SSIs in various hospitals. The data set contains information on hospitals, rate of infections, locations of hospitals, and bed sizes, among other variables.

Sampling and Sampling Procedures

The CDPH data set of SSIs is a collection of infections arising from surgical procedures in various hospitals in California. The 2019 data set utilized for this study contains 28 types of surgical procedures from 336 hospitals in 52 counties of California spread across rural and urban locations. The hospitals were categorized as critical access with 205 cases and acute care hospitals with 6,000 cases. The hospitals by bed sizes were categorized as 125–250 beds (medium), hospitals with less than 125 beds (small), hospitals with 250 or higher beds (large), critical access hospitals (small), and major teaching hospitals (large).

The strategy for the sampling was important, arising from the number of surgical procedures in various hospitals within California yearly and the associated rate of SSIs occurring across all specialties. According to CDPH's (2019) SSI in Adult Patients-Data Dictionary, 3,643 infections were attributed to a total of 682,211 surgical procedures in California hospitals in 2019. The data set used for this study is publicly available with no restrictions of access.

Power Analysis

I conducted a priori power analysis using a free version (3.1.9.2) of the G*Power analysis calculator to ascertain if the number of 2019 SSIs in California hospitals in the study was adequate to establish a significant difference at a small effect size. The result of the calculation showed the sample size and predictive power. The G*Power analysis of sample size in Table 1 was 2,891, processing enough statistical power to identify small effects. The examination of the differences between the two smaller groups of small (*n* = 1547) and medium (*n* = 1344) hospitals with a total of 2,891 hospitals had 80% power to detect an effect of *d* = 0.11 with an alpha level of 0.05.

Table 1

*Mann-Whitney Test Using G*Power*

Input	Tail(s)	Two
	Effect size	0.05
	Power (1-β err prob	0.80
Output	Total sample size	2,891
	Actual Power	0.1069420

Operationalization of Variables

In this study, I investigated the rate of SSIs as the dependent variable, while the independent variables were hospitals in urban and rural locations in California and the size of hospitals categorized into small, medium, and large. The association between the covariates of types of surgeries was also explored. The rate of SSIs was measured by the number of infections arising from the total number of surgical procedures in California hospitals.

Secondary Data Analysis Methodology

I obtained the data from health care facilities from the website of the CDPH, which harbors a data set of SSIs in various hospitals every year. Secondary data sources consisting of administrative data sets procured by governments, research institutes, and other agencies can be effective and valuable in conducting research (Sun & Lipsitz, 2018). The data sets used contained all the information necessary for effective analysis in this study.

Data Analysis Plan

I conducted this research using the Statistical Package for the Social Sciences (SPSS), Version 27, to explore the 2019 CDPH SSIs data set. In the vetting process for the sample data, subheadings related to total procedures allocated to each hospital were excluded to avoid duplication. When examining the sample, I also excluded other sections, such as predicted rate of SSIs, comparison, confidence level, and facility identification numbers. The primary independent and dependent variables of this study were not adjusted. The types of surgeries that represented the covariate in the study comprised 28 identified independent variables in the data set; these were merged into the five surgical specialties of general, orthopedic, gynecology, cardiovascular, and neurology. The data were not normally distributed for the locations (i.e., urban, and rural), for hospital size (i.e., small, medium, and large), and for surgery types (i.e., general, cardiovascular, gynecology, orthopedic, and neurology). Therefore, I used the nonparametric, Mann-Whitney U and Kruskal-Wallis tests for location (i.e., urban, and rural) and size of hospitals (i.e., small, medium, and large), respectively.

Research Questions and Hypotheses

Research Question 1: Is there an association between hospital location (i.e., urban, or rural) and the rate of SSIs in California?

$H_1$1: There is no association between hospital location (i.e., urban, or rural) and the rate of SSIs in California.

$H_0 1$: There is an association between hospital location (i.e., urban, or rural) and the rate of SSIs in California.

Research Question 2: Is there an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California?

$H_1 2$: There is no association between the size of a hospital (small, medium, or large) and the rate of SSIs in California.

$H_0 2$: There is an association between the size of a hospital (small, medium, or large) and the rate of SSIs in California.

External Validity

I procured the data for this study from a secondary database of CDPH, a record of the data set published by the state of California accessible to the public. The data are primarily based on the rate of SSIs for various hospitals spanning all geographical locations within California. However, since the locations of the hospitals were grouped under counties, hospitals of some cities that were considered urban or rural could be wrongly categorized. One critical part of conducting a research design based on secondary data is the management of threats to validity, which lacks cohesive guidelines on the approach to identify the threats and mitigate and appropriately categorize the threats (Ampatzoglou et al., 2019). The rate of SSIs in some hospitals within California could also be missing from the data set.

Internal Validity

Infections arising from surgeries omitted by hospitals or misclassified could pose a validity threat to the data published by CDPH. Another threat to the validity of the data is the requirement that excludes some health facilities from reporting SSIs and the need to report only SSIs resulting from deep or organ space surgical sites. Although California law requires hospitals to report SSIs from deep and organ/space surgical sites to CDPH through the NHSN, the requirement does not include acute inpatient psychiatric facilities or facilities with distinct CMS Certification Numbers (CDPH, n.d.). The SSIs data that were available at the time of this study may, therefore, not have been a comprehensive representation of data for all cases of SSIs in California hospitals in 2019.

Ethical Procedure

The CDPH data of 2019 SSIs is a publicly available secondary data set with no specific patient information; therefore, there were no risks for nondisclosure in using the data set for this study. I did not utilize a primary data set in this study. The data set was downloaded and saved on a private computer not accessible to other users and was deleted after the study was completed. I notified and obtained approval from the Walden University Institutional Review Board to use the data set for this study.

Summary

In Section 2, I highlighted the study design and data collection methods used to examine the association between urban and rural locations and the size of the hospitals with the rate of SSIs. Analyses were also performed to establish if any of the covariates showed a statistically significant association. In Section 3, I will provide additional information about the statistical analyses and results of the study.

Section 3: Presentation of the Results and Findings

The primary purpose of this quantitative study was to determine if urban and rural locations and the size of hospitals affect the rate of SSIs in California using Donabedian's framework for structural quality measures, processes, and outcomes to achieve a quality of care. I used the CDPH 2019 SSIs data set containing information on the dependent and independent variables to analyze the association between rural and urban locations of hospitals and the sizes of the hospitals with the rate of SSIs.

The dependent variable for this study was the rate of SSIs, while the independent variables were hospitals in rural and urban locations in California and the size of the hospitals categorized into small, medium, and large. Excessive utilization of the capacity of hospitals could have a significant effect on the prevalence of SSIs. Higher bed occupancy rates and the overcrowding of hospitals can increase SSIs (Wong & Holloway, 2019). The need to understand the roles of the size of the hospitals and locations could help policymakers implement appropriate strategies to decrease the rate of SSIs in health care facilities. The following research questions and hypotheses guided this study:

Research Question 1: Is there an association between hospital location (i.e., urban, or rural) and the rate of SSIs in California?

$H_1$1: There is no association between hospital location (i.e., urban, or rural) and the rate of SSIs in California.

$H_0$1: There is an association between hospital location (i.e., urban, or rural) and the rate of SSIs in California.

Research Question 2: Is there an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California?

$H_1$2: There is no association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California.

$H_0$2: There is an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California.

Section 3 of this study contains the statistical analyses conducted on the CDPH 2019 SSI data set, namely the Mann-Whitney U and Kruskal-Wallis tests. In this section, I provide the data collection timeframe, the total number of surgical cases, anomalies observed in the data set, associated descriptive characteristics, and the populations. This section also includes a discussion of the analysis of the sample, followed by a summary of the results.

Data Collection of Secondary Data

Time Frame of Collection and Discrepancies in Secondary Data

I collected the data for this study from the CDPH website containing SSIs that occurred in 2019 within California hospitals from different geographical locations. The data included names of hospitals, counties, types of surgical procedures, rate of SSIs in each hospital, hospital types, and hospital category. No discrepancies were observed in the data except for missing values and total surgical procedures for each specialty that were excluded to avoid duplication. I also excluded other variables in the data not relevant to this study. The G*Power analysis of sample size was 2,891, processing enough statistical power to identify small effects. The examination of the differences between small (n = 1,547) and medium (n = 1,344) hospitals had 80% power to detect an effect of d = 0.11 with an alpha level of 0.05.

