A Retrospective Chart Review of a Nasal Decolonization Program to Decrease Surgical Site Infections at a Community Based Medical Center

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Abstract

Background: Surgical site infections (SSI's) are a major concern for patients, providers, and healthcare organizations worldwide. SSI's remain the costliest and most common of all hospital-acquired infections (HAI's) (Septimus, 2019). It is estimated that SSI's occur in 2 percent to 5 percent of all patients undergoing surgery, translating to 160,000 to 300,000 people annually at a cost of $3.5 to $10 billion (Ban et al., 2017). An SSI substantially increases morbidity and mortality as patients are twice as likely to die, are 60% more likely to be admitted to the intensive care unit (ICU), and the readmission rate is five times higher than patients who do not have a hospital-acquired SSI (Darouiche, 2019).

Research Question: Did the intervention of preoperative nasal decolonization using the Profend Nasal Decolonization Kit, 10% povidone-iodine (PVP-I), reduce surgical site infections in patients undergoing an orthopedic surgery with implantation, to include total joint arthroplasty (TJA) and an orthopedic fracture repair, in a 12-month period preintervention compared to a 12-month period post-intervention?

Objective: The objective of this DNP project was to evaluate the effectiveness of using a 10% PVP-I Nasal Decolonization Kits in the prevention of SSI's in patients undergoing an orthopedic surgery for a TJA or fracture repair at the medical center.

Methods: This DNP project used a retrospective data review from data points previously collected as part of standard work performed in the EMR. All patient information was blinded when the information was displayed. A standard report from the EMR was run to collect all data.

Results: The preintervention group was composed of 431 patients and the postintervention group contained 365 patients. The preintervention group had eight postoperative infections for an infection rate of 1.86%. The postintervention group had an infection rate of 0.27%. This resulted in a p-value of 0.0367 using a two proportions z-score, showing a statistical improvement in SSI's.

Conclusion: The facility successfully implemented a nasal decolonization program with 10% PVP-I that decreased the number of infections, had a higher compliance rate for PVP-I nasal swab over the national average for mupirocin, and showed potential cost savings for the medical center.

Keywords: Nasal decolonization, povidone-iodine decolonization, surgical site infections, SSI reduction.

Dedication

I dedicate this doctorate project to my wife, Danielle, and my 5 children: Grace, William, Ellie, Nick and Vaughn. Paise YHVH for His grace and mercy forever.

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Chapter 1

Introduction

Surgical site infections (SSI's) are a major concern for patients, providers, and healthcare organizations worldwide. That is one reason why The Joint Commission (TJC), the Centers for Disease Control (CDC), American College of Surgeons (ACS), Association of Operating Room Nurses (AORN), and other organizations continue to make SSI's a major focal point for continued process improvement. SSI's remain the costliest and most common of all hospital-acquired infections (HAI's) (Septimus, 2019).

The CDC defines an SSI as occurring within 30 days of surgery, except for surgeries with implants, and classifies SSI's in three categories (*Surgical Site Infection*, n.d.). The CDC definition for SSI's is used by the ACS and other organizations for reporting and tracking SSI's. The 3 SSI classifications are:

- Superficial- A surgical site infection that occurs in the area of the skin where the incision is made.
- Deep- A surgical site infection that occurs beneath the incision area around the muscle and the surrounding muscle tissue.
- Organ space- A surgical site infection that can be in any area of the body other than the skin, muscle, or surrounding tissue that was involved in the surgery. This can include an organ or the body space between the organs.

The Joint Commission is a voluntary accreditation organization for acute care medical centers and healthcare organizations. They conduct triannual surveys of hospitals and assess them on a list of established standards and criteria. One of these standards, IC.01.03.01, states an organization must conduct surveillance of its risk procedures and target resources to reduce the risk for procedures that are classified as high-risk (*Surgical Site Infections (SSI) - Surveillance and Resources*, n.d.). This standard prompts organizations to continually monitor SSI's, and look for ways to prevent harm for patients undergoing invasive procedures in their facilities. Proactive risk assessment, retrospective chart reviews, and deep dives into fallouts are some ways in which an organization conducts surveillance. Out of the surveillance, programs to optimize care preoperatively, intraoperatively, and postoperatively are developed and practice changes are implemented to reduce risk. SSI bundles are common practice changes designed to reduce the risk of an SSI and improve patient outcomes that are based on scientific underpinning, expert opinion, and best practices from leading organizations. Common SSI Bundle elements include:

- Smoking cessation prior to surgery.
- Maintaining normothermia through the perioperative setting to include pre-, intra-, and postoperative phases of care.
- Hair removal preoperatively outside of the surgical suite.
- Antibiotic dosing preoperatively with redosing intraoperatively as indicated.
- Appropriate surgical skin prep supported by literature as opposed to personal preference.
- Surgical hand scrub with the correct product, for the correct time.

In addition to SSI bundles, other recommendations and practice changes have been made to include things such as SCIP Core Measures and ERAS protocols. SCIP is the Surgical Care Improvement Project. Born in 2005 out of the Surgical Infection Prevention (SIP) project from 2002 driven by a joint effort between the Centers for Medicare and Medicaid Services (CMS) and the CDC with the primary goal of reducing SSI's by 25% by 2010 (Drake, 2011). While SIP primarily focused on antibiotic stewardship, SCIP expanded on antibiotics to include reconditions specific to surgery service lines such as colorectal surgery, cardiac, and gynecology. SCIP also outlined recommendations to address venous thromboembolism and preoperative hair removal. Though SCIP has had a lot of mixed reviews and implementing standard protocols to reduce SSI's, it did not achieve the stated goal of a reduction of SSI's by 25% by 2010 (Rosenberger et al., 2011). SCIP did establish a set of standard core measures that have been built on since its initial implementation.

The ERAS program is the Enhanced Recovery After Surgery. Starting in Europe around the same time as SCIP, ERAS was also a program to reduce SSI's. ERAS added expanded interventions when it came to the United States, building on its European origins. ERAS is made up of various elements in 3 stages of the surgical process to include the pre-, intra-, and postoperative phase of care in the surgical setting. The 3 stages are:

- Preoperatively:
    - Preoperative patient education and counseling.
    - Meeting with the surgeon or intake nurse.
    - Use of multimodal analgesia.
    - A carbohydrate drink two hours before surgery.
- Intraoperatively:

  - Goal-oriented fluid management.
  - Judicious use of opioid pain relievers.
  - Minimally invasive surgery, when possible.
- Postoperatively:
  - Early ambulation postoperatively.
  - Early oral nutrition postoperatively.
  - Early removal of all lines, tubes, and drains,
  - Early transitioning to oral pain medications.

ERAS initially targeted orthopedic total joints, orthopedic fractures, and hysterectomies as their primary service lines. Since the launch, and due to the success, ERAS has been expanded to most surgical services lines in some way, shape, or form. The carbohydrate drink to keep the gut working, multimodal analgesia to reduce opioid usage, early postoperative nutrition to get the gut working postoperatively, and early ambulation are key pillars of ERAS that can be seen across service lines.

Clinical Problem

Despite the efforts over the years, SSI continues to be a priority for improved outcomes and patient care in the surgical population. It is estimated that SSI's occur in 2 percent to 5 percent of all patients undergoing surgery, translating to 160,000 to 300,000 people annually at a cost of $3.5 to $10 billion (Ban et al., 2017). An SSI substantially increases morbidity and mortality as patients are twice as likely to die, are 60% more likely to be admitted to the

intensive care unit (ICU), and the readmission rate is five times higher than patients who do not have a hospital acquired SSI (Darouiche, 2019).

In addition to the financial cost, the human burden of an SSI can be extraordinary. The average SSI increases the length of stay (LOS) by 9.7 days, causing prolonged hospitalization as well as separation from family and loved ones (Ban et al., 2017). Pain, anxiety, and loss of function can have a lasting impact on the patient and those close to them. Healthcare providers involved in the care of a patient impacted by an SSI may experience "second victims" trauma. A "second victim" in healthcare is a member of the care team that is having difficulty managing emotional distress related to the poor outcome of the patient (Tartaglia & Matos, 2020).