Descriptive Characteristics of Sample and Population

The data consisted of 6,205 surgical procedures that occurred in 336 hospitals scattered across 52 counties in California. The independent variables were the counties, which were categorized into rural and urban locations, and the hospitals, which were measured as small, medium, and large. There were 28 types of surgeries in the data set, and I narrowed them down into the five categories of general surgery, cardiovascular surgery, gynecology surgery, orthopedic surgery, and neurology surgery to determine the covariate effect. A test of normality assumption was conducted to select a suitable statistical analysis method for the data set.

Test of Normality Assumption

Table 2 shows that the p values for the Kolmogorov-Smirnov test and Shapiro-Wilk test for all the variables are less than a 0.05 level of significance (p = 0.000). This indicates that the data were not normally distributed for the locations (i.e., urban, and rural), for hospital size (i.e., small, medium, and large), and for surgery types (i.e., general, cardiovascular, gynecology, orthopedic, and neurology). Therefore, I used nonparametric, Mann-Whitney U and Kruskal-Wallis tests for location and size of hospitals, respectively. The Kruskal-Wallis test was also used to examine the differences among the five surgical specialties and the rate of SSIs. The nonparametric statistical test is used by researchers instead of the parametric test when there is evidence that the assumptions of the parametric test are not met (Nordstokke & Colp, 2018). The normality test in Table 2 is not intended to establish an overall association between the variables but to justify using a nonparametric test for this study.

Table 2

Normality Test for SSIs Between the Groups

		Kolmogorov-Smirnov			Shapiro-Wilk		
SSI	Location	Statistic	*df*	*p*	Statistic	*df*	*p*
	Rural	.412	1605	.000	.208	1605	.000
	Urban	.412	4600	.000	.198	4600	.000
SSI	Hospital size						
	Small	.449	1547	.000	.167	1547	.000
	Medium	.427	1344	.000	.150	1344	.000
	Large	.392	3314	.000	.253	3314	.000
SSI	Surgery type						
	General	.397	2892	.000	.254	2892	.000
	Cardiovascular	.428	893	.000	.164	893	.000
	Gynecology	.435	1079	.000	.138	1079	.000
	Orthopedic	.394	907	.000	.221	907	.000
	Neurology	.383	434	.000	.294	434	.000

Descriptive Statistics

In the results, 25.9% (n = 1,605) of SSIs occurred in hospitals within rural locations, while hospitals in urban locations accounted for 74.1% (n = 4,600) of SSIs. Small hospitals accounted for 24.9% (n = 1,547), while 21.7% (n = 1,344) occurred in medium-sized hospitals and 53.4% (n = 1,344) occurred in large hospitals within California. The results for the covariates of the five types of surgeries were general surgery accounting for 46.6% (n =2892), cardiovascular surgery accounting for 14.4% (n = 893), gynecology representing 17.4% (n = 1079), orthopedic accounting 14.6% (n = 907), and neurology with 7% (n = 434) of the total samples.

The CDPH data set contains the rate of SSIs reported by various hospitals within California in 2019. The results were for 28 surgical procedures, some of which had a zero rate of reported SSI infections for relevant surgical procedures. The rate of SSIs ranged from zero to 100 in all hospitals, with a total of 6,205 cases.

Study Results

This final part of Section 3 contains statistical assumptions and the results of the statistical analysis. The study findings relating to the research questions and hypotheses are elaborated on the concluding part of this section.

Statistical Assumptions

The assumption of a nonparametric test was met using Mann-Whitney U analysis to examine the association between urban and rural locations and the rate of SSIs in California hospitals. The assumption of a nonparametric test was also met using the Kruskal-Wallis test to determine the association between small-, medium-, and large-sized hospitals and the rate of SSIs in California. According to Schober and Vetter (2020), assumptions in nonparametric tests rely on the use of Mann-Whitney U analysis for comparing two groups of cases on one variable. The Kruskal-Wallis test can compare more than two groups on one variable, especially when the parametric test does not meet the assumption (Schober & Vetter, 2020). The distribution of the variables in this study was not normal regarding the population distribution; hence, I considered the nonparametric test as appropriate to determine the statistical differences.

Results of Statistical Analysis for Research Question 1

I employed a Mann-Whitney U test to examine the association between urban and rural hospital locations and the rate of SSIs in California using SPSS with a 99% confidence level. The sample size of SSIs for the rural location was 25.9%, while that of urban locations was 74.1%. As shown in Table 3, the independent variables (i.e., rural, and urban) were statistically significant with the rate of SSIs. The result, therefore, met the determination that a significant difference is evident in the association between SSIs and urban and rural counties ($p < 0.05$) and Mann-Whitney U test (*U)* = 3,461,889.000. The *p* value of .000 is less than the conventional threshold of .05; therefore, there is an association between urban and rural locations and the rate of SSIs in California hospitals.

Table 3

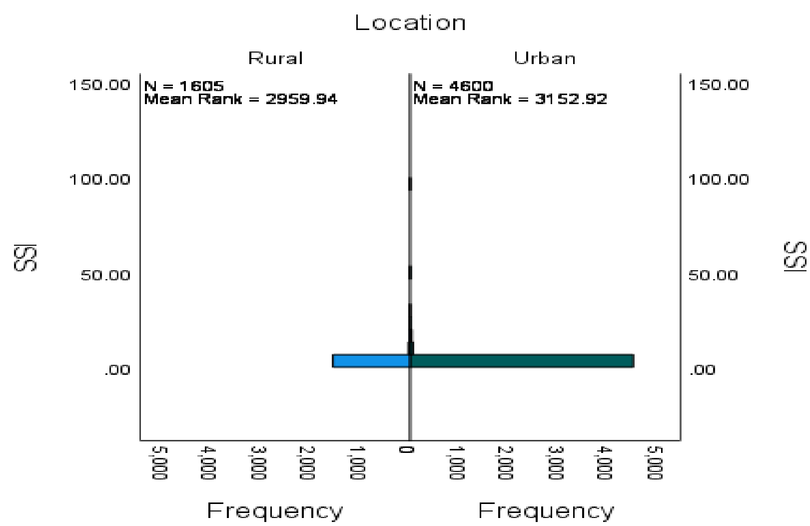
Mann U Whitney Test - SSIs and Locations (Rural and Urban)

Variable	*n*	*%*	Mean Rank	*U*	*p*
Rural	1,605	25.9	2,959.94	3,461,889	.000
Urban	4,600	74.1	3,152.92		
Total	6,205	100			

The independent sample, Mann-Whitney U test displays the sample size, the frequency of SSIs, and the mean ranks. Figure 1 shows the sample size of 1,605 for rural and a mean rank of 2,959.94, while urban had a sample size of 4,600 and a mean rank of 3,152.92. These results revealed that the rate of SSIs was greater in urban hospitals than in hospitals in rural locations.

Figure 1

Independent -Samples Mann-Whitney U Test for Location



Summary Results of Research Question 1

Research Question 1 attempted to determine if there was an association between urban and rural hospital locations and the rate of SSIs in California. The Mann-Whitney U test with a 99% confidence level showed that the independent variable of location was statistically significant in association with the rate of SSIs in California hospitals. The *p* value of .000 is statistically significant and is below the conventional threshold of .05. The results indicated a statistically significant difference between hospital location (i.e., rural, or urban) and the rate of SSIs; therefore, the alternative hypothesis was met, and the null hypothesis was rejected. From the analysis, I concluded that the rate of SSIs was higher in urban hospitals than hospitals in rural locations. This result aligns with some previous studies, such as Bagheri et al. (2019), who found disparities in the rate of SSIs are evident among different communities and geographical locations.

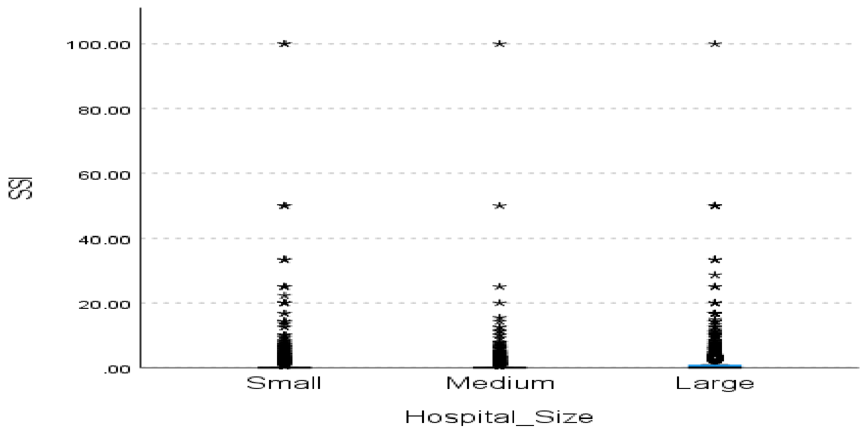
Results of Statistical Analysis for Research Question 2

I used the Kruskal Wallis test to examine if there was an association between the size of a hospital (i.e., small, medium, or large) and the rate of SSIs in California using SPSS with a 99% confidence level. The sample size of SSIs for small hospitals was 24.9%, while that of medium hospitals was 21.7%, and that of large hospitals was 53.4%. The independent variables (i.e., small, medium, and large hospitals) were statistically associated with the SSI rate. Small hospitals had a mean rank of 2,717.25 with a sample size of 1,547, medium hospitals had a mean rank of 2,901.15 with a sample size of 1,344, and large hospitals had a mean rank of 3,364.93 with a sample size of 3,314. The result, therefore, met the determination that a significant difference is evident in SSIs between small-, medium-, and large-sized hospitals (chi-square = 267.039, $p < 0.05$). The p value of .000 is less than the conventional threshold of .05; therefore, there is a significant difference between the size of hospitals and the rate of SSIs in California.

The independent samples Kruskal-Wallis test in Figure 2 show predominant SSI rate between zero and 10 in small, medium, and large-sized hospitals in California. Interestingly, a high rate of 50 and 100 also occurred in the three categories of hospitals size, as revealed in Figure 2. There was no other SSI rate recorded for small, medium, and large hospitals between 51 and 99, showing further evidence that the rate of SSIs mainly occurred in all hospitals between 0 and 10.

Figure 2

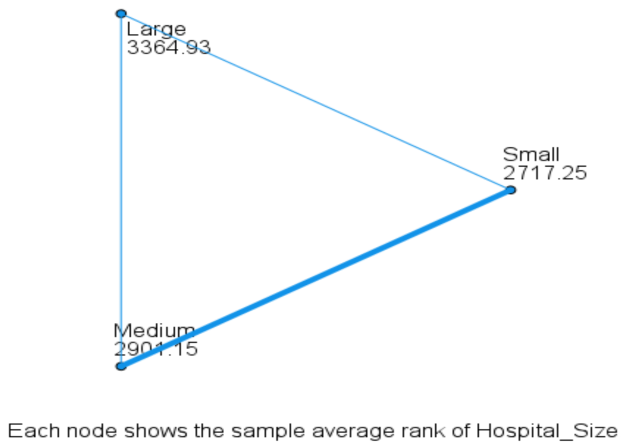
Independent - Samples Kruskal-Wallis Test for Hospital size



The results in Figure 3 showed that the rate of SSIs was higher in large hospitals (*MR* = 3,364.93) than in medium-sized hospitals (*MR* = 2,901.15) and small hospitals (*MR* = 2,717.25). The results also revealed that the rate of SSIs was lower in small hospitals than the medium and large hospitals. The difference in the Mean Rank between medium and small hospitals (183.90) was relatively lower than the difference between the Mean Rank of medium and large hospitals (463.78), as well as the Mean Rank between small and large hospitals (647.68).

Figure 3

Pairwise Comparisons of Hospital Size



In comparing the hospital sizes to determine if the rate of SSIs were different between the groups, Table 4 shows test statistics of -183.906 between small and medium hospitals with a standard error of 51.650 adjusted *p* value of .001. Pair-wise comparison between small and large hospitals had test statistics of -647.687 with a standard error of 42.651 and an adjusted *p* value of .000. In contrast, medium and large hospitals had test statistics of -463.781 with a standard error of 44.793 and an adjusted *p* value of .000. The *p* values of .000 between small and medium, between small and large, and between medium and large hospitals are less than the conventional threshold of .05. The results, therefore, indicated that there are statistically significant differences among the three groups.

Table 4

Kruskal Wallis Test - SSIs and Pairwise Comparison of Hospital Size

Sample 1-Sample 2	Test Statistics	Std. Error	*p*	Adj. *p*
Small-Medium	-183.906	51.650	.000	.001
Small - Large	-647.687	42.651	.000	.000
Medium -Large	-463.781	44.793	.000	.000

Summary Results of Research Question 2

Research Question 2 sought to ascertain if there is an association between the size of a hospital (small, medium, and large) and the rate of SSIs in California. A Kruskal-Wallis test with a 99% confidence level showed that the independent variable, size of hospitals (small, medium, and large), was statistically significant in association with the rate of SSIs in California hospitals. The *p* value = .000 is statistically significant, which is below the conventional threshold of .05. The *p* value of .000 for the three groups also revealed differences in the rate of SSIs among the sizes of hospitals in California between small and medium, between small and large, and between medium and large. The results showed statistically significant differences between small, medium, and large hospital sizes and the rate of SSIs in California hospitals; therefore, the alternative hypothesis was met, and the null hypothesis was rejected.

The analyses showed that the rate of SSIs was higher in large hospitals than medium and small hospitals in California with (*MR* = 3364.930). The results also aligned with some previous studies. According to Bagheri et al. (2019), the highest number of patients with SSIs are associated with high and medium-volume hospitals compared to infections in low-volume hospitals. The rate of SSIs was lower in small hospitals among the three-sized group of hospitals in California, as revealed in this study.

Results of Statistical Analysis for Covariates

A Kruskal-Wallis test was also conducted to examine the association between types of surgeries (general, cardiovascular, gynecology, orthopedic, and neurology) and the rate of SSIs in California hospitals, exploring if the rate of SSIs in one surgical specialty was higher than the rate in the other surgical specialties. An SPSS with a 99% confidence level was utilized. The sample size for general surgery was larger with 46.6%, while that of cardiovascular was 14.4%. The cases of SSIs for gynecology, orthopedic, and neurology were 17.4%, 14.6%, and 7.0%, respectively. As revealed in Table 5, the independent variables of types of surgeries were statistically significant with the rate of SSIs. The result, therefore, met the determination that a significant difference is evident in the association between the rate of SSIs and general, cardiovascular, gynecology, orthopedic, and neurology surgeries (chi-square = 158.987, $p < 0.05$). The p value of .000 is less than the conventional threshold of .05; therefore, there is an association between type of surgeries and the rate of SSIs.

Table 5

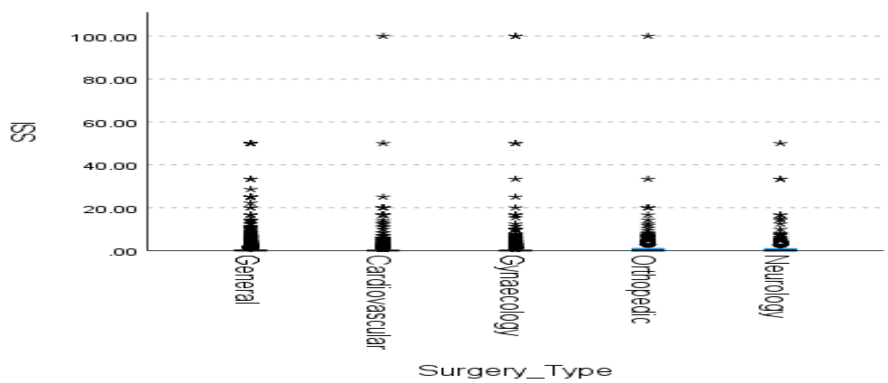
Kruskal Wallis Test - SSIs and Types of Surgery (Covariate)

Variable	*u*	%	Mean Rank	Chi-square	*p*
Types of Surgeries (Covariate)				158.987	.000
General	2,892	46.6	3,123.14		
Cardiovascular	893	14.4	2785.04		
Gynecology	1,079	17.4	2,883.63		
Orthopedic	907	14.6	3,475.82		
Neurology	434	7.0	3,389.32		

The independent samples Kruskal-Wallis test as per Figure 4 shows that cardiovascular, gynecology, and orthopedic had a high SSI rate of 100. General, cardiovascular, gynecology, and neurology recorded SSI rate of 50, with SSI rate predominantly concentrated between 0 and 10 in the five surgical specialties. Interestingly, again no rate of SSIs was recorded for all the surgical specialties between 51 and 99.

Figure 4

Independent - Samples Kruskal-Wallis Test for Surgery Type



In comparing the hospital sizes to determine if the rate of SSIs were different between the groups, Table 6 shows that the *p* value of .000, which is less than the conventional threshold of .05, was recorded between cardiovascular and general, cardiovascular and neurology, cardiovascular and orthopedic, as well as, between gynecology and orthopedic. Also, the *p* value of .000 is less than the conventional threshold of 0.05 between gynecology and general, gynecology and neurology, general and neurology, and between general and orthopedic. The results revealed that there is a statistically significant difference among the groups. However, Table 6 also revealed that between cardiovascular and gynecology, the *p* value was .116, and between neurology and orthopedic, the *p* value was .285, both are greater than the conventional threshold of 0.05. Therefore, there are no statistically significant differences between cardiovascular and gynecology, and between neurology and orthopedic.