Methicillin-sensitive Staphylococcus aureus (MSSA) and methicillin-resistant staphylococcus aureus (MRSA) infections are the most common pathogens causing an SSI (Septimus, 2019). Nasal decolonization prior to surgery has shown to be an effective intervention to reducing MSSA and MRSA SSI's (Zhu et al., 2020). As nasal decolonization is not part of SCIP, ERAS or many SSI bundles, this is an area of opportunity for focused targeted improvement.

Nasal mupirocin is the most commonly used antibacterial agent used for preoperative nasal decolonization (Sporer et al., 2016). The use of nasal mupirocin has shown to decrease the risk for an SSI in patients who were colonized for Staphylococcus aureus in their nares prior to surgery. Mupirocin is a cream prescribed and dispensed from a tube. It is applied to both nares, three times a day for five days by the patient at home, prior to surgery. Though mupirocin is the most widely used antibacterial for nasal decolonization, due to the application regimen compliance by the patient can is low. Up to 75% of all patients fail to follow

the mupirocin application regimen, thus decreasing the effectiveness of the regimen (Tsang et al., 2018). This was attributed to the uncomfortableness of applying the nasal swab three times a day for five days, and the mess caused by applying the cream to the cotton tip applicator that is then placed in both nares.

Three years prior to this project, this medical center participated in a mupirocin nasal decolonization trial with other medical centers in the health system. As referenced in Tsang, et al, patient compliance was poor and no reduction in SSI's was realized from this work. Given the effectiveness of nasal decolonization, more exploration was done by the medical center where it was discovered povidone-iodine (PVP-I) is another antibacterial used in nasal decolonization.

A literature review was performed, and key stakeholders were consulted. After reviewing the literature and discussing with appropriate parties, the medical center decided to use the Profend Nasal Decolonization Kit. The kit consists of four applicators applied, two to each naris, containing 10% PVP-I. PVP-I is applied in the preoperative area by the registered nurse prior to the patient being transported to the operating room (OR) for surgery. The initial population identified were all patients undergoing orthopedic surgery with implantation. This included total joint arthroplasty (TJA) or a fracture repairs with hardware, followed by spine surgery. The rest of the surgical population followed within weeks of the initial orthopedic rollout.

Purpose

The purpose of this project was to evaluate the effectiveness of using a 10% PVP-I Nasal Decolonization Kits in the prevention of MSSA, MRSA, and other infections for patients

undergoing orthopedic surgery for a TJA or fracture repair at the medical center and patients with active MRSA or a history of MRSA.

Significance in Nursing

Nurses within the facility are responsible for educating, advocating, and partnering in the prevention of SSI's. The American Association of Colleges of Nurses (AACN) (2006) states the role of the DNP graduate nurse is to be initially involved in a practice that includes interdisciplinary collaboration, quality improvement, patient safety, and the knowledge of organizational and community systems. The AACN list eight DNP Essentials that the graduate nurse is to master prior to graduation. The DNP Essentials include:

- Scientific underpinning of practice.
- Organizational and System leadership for quality improvement and system thinking.
- Clinical scholarship and analytical methods for evidence-based practice.
- Information systems/ technology and patient care technology for the improvement and transformation of health care.
- Health care policy for advocacy in health care.
- Interprofessional collaboration for improving patient and population health outcomes.
- Clinical prevention and population health for improving the nation's health.
- Advanced nursing practice.

This DNP project used several of the 2006 AACN Essentials to guide the development of the project. DNP Essential I states that a DNP will be able to critically appraise literature to identify best practices and translate those findings into clinical practice. Prior to the start, a

literature search was performed to identify guidelines and best practices related to the prevention of SSI's and nasal decolonization. Review and assessment of the guidelines allowed for comparison of past and current practices at this community based medical center compared to best practices and current guidelines outlined by experts and governing bodies in the literature.

The basis for this project is nasal decolonization to decrease harm events for patients undergoing surgery. After the literature review was complete and a process was determined, the information was presented to the Regional Infection Prevention (IP) group for the health system. the Regional IP committee came back with a recommendation not to proceed with the use of PVP-I nasal decolonization. Despite the recommendation, nursing worked with local IP, surgeons from the facility, anesthesia providers, and pharmacy to review the data. DNP Essential II (AACN, 2006) relates to the critical need for nursing leaders to use organizational and system leadership to improve care. Gaining local consensus, the project was able to move forward.

DNP Essential III outlines the DNP graduate will engage to provide scholarly practice and the application of new discoveries in a complex practice (AACN, 2006). Mupirocin was a known intervention to the medical center for SSI's and had drawbacks that were deemed not sustainable to continue in practice. Searching the literature for viable alternatives produced the discovery of a single application of 10% PVP-I intervention. Upon analyzing the literature and presenting it to key stakeholders such as surgeons, anesthesia, and pharmacy, the project moved forward.

Information systems in the form of the electronic medical record (EMR) were utilized for effectively and reliably. This is encompassed in DNP Essential IV (AACN, 2006). The EMR

allows for information to be extracted in a systematic way and in a format ready for use in analyzing the data to determine outcomes.

DNP Essential VI (AACN, 2006) interprofessional collaboration to improve patient and population health. A team of professionals that included nursing surgeons, anesthesia and pharmacy worked in an interprofessional manner to deliver care to the patient population for this study. By keeping the patient at the center of the care, healthcare professionals were able to overcome initial objections to change and deliver care designed to reduce risk and improve outcomes.

The DNP nurse overseeing care in perioperative services is in a unique position to see all aspects of care through the department. Where other disciplines are focused on their phase of care, the DNP nurse in this case is tasked with coordinating multiple phases of nursing care as well as communicating and collaborating with the interprofessional team. These skills, coupled with the knowledge gained during this DNP program make up the foundation of DNP Essential VIII (AACN, 2006).

Project Objectives.

- Identify the patient population pre- and post-intervention at a community-based medical center.
- Identify areas for quality improvement in SSI rates for the pre- and post-intervention groups.
- Identify the impact of the intervention, both human and financial cost.

Chapter 2

Review of Literature.

Summary of Literature.

Surgical Site Infections are a worldwide health concern. SSI's are nondiscriminatory as they impact any age or gender, and are seen in all racial and ethnic populations. SSI's are a healthcare-associated infection that contributes to a longer length of hospital stay, higher mortality, increased readmissions, and increased cost associated with care (Copanitsanou, 2020). MSSA and MRSA are two of the most common organisms causing SSI's (George et al., 2016).

Nasal decolonization for MSSA and MRSA has shown to decrease infection rates (Huang et al., 2019). Pelfort et al. (2019) show SSI's involving MRSA and MSSA present a major adverse event in a total joining arthroplasty (TJA). Carriers of MSSA and MRSA are two to nine times more likely to develop a Staphylococcus aureus (S. aureus) SSI than patients that are not colonized (Elshafie et al., 2018). This is for all surgical outcomes. The purpose of targeted intervention for MSSA and MRSA are these organisms are generally considered to be a modifiable risk factor for SSI's (Zhu et al., 2020). A modifiable risk factor means preoperative nursing interventions can have an impact to positively change patient outcomes.

S. aureus is the leading cause of SSI's nationwide (Rezapoor et al., 2017). Patients who are colonized with MRSA are at high risk for infections after discharge from surgery (Huang et al., 2019). Although the prevalence of MSSA and MRSA in the nares varies by population, the general population's mean carriage rate is estimated to be at 37.2% (Kent et al., 2019). This

makes MSSA and MRSA a significant risk factor for patients undergoing surgery. Identification of the risk factors that contribute to a greater risk of MSSA and MRSA colonization may allow the reduction of SSI's and improve patient outcomes (Kent et al., 2019).

Did the intervention of universal preoperative nasal decolonization using a Nasal Decolonization (10% povidone-iodine solution) Kit reduce MSSA and MRSA infections in patients undergoing surgery in a 12-month period preintervention compared to a 12-month period post-intervention?

Related Research.

Meaningful Limits.

A search for literature was conducted for SSI interventions to include randomized controlled studies (RCS), Meta-analysis reviews, and systematic reviews. The literature was searched for MSSA and MRSA nasal decolonization processes and effectiveness. These limits were used to identify studies related to the clinical question on hand.

Identification.

PubMed was utilized for the literature search. The initial search had a date limit of 2016 to the present and resulted in 254 articles returned for review. This was the only source utilized for publications at this time.

Screening.