Table 6

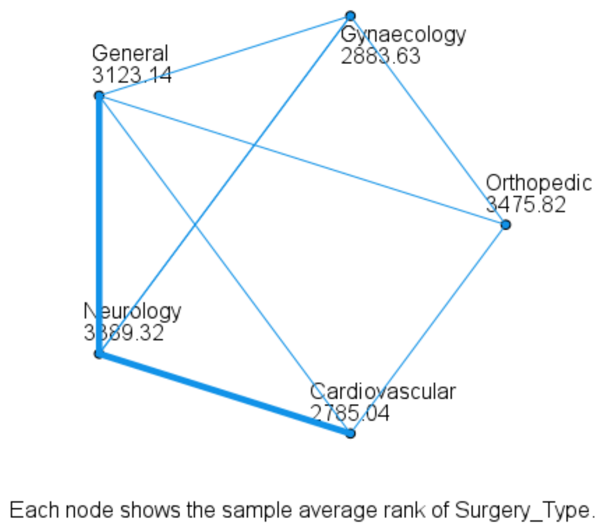
Kruskal Wallis Test - SSIs and Pairwise Comparison of Types of Surgery

Sample 1-Sample 2	Test Statistics	Std. Error	*p*	Adj. *p*
Cardiovascular-Gyn	-98.589	62.662	.116	1.000
Cardiovascular-Gen	338.097	53.027	.000	.000
Cardiovascular-Neuro	-604.278	81.050	.000	.000
Cardiovascular-Ortho	-690.782	65.297	.000	.000
Gynecology-General	239.508	49.411	.000	.000
Gynecology-Neurology	-505.689	78.732	.000	.000
Gynecology-Orthopedic	-592.193	62.397	.000	.000
General-Neurology	-266.181	71.303	.000	.002
General-Orthopedic	-352.684	52.713	.000	.000
Neurology-Orthopedic	86.503	80.845	.285	1.000

The results using the Kruskal-Wallis test showed that the rate of SSIs was greater in Orthopedic (*MR* = 3475.82, followed by neurology (*MR* = 3389.32), and general with (*MR* = 3123.14) as shown in Figure 5. The results further revealed that the rate of SSIs was lower in gynecology (*MR* = 2883.63) and cardiovascular (*MR* = 2785.04), with the lowest rate of SSIs. Figure 5 also indicates no association between cardiovascular and gynecology and the rate of SSIs and between neurology and orthopedic, evidence that there was no association between the two groups and the rate of SSIs in California hospitals.

Figure 5

Pairwise Comparisons of Surgery Types



Summary Results of the Covariates

The results of the covariates answered the question of whether there is an association between types of surgical specialties and the rate of SSIs in California hospitals. A Kruskal Wallis test with a 99% confidence level showed that the independent variable, types of surgical specialties (general, cardiovascular, gynecology, orthopedic, and neurology), was statistically significant in association with the rate of SSIs in California hospitals. The p value = .000 is statistically significant, which is below the conventional threshold of .05. The results indicated statistically significant differences between types of surgical specialties and the rate of SSIs in California hospitals; therefore, the alternative hypothesis was met, and the null hypothesis was rejected.

In comparing the groups, however, the results showed no statistically significant difference between cardiovascular and gynecology and the rate of SSIs in California hospitals with a *p*-value = .116. The *p*-value is greater than the conventional threshold of 0.05; therefore, the alternative hypothesis was not met, and the null hypothesis was accepted. The results also showed no statistically significant difference between neurology and orthopedic and the rate of SSIs in California hospitals with *p* value = .285, which is greater than the conventional threshold of 0.05; therefore, the alternative hypothesis was not met, and the null hypothesis was accepted. Other groups within the surgical specialties and the rate of SSIs had no statistically significant differences; therefore, the alternative hypothesis was met, and the null hypothesis was rejected.

Summary of Research Questions Results and Hypotheses

The results of Research Question 1, which attempted to establish an association between urban and rural hospital locations and the rate of surgical site infections in California, showed that the *p* value = .000 is statistically significant and is below the conventional threshold of .05. The results also indicated a statistically significant difference between hospital locations (rural and urban) and the rate of SSIs; therefore, the alternative hypothesis was met, and the null hypothesis was rejected. The results of Research Question 2 that explored an association between the size of a hospital (small, medium, and large) and the rate of SSIs in California showed that the *p* value = .000 is statistically significant, which is below the conventional threshold .05. The results also indicated statistically significant differences between small, medium, and large hospital sizes and the rate of SSIs in California hospitals; therefore, the alternative hypothesis was met, and the null hypothesis was rejected.

Summary

Section 3 displayed the results and the findings of this study detailing the data collection process, results of descriptive statistics, and Mann-Whitney U statistical method used to determine the association between locations and the rate of SSIs in California hospitals. The section also examined, enumerated the results, and determined the association between the size of hospitals in California and the rate of SSIs using the Kruskal-Wallis test. This doctoral study also helped answer the questions inherent in the covariates, showing that the rate of SSIs was higher in some surgical specialties than other surgical specialties in California hospitals.

In Section 4 of this study, I will highlight a detailed examination and interpretation of the results and findings of the research questions. Section 4 also focuses on examining the findings and interpretation as derived from the conceptual framework of Donabedian. The section further highlights the limitations, recommendations, and concluding parts of the doctoral study.

Section 4: Application to Professional Practice and Implication for Social Change

The primary objective of this quantitative study was to address the gap in research regarding the association between location (i.e., rural and urban) and the size (i.e., small, medium, and large) of hospitals with the rate of SSIs in California. The results from the Mann-Whitney U and Kruskal-Wallis analyses indicated significant differences between the rate of SSIs and hospitals in the rural and urban locations and between small, medium, and large hospitals in California. The results also showed that the rate of SSIs was different among some of the surgical specialties. The findings reaffirmed that the prevalence of SSIs is predicated on the location and size of hospitals as well as the type of surgery.

In Section 4, I provide the interpretation of the findings, limitations of the study, and recommendations for future research. The concluding part of this section contains a discussion of the study's relevance concerning the implications for professional practice and social change. In this section, I also consider the findings through the lens of the Donabedian framework of achieving quality of care by implementing a structure, process, and outcome.

Interpretation of the Findings

Research Question 1 Analysis

The study findings showed a significant association between the location of a hospital (i.e., rural or urban) and the rate of SSIs in California with p = 000, which is less than the conventional threshold of 0.05. The prevalence of SSIs is higher in hospitals located in urban locations than the rate in hospitals located in the rural regions of California; therefore, the null hypothesis was rejected.

The results of the data set analyses show that there was a significant association between rural and urban locations and the rate of SSIs in California hospitals. Although no previous studies are available that indicate an association between rural and urban locations and the rate of SSIs in California hospitals, other studies have shown a significant association between locations and the rate of SSIs in countries outside the United States. A considerable variation is evident in the rate of SSIs after colorectal surgery among hospitals in different communities across the Australian state of New South Wales (Bagheri et al., 2017). Therefore, the results of this study align with the research of Bagheri et al., which affirmed the existence of differences in the rate of SSIs between different regions. However, Qi et al. (2019) stated that living in low-income, zip code locations may indicate a high rate of SSIs. Furthermore, Tariq et al. (2018) noted that SSIs could vary due to factors such as geographical locations. The current study revealed that the rate of SSIs was more prevalent in hospitals located in urban regions than the rate in hospitals located in the rural regions of California.

Research Question 2 Analysis

The findings indicated a significant association between the rate of SSIs and the size of hospitals, with $p = 000$, which is less than the conventional threshold of 0.05. The prevalence of SSIs from the result of this study was higher in large hospitals (*MR* = 3,364.93) than in the medium (*MR* = 2,901.15) and small (*MR* = 2,717.25) hospitals in

California. The results indicate a statistically significant difference between the size of hospitals and the rate of SSIs; therefore, the null hypothesis was rejected.

According to Buchanan et al. (2018), factors, such as hospital bed size, teaching status, and annual procedural volume of hospitals, may predict the rate of SSIs. Although other researchers have attempted to examine the association between the size of hospitals and the rate of SSIs, such studies narrowed the scope to specific surgical specialties. To establish the relationship between surgical volume and the rate of SSIs, Calderwood et al. (2017) stated that the rate of SSIs is higher among hospitals with a low annual volume of procedures in patients that underwent CABG. In contrast, I used the total number of 2019 surgical cases in California in this study to determine that the rate of SSIs was higher in large- and medium-sized hospitals than in small-sized hospitals.