The initial 254 articles were all screened as related to the clinical question. Titles and keywords in the articles were reviewed to look at the relationship to the clinical question. The following exclusion criteria were used to reduce the sample size:

- Intervention that did not include nasal decolonization.
- Multiple interventions that included nasal decolonization.
- Too specific of a population or age group.

Forty-six articles were left for review after this screening for exclusion criteria.

Eligibility.

Eligibility was assessed for the 46 articles remaining. Out of the articles reviewed, 19 were deemed applicable to the clinical question. Reasons for exclusion included the following:

- The full-text article was not available.
- An article in English was not available.
- The sample size was too small.
- It was a repeat study.
- The setting was not applicable.
- The study was not pertinent to the clinical question.

Review of findings.

Decreasing SSI's through nasal decolonization remains controversially related to mixed outcomes in published literature (Rohrer et al., 2020). Mupirocin is the most common choice for intervention for nasal decolonization. Combined with chlorhexidine (CHG) skin wipes, 2% topical mupirocin is the most widely used topical antibacterial agent used for nasal

decolonization (Septimus, 2019). Mupirocin instructions for use, or application, include three times daily applications at home for 5-days by the patient prior to the day of surgery using a 2% mupirocin ointment (Tsang et al., 2018).

George, Leasure, and Horstmanshof (2016) concluded that nasal decolonization using mupirocin in conjunction with chlorhexidine skin cleansing effectively reduced MSSA and MRSA SSI's. This conclusion was reached meta-analysis of the literature for this intervention. Sources were identified by searching electronic databases to include Medline, Embase, EBSCO, CINHAL, EMB reviews, and Google Scholar. A summary of the data concluded SSI's are among the most common hospital-acquired infections (HAI's) and demonstrated that eradication of nasal decolonization was associated with a reduction of the introduction of S. aureus bacteremia, along with the conclusion that nasal decolonization reduced MSSA and MRSA SSI's (George et al., 2016).

Sporer et al. (2016) examined 9,690 patients undergoing a total joint arthroplasty (TJA) and realized an initial SSI rate of 1.11% reduced to 0.34% post-intervention using MSSA screening with mupirocin nasal decolonization. This review was conducted at a single medical center site from 2009 to 2014. The savings for this reduction at this one facility was estimated at $231,741 for this single medical center.

MSSA, MRSA, and Methicillin-resistant Staphylococcus epidermidis (MRSE) nasal carriage is listed as the only independent risk factors for patients undergoing orthopedic surgery (Elshafie et al., 2018). The use of a mupirocin protocol preoperatively reduced the identified SSI's from 8 SSI's to 1 in the study group of 1108 patients at a single surgery site. This is credited with a shorter length of stay, higher postoperative patient function, and increased patient satisfaction post-surgery (Elshafie et al., 2018).

While many studies show promising outcomes for the use of mupirocin, with some studies showing internasal mupirocin has decreased 85% of MSSA and MRSA colonization after treatment, other literature is not as clear (Stambough et al., 2017). Four studies that used mupirocin for nasal decolonization in cardiothoracic surgery showed no statistical difference before and after the intervention (Tang et al., 2020). Also, other reviews have shown MRSA strands that are resistant to mupirocin (Humphreys et al., 2016). This leads to a knowledge gap, as more research is needed to determine efficacy. Despite this, mupirocin is the most studied and considered the most effective agent for eradicating S. Aureus colonization in the nares (Septimus, 2019).

This project reviews the use of a 10% povidone-iodine solution for Kaiser Fresno Medical Center. PVP-I is a complex polyvinylpyrrolidone and tri-iodine ions used as an antiseptic for skin, wounds, and mucous membranes (Septimus, 2019). While providing an affordable intervention, PVP-I is also an effective and readily available antiseptic option for nasal decolonization (Eggers, 2019). PVP-I has shown to have a broad antibacterial spectrum and is active against many viruses and antibacterial-resistant strains, including MRSA (Elshafie et al., 2018).

Eggers (2019) points out PVP-I has high potency for virucidal activity with MRSA along with MSSA, hepatitis A, influenza, Middle- East Respiratory Syndrome (MERS), and Sudden Acute Respiratory Syndrome (SARS). This has led it be used for nasal decolonization for MSSA and MRSA, as it has not shown the cross-resistance that has been documented in other nasal decolonization agents. PVP-I is well tolerated by most patients, particularly when applied to the skin and nares, and is rarely associates with allergic contact dermatitis or other reactions to the medication (Eggers, 2019).

Rezapoor et al. (2017) noted a significant decrease in positive nares cultures 4 hours and 24 hours after swabbing with a 5% PVP-I solution and a 10% PVP-I solution. This protocol is to swab each naris twice, two minutes apart in the preoperative area of the facility prior to entering the operating room (OR) suite. The effectiveness of PVP-I has been criticized due to inactivation by nasal secretions. This has been mitigated by PVP-I using film-forming excipients that improve adhesion of the solution and protection from inactivation from the nasal secretions by changing the pH levels or my interacting with the organic nasal compounds (Rezapoor et al., 2017).

A surgical site infection, especially a deep or organ space, can have a devastating effect on the patient, family, and providers. SSI's in the United States increase hospital costs by $3-$10 billion per year, add 7- 10 additional hospital days per patient and have a mortality rate of 3% that is directly attributed to the SSI (Rezapoor et al., 2017). The average cost of a periprosthetic joint infection (PJI) was reported in one study as $25,692 for a total hip arthroplasty (THA) and $31,753 for a total knee arthroplasty (TKA) (Kerbel et al., 2018). Other studies note the cost of a revision for a total joint arthroplasty related to a PJI between $23,000 and $25,000, or more, per incident (Sporer et al., 2016).

In addition to the financial impact on the healthcare system, a patient is ultimately impacted. A postoperative SSI for a patient decreases mobility, increases pain, and increased morbidity. The significant morbidity and the enormous cost associated with TJA SSI make preventive measures to reduce infection rates of major importance (Pelfort et al., 2019).

Nasal decolonization can be a cost-effective means to treat and eliminate colonized MSSA and MRSA prior to undergoing elective surgery in order to reduce the risk of a postoperative SSI (Peng et al., 2018). As noted above, an SSI can significantly impact the cost

of care, length of stay, quality of life, quality of function, and morbidity and mortality for the patient. The cost of decolonization can vary depending on product use but is noted between $5 and $18 per application (Stambough et al., 2017).

Universal nasal decolonization programs produce a similar reduction in SSI's compared to facilities using targeted screening programs (Tang et al., 2020 and Stambough et al., 2017). Additionally, direct culture is the least sensitive method used for detecting MSSA and MRSA and could provide a false negative for a colonized patient as well as an increased cost (Tansarli et al., 2020).

PVP-I is applied using four swabs, two each naris, in the preoperative department before the patient goes to the OR. This is considerably easier than the mupirocin regiment of three times a day for 5-days at home before surgery. Profend is also an immediate intervention when a 5-day read time is not always available for surgery. This is especially important in orthopedic trauma cases such as fractures. The ease of use and increased compliance, along with no known cross resistance, made PVP-I the intervention of choice for this study. Universal nasal decolonization was chosen for this study related to the increased cost and effort needed to culture patients prior to surgery, and the reliability of the swabbing technique related to collecting a specimen.

Gaps in literature.

Mupirocin is the intervention that has been studied the most with promising results for TJA (Elshafie et al., 2018). With this, inconclusive results related have been noted with other service lines within perioperative services (Stambough et al., 2017). This leads to the need for further investigation. This medical center has used mupirocin and did not continue with the

intervention after the trial period related to poor patient compliance with the preoperative application protocol and no significant impact on SSI's.

PVP-I has shown to be effective at SSI reduction for MSSA and MRSA. This leads to the question of whether an intervention with PVP-I can improve compliance to decrease SSI's in the surgical population.

Chapter 3

Methods.

Project Design.

This project took place in a perioperative services department at a community-based medical center in central California in the heart of the San Joaquin valley. This department performs about 10,000 cases annually, though the past year has experienced about a 20% decrease in surgical volume related to Covid- 19 and the subsequent shutdowns of the operating room (OR) related to inpatient surge volumes that impacted hospital capacity. This medical center has:

- 169 licensed beds.
- 2,533 employees.
- 326 physicians.
- 46,721 emergency department visits in 2019.
- 1,596 newborn deliveries in 2019. (*Fresno*, n.d.)