Analysis of Covariates

The results showed an association between the types of surgeries and the rate of SSIs in California hospitals, with $p = 000$, which is less than the conventional threshold of 0.05. The covariates revealed that the rate of SSIs was higher in orthopedic surgery, followed by neurology and general surgery. The lowest rate of SSIs occurred in cardiovascular surgery, followed by gynecology surgery. The results indicated a statistically significant difference between the types of surgical procedures and the rate of SSIs; therefore, the null hypothesis was rejected.

However, exploring the differences among the types of surgeries revealed a significant difference between cardiovascular and general, cardiovascular and neurology, and cardiovascular and orthopedic. A significant difference was also evident between gynecology and general, gynecology, neurology, and gynecology and orthopedic. A significant difference between general and neurology and general and orthopedic, with $p < 0.05$ was identified; therefore, the null hypothesis was rejected. Conversely, I observed no significant differences between cardiovascular and gynecology ($p = 0.116$) and between neurology and orthopedic ($p = 0.285$); therefore, the null hypothesis failed to be rejected.

Findings to the Literature

The findings of this study reaffirmed the need for hospitals to adopt the best structural processes to minimize the rate of SSIs. The results showed a significantly higher rate of SSIs in hospitals located in urban locations than the hospitals in rural areas, which may be attributed to population density and overutilization of resources within hospitals located in urban regions. This topic was out of the scope of this study. The findings also showed a higher prevalence of SSIs in large-sized hospitals than in small-sized hospitals, which calls for the adoption of remedial programs to reduce the rate of SSIs in large hospitals. Developing quality measures could allow health care professionals to adopt necessary strategies to improve quality, minimize care costs, and attain patient satisfaction. Furthermore, examining the types of surgeries with a high rate of SSIs is imperative to implement the necessary programs within the operative team and clinical staff to minimize the rate of SSIs within a surgical specialty. The following subsection is dedicated to the findings of the independent variables concerning the rate of SSIs in California hospitals.

Findings to Theory

Various researchers have explored several risk factors related to SSIs; however, few have attempted to determine the association between location and size of hospitals with SSIs rate, especially within the United States. This study was based on the Donabedian model of structure, process, and outcome to improve the quality of care. I did not find any similar topic in my review of the literature. According to Ameh et al. (2017), applying Donabedian model concepts of the association between structure, process, and the outcome can achieve positive results.

The process of improving the quality of care through the reductions of SSIs in hospitals is critical to the realization of cost savings associated with health treatments and overall patient satisfaction. The structure variables (i.e., rural, urban, small, medium, and large hospitals) employed to determine the results of this study may be used to yield processes for improvement leading to the attainment of quality of care. This analysis suggested that the rate of SSIs is more prevalent in urban and large hospitals in California, which provides information for health care administrators to apply when examining the various processes that may minimize the rate of SSIs in these settings.

Limitations of the Study

I identified some limitations regarding use of the CDPH data set that affected the generalizability, reliability, and validity of the study findings. I utilized a CDPH data set containing the 2019 rate of SSIs in California hospitals. I listed the variables planned for this study in the prospectus and proposal. The data set of the rate of SSIs in California hospitals for 2019 was not assessed before the study began; therefore, the use of crosstabulations and chi-square followed by multiple regression was proposed. Once approval was obtained from the Walden University Institutional Review Board and the data set was downloaded, it became evident that the variables were not normally distributed, and the assumption for the parametric test was not met; hence, I had to use a nonparametric test for this study instead.

The rate of SSIs in health care facilities is self-reported per the CMS requirements, under the auspices of the Affordable Care Act. One limitation identified in this study is the variation in reporting cases of SSIs among health care facilities; therefore, the website may not have captured a comprehensive list of the rate of 2019 SSIs in all hospitals within California. The current reimbursement system based on performance, including financial penalties, carries some setbacks arising from the unwillingness of some hospitals to share publicly or underreport the incidences of SSIs (Iskandar et al., 2019).

Another limitation is the 28 surgical procedures inherent in this study that did not capture SSIs of other surgical specialties in California hospitals. The NHSN, a database of HAI-tracking platforms developed by the CDC, has records of SSIs for 39 various surgical procedures (Reese et al., 2017).

The results of the current study were based on the rate of SSIs within California hospitals for 2019; therefore, the results may not represent the rate of SSIs in all hospitals in the United States. Additionally, I only explored the association between urban and rural locations and the rate of SSIs in California hospitals. Semiurban locations were not included in the analysis of the regions, which may have skewed some hospitals being placed into different settings that may have otherwise fallen into semiurban. The identification of areas as rural and urban could be challenging. According to United Nations Statistics Division (n.d.), no single definition exists to describe rural and urban that applies to all countries or regions within the same country, and the distinction between rural and urban even in developed economies is marred with uncertainties.

Recommendations

The limitations of this study highlight the need for future researchers to explore various issues related to SSIs, such as the association between specific surgical specialties and the rate of SSIs in hospitals of different sizes within the United States. Furthermore, I recommend that future researchers expand the scope of this research to other states within the United States to determine differences in the prevalence of SSIs among the states. This expansion of research could highlight the rate of SSIs for specific surgical procedures among the same size of hospitals in various locations, including semiurban regions.

My recommendations also include the need for researchers to contact hospitals directly and obtain the rate of SSIs instead of relying on data from government data sets that may be missing some information. The data collection system within the NHSN has variations within the data (Ju et al., 2015). Therefore, the need to establish a reliable method for collecting and interpreting data regarding the rate of SSIs is critical.

Implications for Professional Practice and Social Change

The sanctions imposed on health care facilities for failing to meet the standard to achieve quality care demands strategic approaches to minimize SSIs. The need for hospital administrators to implement strategies that would improve the quality of care, reduce the cost associated with the delivery of care, and attain patient satisfaction is imperative. The requirement for hospitals to report the rate of SSIs to the public through the CMS and the financial penalty associated with a high rate of SSIs serves as an incentive for health care facilities to monitor, control, and manage SSIs (Turner & Migaly, 2019). According to Turner and Migaly, the prevalence of SSIs is a significant concern to patients and surgeons, and the development of quality metrics has led to the examination of several risk factors associated with SSIs.

Professional Practice

SSIs are a major challenge in health care, and the need to adopt the necessary strategies to minimize the rate across all surgical specialties is great. According to De Simone et al. (2020), SSIs are frequently a cause of hospital readmissions after surgery, extended hospital stays, admissions to intensive care units, and increased costs associated with treatment. Understanding the risk factors is critical to health care administrators determining the best strategies to minimize the rate of SSIs. The collaboration of frontline clinical staff, surgeons, and health care administrators is needed to reduce SSIs in health care facilities.

Positive Social Change

SSIs are a major concern in hospitals due to associated factors, such as increases in treatment costs, hospital readmissions, and extended hospitalization stays. In this study, I found an association between the rate of SSIs and rural and urban locations and the size of hospitals in California; therefore, the mobilization of resources is needed to address the inequalities inherent in the prevalence of SSIs in different communities. According to Qi et al. (2019), people living in low-income locations and patients with Medicaid are associated with a higher rate of SSIs. The results of this study could lead to more interest in conducting studies that explore the differences in the rate of SSIs in hospitals in various geographical locations and hospitals of different sizes. Further research may also lead to more strategies to improve health care delivery through the reduction of SSIs.

Conclusion

This study revealed a statistically significant association between rural and urban locations and the rate of SSIs in California hospitals. The study further demonstrated an association between the size of hospitals (i.e., small, medium, and large) and the rate of SSIs in California hospitals. An examination of the covariates in the study revealed an association between groups of surgical specialties and the rate of SSIs, such as between cardiovascular and general, cardiovascular and neurology, and cardiovascular and orthopedic. There was also an association between gynecology and general, gynecology and neurology, gynecology and orthopedic, general and neurology, and general and orthopedic. Conversely, the covariates showed no association in SSI rate between cardiovascular and gynecology and between neurology and orthopedic in California hospitals.

This study did have limitations, such as utilizing only 28 surgical procedures inherent in the CDPH data set and excluding semiurban regions. Further research is recommended to examine the rate of SSIs in the United States to comprehensively determine an association between locations and the size of health care facilities with the rate of SSIs. Determining the association between the size of the hospitals and the location of hospitals in urban, semiurban, and rural locations with SSI rate could provide researchers with the necessary information to identify any gaps in infection control practices among different hospitals in different communities.

The current study may serve as a guide for health care administrators to understand the interplay of the size and locations of hospitals in the prevalence of SSIs, thereby addressing the problem of SSI rate disparities among communities, leading to an improvement in the quality of care, reduction in financial burden on hospitals and patients, and the attainment of patient satisfaction.

References

Agency for Healthcare Research and Quality. (2019). *Surgical site infections.* PSNET. https://psnet.ahrq.gov/primer/surgical-site-infections

Alfonso-Sanchez, J. L., Martinez, I. M., Martín-Moreno, J. M., González, R. S., & Botía, F. (2017). Analyzing the risk factors influencing surgical site infections: The site of environmental factors. *Canadian Journal of Surgery*, *60*(3), 155–161. https://doi.org/10.1503/cjs.017916

Alfouzan, W., Al Fadhli, M., Abdo, N., Alali, W., & Dhar, R. (2019). Surgical site infection following cesarean section in a general hospital in Kuwait. *Trends and Risk Factors. Epidemiology and Infection*, *147*, e287. https://doi.org/10.1017/S0950268819001675

Alkaakl, T. A., Chung, H., Riad, C., Reardon, S., Kazanjian, K., Cherry, R., Hines, O. J., & Lin, A. (2019). Sustaining improvement: implementation and spread of a surgical site infection bundle. *American Surgeon, 84*(10), 1665–1669. https://doi.org/10.1177/000313481808401026

Allegranzi, B., Bischoff, P., de Jonge, S., Kubilay, N. Z., Zayed, B., Gomes, S. M., Abbas, M., Atema, J. J., Gans, S., van Rijen, M., Boermeester, M. A., Egger, M., Kluytmans, J., Pittet, D., & Solomkin, J. S. (2016). New WHO recommendations on preoperative measures for surgical site infection prevention: An evidence-based global perspective. *The Lancet Infectious Diseases, 16*(12). https://doi.org/10.1016/S1473-3099(16)30398-X

Ameh, S., Gómez-Olivé, F.X., Kahn, K., Tollman, S. T., & Klipstein-Grobusch, K. (2017). Relationships between structure, process, and outcome to assess the quality of integrated chronic disease management in a rural South African setting: Applying a structural equation model. *BMC Health Serveries Research, 17*(229). https://doi.org/10.1186/s12913-017-2177-4

American College of Surgeons (n.d.). *What are the surgical specialties?* https://www.facs.org/education/resources/medical-students/faq/specialties

Ampatzoglou, A., Bibi, S., Avgeriou, P., Verbeek, M., & Chatzigeorgiou, A. (2019). Identifying, categorizing, and mitigating threats to validity in software engineering secondary studies. *Information and Software Technology, 106*, 201–230. https://doi.org/10.1016/j.infsof.2018.10.006

Anthony, C. A., Peterson, R. A., Polgreen, L. A., Sewell, D. K., & Polgreen, P. M. (2017). The seasonal variability in surgical site infections and the association with warmer weather: A population-based investigation. *Infection Control and Hospital Epidemiology, 38*(7), 809–816. https://doi.org/10.1017/ice.2017.84

Anthony, C. A., Peterson, R. A., Sewell, D. K., Polgreen, L. A., Simmering, J. E., Callaghan, J. J., & Polgreen, P. M. (2018). The seasonal variability of surgical site infections in knee and hip arthroplasty. *The Journal of Arthroplasty, 33*(2): 510. https://doi.org/10.1016/j.arth.2017.10.043

Atkinson, A., Eisenring, M., Troillet, N., Kuster, S., Widmer, A., Zwahlen, M., & Marschall, J. (2021). Surveillance quality correlates with surgical site infection rate in the knee and hip arthroplasty and colorectal surgeries: A call to action to adjust reporting of SSI rate. *Infection Control & Hospital Epidemiology*, 1-7. https://doi.org/10.1017/ice.2021.14

Ayanian, J. Z., & Markel, H. (2016). Donabedian's lasting framework for health care quality. *The New England Journal of Medicine, 375*, 205-207. https://www.nejm.org/doi/full/10.1056/NEJMp1605101

Badia, J. M., Casey, A. L., Petrosillo, N., Hudson, P. M., Mitchell, S. A., & Crosby, C. (2017). Impact of surgical site infection on healthcare costs and patient outcomes: A systematic review in six European countries. *Journal of Hospital Infection, 96*(1), 1-15. https://doi.org/10.1016/j.jhin.2017.03.004

Baek, H., Cho, M., Kim, S., Hwang, H., Song, M., & Yoo, S. (2018). Analysis of length of hospital stays using electronic health records: A statistical and data mining approach. *PLOS ONE, 13*(4), Article e0195901. https://doi.org/10.1371/journal.pone.0195901

Bagheri, N., Furuya-Kanamori, L., Doi, S. A. R., Clements, A. C. A., & Sedrakyan, A. (2019). Geographical outcome disparities in infection occurrence after colorectal surgery: An analysis of 58,096 colorectal surgical procedures. *International Journal of Surgery, 44*, 117–121. https://doi.org/10.1016/j.ijsu.2017.06.048

Ban, K. A., Minei, J. P., Laronga, C., Harbrecht, B. G., Jensen, E. H., Fry, D. E., Itani, K. M. F., Dellinger, E. P., Ko, C. Y., & Duane, T. M. (2017). Surgical site infection guidelines, 2016. *Journal of the American College of Surgeons, 224*(1), 59-74. https://doi.org/10.1016/j.jamcollsurg.2016.10.029

Bond, A. M., Volpp, K. G., Emanuel, E. J., Caldarella, K., Hodlofski, A., Sacks, L., Patel, P., Sokol, K., Vittore, S., Calgano, D., Nelson, C., Weng, K., Troxel, A., & Navathe, A. (2019). Real-time feedback in pay-for-performance: Does more information lead to improvement? *Journal of General Internal Medicine, 34*(9), 1737–1743. https://doi.org/10.1007/s11606-019-05004-8

Buchanan, I. A., Donoho, D. A., Patel, A., Lin, M., Wen, T., Ding, L., Giannotta, S. L., Mack, W. J., & Attenello, F. (2018). Predictors of surgical site infection after nonemergent craniotomy: A nationwide readmission database analysis. *World Neurosurgery, 120*, 440–452. https://doi.org/10.1016/j.wneu.2018.08.102

Calderwood, M. S., Kleinman, K., Huang, S. S., Murphy, M. V., Yokoe, D. S., & Platt, R. (2017). Surgical site infections: Volume-outcome relationship and year-to-year stability of performance rankings. *Medical Care, 55*(1), 79–85. https://doi.org/10.1097/MLR.0000000000000620

California Department of Public Health. (n.d.). *Healthcare-associated infections program.* https://www.cdph.ca.gov/Programs/CHCQ/HAI/Pages/CA_SpecificReportingGuidelines.aspx

California Department of Public Health. (2019). *SSI in adult patients-Data dictionary.* https://data.chhs.ca.gov/dataset/surgical-site-infections-ssis-for-28-operative-procedures-in-california-hospitals/resource/0d36eb0e-2575-4a9f-a63c-39630272e5cf

Çelik, G. H., Çelik, E., Turan, G., Doğa S. K., & Gedikbaşi, A. (2017). Risk factors for surgical site infection after hysterectomy. *Journal of Infection in Developing Countries, 11*(4), 355–360. https://doi.org/10.3855/jidc.9053

Cheng, H., Chen, B. P., Soleas, I. M., Ferko, N. C., Cameron, C. G., & Hinoul, P. (2017). Prolonged operative duration increases the risk of surgical site infections: a systematic review. *Surgical Infections, 18*(6). https://doi.org/10.1089/sur.2017.089

Cornett, B. S. (2017). Seeking value in health care: Have we reached the tipping point? It's time to make the changes needed to lead the world in the health status of the population. *Journal of Health Care Compliance, 19*(3), 15–53.