This medical center is an integrated health system comprised of three entities with exclusive contracts with one another. The three entities include the health plan, network hospitals, and the corresponding medical group. All patients undergoing surgical procedures are members of the health plan, meaning all care is provided at the system hospital with a surgeon from the system's medical group. Therefore, all information is tracked in a single electronic medical record (EMR). Should a patient experience an emergency or some other situation after surgery that would result in that patient seeking care outside of a system medical center, the health plan is notified to pay the claim, and information from the outlying hospital will be transmitted back to the system medical center for insertion into the EMR, ensuring the ability to track all patients postoperatively for complications. The only exception to this process would be

a patient seeking care at an outside facility and that patient does not submit the claim to the health plan for coverage and reimbursement. This is important to note as all medical care is captured in a single EMR, accessible for review in this project.

This DNP project will focus on a retrospective chart review for the collection of data from the medical centers EMR. Data included the date of surgery, the type of surgery, age, sex, and BMI. For patients that experience an SSI, the date of diagnosis for infection, type of organism causing the SSI, and whether or not Profend was used preoperatively was captured. Number of infections in the preintervention and postintervention group were examined along with demographic variables for each patient. The data collection provided for a better understanding of SSI's for this medical center.

This medical center implemented a 10% PVP-I nasal decolonization program in July 2019 in an effort to reduce SSI's. This DNP project is a program review to evaluate the effectiveness of that intervention. The sample used for this review was all patients undergoing an orthopedic procedure for a total joint arthroplasty or an orthopedic fracture in the operating room of a community-based medical center. The time period will be the 12-month period immediately prior to and the 12-moht period after the implementation of PVP-I nasal decolonization. The preintervention group timeframe is July 1, 2018, to June 30, 2019. The postintervention group timeframe is August 1, 2019, to July 31, 2020. Implementation of the intervention was conducted in July 2020.

Implementation started with an introduction to the physician chiefs for each service line by members of the SSI reduction committee to include the perioperative services director, physician OR director (PORD), assistant physician in chief (APIC) for quality, and members of the infection prevention team. Staff education for the preoperative RN's and OR RN's was

conducted in partnership with the vendor and included written material and hands-on application of the nasal swab. PVP-I nasal decolonization orders were added to the anesthesia order set in the EMR and were also an ad-hoc order that could be placed by any provider.

The rollout occurred over a 2-week period starting with orthopedic surgery at the medical center, followed by neurosurgery, and then continued through all service lines. This was to allow for 1:1 observation of RN's performing the intervention and allow for workflows to be finalized and barriers addressed. No major issues occurred in the July 2019 rollout of the nasal decolonization process. The implementation was planned over a four-week period, but due to ease of use by the nursing staff and buy in from providers, the timeframe was compressed and completed within two weeks.

Sample.

Data was collected from the EMR in a retrospective chart review for patients undergoing an orthopedic procedure with implantation at the community-based medical center. Information from the EMR was exported to a spreadsheet for review. An exhaustive census sample was used to capture all patients. Being an integrated healthcare system, the postoperative follow-up was captured for 100% of patients undergoing surgery.

The preintervention group from July 2018 to June 2019 included 431 unique patients. The postintervention group from August 2019 to July 2020 included 365 patients. Data was compiled by the facility infection prevention manager, the infection prevention analyst, and the author. Patient names and medical record numbers were masked to ensure patient confidentiality. The decrease in surgeries between the two groups was contributed to the facility

reduction of surgeries related to the Covid-19 pandemic and was not seen as significantly significant to impact the outcome.

Methods.

This DNP project used a retrospective data review from data points previously collected as part of standard work performed in the EMR. Informed consent from patients was not required due to the nature of the review. The infection prevention department and the author were the only individuals to see patient-identifying information. All patient information was blinded when the information was displayed. A standard report from the EMR was run to collect all patient data.

For reliability, SSI data from the report was cross-checked with SSI data reports generated by the infection prevention department. Any discrepancy in data between the EMR and infection prevention triggered a manual drill-down to verify the accuracy of data. The findings of the drill-down was then shared between the three members of the data collection team and consensus for the correct data recording was achieved. There were three discrepancies recognized in the data pertaining to an SSI. On all three occurrences, the error was attributed to a transcription error from the EMR to the infection prevention report, and the information from the EMR was deemed correct.