De Simone, B., Sartelli, M., Coccolini, F., Ball, C. G., Brambillasca, P., Chiarugi, M., Campanile, F. C., Nita, G., Corbella, D., Leppaniemi, A., Boschini, E., Moore, E. E., Biffl, W., Peitzmann, A., Kluger, Y., Sugrue, M., Fraga, G., Di Saverio, S., Weber, D…Catena, F. (2020). Intraoperative surgical site infection control and prevention: A position paper and future addendum to WSES intra-abdominal infections guidelines. *World Journal of Emergency Surgery*, *15*(1), 10. https://doi.org/10.1186/s13017-020-0288-4

Dellinger, E. P. (2016). Teamwork and collaboration for prevention of surgical site infections. *Surgical Infection, 17*(2),198-202. https://doi.org/10.1089/sur.2015.260

Deng, H., Chan, A. K., Ammanuel, S. G., Chan, A. Y., Oh, T., Skrehot, H. C., Edwards, C., Kondapavulur, S., Nichols, N., Liu, C., Yue, J., Dhall, S., Clark, A., Chou, D., Ames, C., & Mummaneni, P. V. (2020). Risk factors for deep surgical site infection following thoracolumbar spinal surgery. *Journal of Neurosurgery: Spine SPI, 32*(2), 292-301. https://doi.org/10.3171/2019.8.SPINE19479

Dick, A. W., Bell, J. M., Stone, N. D., Chastain, A. M., Sorbero, M., & Stone, P. W. (2019). Nursing home adoption of the National Healthcare Safety Network Long-term Care Facility Component. *American Journal of Infection Control, 47*(1), 59–64. https://doi.org/10.1016/j.ajic.2018.06.018

Fadayomi, A. B., Kasumova, G. A., Tabatabaie, O., de Geus, S. W. L., Kent, T. S., Ng, S. C., Moser, A. J., Callery, M. P., Ashley, S.W., & Tseng, J. F. (2018). Unique predictors and economic burden of superficial and deep/organ space surgical site infections following pancreatectomy. *Oxford Hepato-Pancreato-Biliary, 20*(7), 658-668. https://doi.org/10.1016/j.hpb.2018.01.008

Fisha, K., Azage, M., Mulat, G., & Tamirat, K. S. (2019). The prevalence and root causes of surgical site infections in public versus private hospitals in Ethiopia: A retrospective observational cohort study. *Patient Safety in Surgery, 13*(26). https://doi.org/10.1186/s13037-019-0206-4

Florschutz, A. V., Fagan, R. P., Matar, W. Y., Sawyer, R. G., & Berrios-Torres, S. I. (2015). Surgical site infection risk factors and risk stratification. *The Journal of the American Academy of Orthopedic Surgeons,* (23), S8–S11. https://doi.org/10.5435/JAAOS-D-14-00447

Fortaleza, C. M. C. B., Padoveze, M. C., Kiffer, C. R. V., Barth, A. L., Carneiro, I. C. D. R. S., Giamberardino, H. I. G., Rodrigues, J. L. N., Filho, L. S., Gonçalves de Mello, M. J., Pereira, M. S., Filho, P. P. G., Rocha, M., Servolo de Medeiros, E. A., & Pignatari, A. C. C. (2017). Multi-state survey of healthcare-associated infections in acute care hospitals in Brazil. *Journal of Hospital Infection, 96*(2), 139–144.

Garner, B. H., & Anderson, D. J. (2016). Surgical site infections: An update. *Infectious Disease Clinics of North America, 30*(4), 909-929. https://doi.org/10.1016/j.idc.2016.07.010

Hamza, W. S., Salama, M. F., Morsi, S. S., Abdo, N. M., & Al-Fadhli, M. A. (2018). Benchmarking for surgical site infections among gastrointestinal surgeries and related risk factors: A multicenter study in Kuwait. *Dove Press Journals*, (11), 1373—1381. https://doi.org/10.2147/IDR.S167213

Haque M, Sartelli M, McKimm J, & Abu Bakar M. (2018). Healthcare-associated infections – An overview. *Infection and Drug Resistance,* (11), 2321–2333. https://doi.org/10.2147/IDR.S177247

Healthypeople.gov. (2020). *Healthcare-associated infections*. https://www.healthypeople.gov/2020/topics-objectives/topic/healthcare-associated-infections

Heena P. Santry, S. A., Strassels, A. M., Ingraham, W. M., Oslock, K. B., Ricci, A. Z., Paredes, A. Z., Heh, V. K., Baselice, H. E., Rushing, A. P., Diaz, A., Daniel, V. T., Ayturk, M. D., & Catarina I. K. (2020). Identifying the fundamental structures and processes of care contributing to emergency general surgery quality using a mixed-methods Donabedian approach. *BMC Medical Research Methodology, 20*(1), 1–19. https://doi.org/10.1186/s12874-020-01096-7

Hijas-Gómez, A. I., Lucas, W. C., Checa-García, A., Martínez-Martín, J., Fahandezh-Saddi, H., Gil-de-Miguel, Á., & Rodríguez-Caravaca, G. (2018). Surgical site infection incidence and risk factors in knee arthroplasty: A 9-year prospective cohort study at a university teaching hospital in Spain. *American Journal of Infection Control, 46*(12). https://doi.org/10.1016/j.ajic.2018.06.010

Iskandar, K., Sartelli, M., Tabbal, M., Ansaloni, L., Baiocchi, G. L., Catena, F., Coccolini, F., Haque, M., Labricciosa, F. M., Moghabghab, A., Pagani, L., Hanna, P. A., Roques, C., Salameh, P., & Molinier, L. (2019). Highlighting the gaps in quantifying the economic burden of surgical site infections associated with antimicrobial-resistant bacteria. *World Journal of Emergency Surgery, 14*(50). https://doi.org/10.1186/s13017-019-0266-x

Jones, R. P. (2020). Would the United States have had too few beds for universal emergency care in the event of a more widespread Covid-19 epidemic? *International Journal of Environmental Research and Public Health, 17*(14). https://doi.org/10.3390/ijerph17145210

Ju, M. H., Ko, C. Y., Hall, B. l., Bosk, C. L., Bilimoria, K. Y., & Wick, E. C. (2015). A comparison of 2 surgical site infection monitoring systems. *Journal of the American Medical Association Surgery, 150*(1), 51–57. https://doi.org/10.1001/jamasurg.2014.2891

Kelly, B. P. (2012). Superficial fungal infections. *Pediatrics in Review, 33*(4). https://doi.org/10.1542/pir.33-4-e22

Li, Z., Liu, P., Zhang, C., Xu, G., Zhang, Y., Chang, Y., Liu, M., & Hou, S. (2019). Incidence, prevalence, and analysis of risk factors for surgical site infection after lumbar fusion surgery: ≥2-year follow-up retrospective study. *World Neurosurgery, 131*, e460-e467. https://doi.org/10.1016/j.wneu.2019.07.207

Ling, M.L., Apisarnthanarak, A., Abbas, A., Morikane, K., Lee, K. Y., Warrier, A., & Yamada, K. (2019). APSIC guidelines for the prevention of surgical site infections. *Antimicrobial Resistance & Infection Control, 8*(174). https://doi.org/10.1186/s13756-019-0638-8

Losh, J. M., Gough, A., Rutherford, R., Romero, J., Diaz, G., & Schweitzer, J. (2017). Surgical site infection reduction bundle: Implementation and challenges at Ventura County Medical Center. *The American Surgeon, 83*(10). https://doi.org/10.1177/000313481708301027

Mamo, T., Abebe, T. W., Chichiabellu, T. Y., & Anjulo, A. A. (2017). Risk factors for surgical site infections in obstetrics: A retrospective study in an Ethiopian referral hospital. *Patient Safety in Surgery, 11*(24). https://doi.org/10.1186/s13037-017-0138-9

Martins, T., Amante, L., Virtuoso, J. F., Girondi, J. B. R., do Nascimento, E., Regina Pereira, & do Nascimento, K. C. (2017). Preoperative period of potentially contaminated surgeries: Risk factors for surgical site infection. *Acta Paulista De Enfermagem, 30*(1), 16-24. http://doi.org/10.1590/1982-0194201700004

Mekhla, & Firoz Rajiv Borle. (2019). Determinants of superficial surgical site infections in abdominal surgeries at a rural teaching hospital in Central India: A prospective study. *Journal of Family Medicine and Primary Care, 8*(7), 2258–2263. https://doi.org/10.4103/jfmpc.jfmpc_419_19

Mengesha, A., Tewfik, N., Argaw, Z., Beletew, B., & Wudu, M. (2020). The practice of and associated factors regarding prevention of surgical site infection among nurses working in the surgical units of public hospitals in Addis Ababa city, Ethiopia: A cross-sectional study. *PLOS ONE,15*(4) article e0231270. https://doi.org/10.1371/journal.pone.0231270

Mohamed J., & Haja A. N. (2018). Surgical site infection in a coastal tertiary care teaching hospital. *International Archives of Integrated Medicine, 5*(1), 100.

Monegro, A. F., Muppidi, V., & Regunath, H. (2020). *Hospital-acquired infections. National Center for Biotechnology Information Resources.* https://www.ncbi.nlm.nih.gov/books/NBK441857/

Mufarrih, S. H., Ghani, M. O. A., Martins, R. S., Qureshi, N. Q., Mufarrih, S. A., Malik, A. T., & Noordin, S. (2019). Effect of hospital volume on outcomes of total hip arthroplasty: A systematic review and meta-analysis. *Journal of Orthopedic Surgery & Research*, *14*(1), 1–13. https://doi.org/10.1186/s13018-019-1531-0

Mujagic, E., Marti, W.R., Coslovsky, M., Soysal, S. D., Mechera, R., von Strauss, M., Zeindler, J., Saxer, F., Mueller, A., Fux, C. A., Kindler, C., Gurke, L., & Weber, W. P. (2018). Associations of hospital length of stay with surgical site infections. *World Journal of Surgery*, *42*(12), 3888–3896. https://doi.org/10.1007/s00268-018-4733-4

Najjar, Y. W., Al-Wahsh, Z. M., Hamdan, m., Saleh, M. Y. (2018). Risk factors of orthopedic surgical site infection in Jordan: A prospective cohort study. *International Journal of Surgery Open*, (15), 1-6. https://doi.org/10.1016/j.ijso.2018.09.003

Nordstokke, D. W., & Colp, S. M. (2018). A note on the assumption of identical distributions for nonparametric tests of location. *Practical Assessment, Research & Evaluation*, *23*(3), 1–9.

Ogawa, T., Yoshii, T., Morishita, S., Moriwaki, M., Okawa, A., Nazarian, A., Fushimi, K., & Fujiwara, T. (2020). Seasonal impact on surgical site infections in hip fracture surgery: Analysis of 330,803 cases using a nationwide inpatient database. *Clinical Key*, *52*(4)898-904 https://doi.org/10.1016/j.injury.2020.10.058

Oriel, B. S., Chen, Q., & Itani, K. M. F. (2017). The impact of surgical hand antisepsis technique on surgical site infection. *The American Journal of Surgery, 213*(1), 24–29.

Peng, X.Q., Sun, C. G., Fei, Z.G., & Zhou, Q. J. (2019). Risk factors for surgical site infection after spinal surgery: A systematic review and meta-analysis based on twenty-seven studies. *World Neurosurgery*, *123*, e318-e329. https://doi.org/10.1016/j.wneu.2018.11.158

Popescu, M., Popescu, C., Per, E., & Csosz, I. (2018). Rural area and rural development. Definition and features. *Agricultural Management*, *20*(2), 88–93.

Pop-Vicas, A., Stern, R., Osman, F., & Safdar, N. (2021). Variability in infection surveillance methods and impact on surgical site infection rate. *American Journal of Infection Control*, *49(*2), 188–193.

Qi, A. C., Peacock, K., Luke, A. A., Barker, A., Olsen, M. A., & Joynt Maddox, K. E. (2019). Associations between social risk factors and surgical site infections after colectomy and abdominal hysterectomy. *JAMA Network Open*, *2*(10), Article e1912339.

Ravaghi, H., Alidoost, S., Mannion, R., & Bélorgeot, V. D. (2020). Models and methods for determining the optimal number of beds in hospitals and regions: A systematic scoping review. *BMC Health Services Research*, *20*(1), 186. https://doi.org/10.1186/s12913-020-5023-z

Ravi. B., Jenkinson, R., O'Heireamhoin, S., Austin, P. C., Aktar, S., Leroux, T. S., Paterson, M., Redelmeier, D. A. (2019). Surgical duration is associated with an increased risk of periprosthetic infection following total knee arthroplasty: A population-based retrospective cohort study. *E Clinical Medicine, 16*, 74-80. https://doi.org/10.1016/j.eclinm.2019.09.015.

Reese, S. M., Gilmartin, H., Rich, K. L., & Price, C. S. (2014). Infection prevention needs assessment in Colorado hospitals: Rural and urban settings. *American Journal of Infection Control, 42*(6), 597–601. https://doi.org/10.1016/j.ajic.2014.03.004

Reese, S. M., Knepper, B., Young, H. L., & Mauffrey, C. (2017). Development of a surgical site infection prediction model in orthopedic trauma: *The Denver Health Model Injury, 48*(12), 2699–2704. https://doi.org/10.1016/j.injury.2017.10.011

Rodrigues de Carvalho, R. L., Campos, C. C., Maciel de Castro Franco, L., De Mattia Rocha, A., & Flávia Ercole. F. F, (2017). Incidence and risk factors for surgical site infection in general surgeries. *Revista Latino-Americana de Enfermagem, 25*(0). https://doi.org/10.1590/1518-8345.1502.2848

Roof, M. A., Hutzler, L., Stachel, A., Friedlander, S., Phillips, M., Bosco, J. A. (2019). Seasonal, monthly, and yearly variability of surgical site infections at a single institution-A report of more than 95,000 procedures. *Observational Study Infection Control Hospital Epidemiology, 41*(1), 127-129. https://doi.org/10.1017/ice.2019.301

Russell, T., & Chen, F. (2020). Quality issues in emergency colorectal surgery. *Seminars in Colon and Rectal Surgery*. https://doi.org/10.1016/j.scrs.2020.100784

Russell, T. A., Chung, H., Riad, C., Reardon, S., Kazanjian, K., Cherry, R., Hines, O. J., & Lin, A. (2018). Sustaining improvement: Implementation and spread of a surgical site infection bundle. *American Surgeon, 84*(10), 1665–1669. https://doi.org/10.1177/000313481808401026

Schober, P., & Vetter, T. R. (2020). Nonparametric statistical methods in medical research. *Anesthesia & Analgesia, 131*(6), 1862-1863. https://doi.org/10.1213/ANE.0000000000005101

Shena, J. J., Jemec, G. B. E., Arendrup, M. C., & Saunte, D. M. L. (2020). Photodynamic therapy treatment of superficial fungal infections: A systematic review. *Science Direct*, *31*. https://doi.org/10.1016/j.pdpdt.2020.101774

Sinha, S. (2019). Management of post-surgical wounds in general practice. *Australian Journal of General Practice*, *48*(9), 596-599. https://doi.org/10.31128/AJGP-04-19-4921. PMID: 31476832.

Sodhi, N., Anis, H. K., Garbarino, L. J., Gold, P. A., Kurtz, S. M., Higuera, C. A., Hepinstall, M. S., & Mont, M. A. (2019). Have we reduced our 30-day short-term surgical site infection rate in primary total hip arthroplasty in the United States? *The Journal of Arthroplasty*, *34*(9), 2102–2106. https://doi.org/10.1016/j.arth.2019.04.045

Statista (n.d.). *Bed size of hospitals*. https://www.statista.com/statistics/459783/total-hospital-bed-numbers-in-the-us-by-hospital-size/

Sun, M., & Lipsitz, S. R. (2018). Comparative effectiveness research methodology using secondary data: A starting user's guide. Urologic Oncology: *Seminars and Original Investigations*, *36*(4), 174–182. https://doi.org/10.1016/j.urolonc.2017.10.011

Talsma, A., McLaughlin, M., Bathish, M., Sirihorachai, R., & Kuttner, R. (2014). The quality, implementation, and evaluation model: A clinical practice model for sustainable interventions. *Western Journal of Nursing Research*, *36*(7), 929.

Tariq, A., Ali, H., Zafar, F., Sial, A. A., Hameed, K., Rizvi, M., Bushra, R., Salim, S., Nisa, Z. U., Naqvi, R., & Zubair, S. (2018). Assessment of predictor variables and clinical consequences associated with surgical site infection in a tertiary care setting, Karachi, Pakistan. *Pakistan Journal of Pharmaceutical Sciences*, *31*, 269–275.

Tomsic, I., Heinze, N.R., Chaberny, I.F., Chaberny, I. F., Krauth, C., Schock, B., & von Lengerke, T. (2020). Implementation interventions in preventing surgical site infections in abdominal surgery: A systematic review. *BMC Health Services Research*, *20*(1), 236. https://doi.org/10.1186/s12913-020-4995-z

Turner M. C., & Migaly J. (2019). Surgical site infection: The clinical and economic impact. *Clinical Colon Rectal Surgery*, *32*(3),157-165. https://doi.org/10.1055/s-0038-1677002

Wineman, A., Alia, D. Y., & Anderson, C. L. (2020). Definitions of "rural" and "urban" and understandings of economic transformation: Evidence from Tanzania. *Journal of Rural Studies, 79,* 254–268. https://doi.org/10.1016/j.jrurstud.2020.08.014