The number of infections in each group was identified and reviewed. Observer bias or the Hawthorne effect by the surgeons or the perioperative team was not considered a factor for this review. The Hawthorne effect is when individuals, or a group of individuals, change normal behavior when they are aware, they are being observed (Demetriou et al., 2019). The chart

review was conducted after the completion of the post-intervention group; therefore, no member of the perioperative team was aware a review for this data would occur.

Instruments.

The primary data collection tool was an Excel spreadsheet. An internal report from the EMR was run to extract most data into the Excel spreadsheet. Tableau software was used to extract PVP-I use in the post-intervention group. Tableau is an interactive visual software used by the medical center to extract reports and data not available on the EMR platform (*Tableau*, n.d.).

The primary data for the review was the presence of an SSI within 30-days of the surgical date. In addition to the presence of an infection, date of surgery, the type of surgery, age, sex, BMI, date of diagnosis for infection, type of organism causing the SSI, and whether or not Profend was used preoperatively were collected. Cultures were not performed on all documented SSI's. In those cases, "no culture" was noted on the collection tool.

Patient age, sex, surgical wound classification, ASA classification, SSI level of infection, and date the infection is detected will also be collected. The CDC has standardized classification definitions for wound classifications to correctly establish the cleanliness and condition of the surgical site prior to surgery. These classifications are:

- Class 1- clean wound. Wounds that are uninfected with no signs and symptoms of infection and are closed postoperatively with primary closure.
- Class 2- clean-contaminated wound. Controlled entry through the mouth, ears nose, or urinary system are classified as a wound class 2. A puncture wound, either external by a nail, knife, or gunshot wound, or internal by a broken bone protruding through the skin can also be a Class 2 wound.
- Class 3- contaminated wound. Contaminated wounds occur from a gross break in sterile technique, or an internal leak from the gastrointestinal tract into the wound. The break in sterile technique can be before or during surgery.

- Class 4- dirty infected wound. These wounds are typically the result of trauma where the infection is already present or contaminated contents, such as stool in the abdominal cavity, are present at the time of surgery.

(Herman & Bordoni, 2020)

The ASA Classification, also known as the American Society of Anesthesiologists Physical Status Classification System, is used to stratify risk factors related to anesthesia and has been used for over 60 years (*ASA Physical Status Classification System*, 2020). The ASA Classification categories are:

- ASA 1- A normal healthy patients
- ASA 2- A patient with mild systemic disease.
- ASA 3- A patient with sever systemic disease.
- ASA 4- A patient with sever systemic disease that is a constant threat to life.
- ASA 5- A patient that is not expected to survive without the surgery.
- ASA 6- A brain-dead patient for the purpose of organ donation.

Wound Class and ASA Class are important indicators for complications and risk stratification in the comparison of outcomes in two groups.

Data analysis.

Upon completion of data collection, the information will be saved and uploaded into the department's secure shared drive. Limited file access was given to the data. The author, the IP manager, and the IP analyst are the only individuals with file access.

A two proportions z-score will be used to determine statistical significance of the data set. The hypothesis for implementation of the nasal colonization was 10% PVP-I is the reduction of risk for postoperative infections, SSI's, at the medical center. In statistics, a hypothesis test will determine quality under a given assumption (Hamasaki et al., 2021). The z-test will determine whether the assumption has been violated or rejected. Calculating the p-value of the

data in a z-test determines the validity of the hypothesis. The lower the p-value, the stronger the evidence to reject the null hypothesis. A p-value less than 0.05 indicates statistical significance.

Chapter 4

Results.

The purpose of this DNP project review was to review the impact PVP-I nasal decolonization had on the reduction of SSI's at a community-based medical center. The data for the review was divided into two groups consisting of the preintervention, from July 1, 2018, to June 30, 2019, and the postintervention group, from August 1, 2019, to July 31, 2020.

The preintervention group was composed of 431 patients. The postintervention group contained 365 patients. The average age was 70.9 years and 71.3 years for the preintervention and postintervention groups respectively. The breakdown was 62% female and 38% male for both groups. The average wound classification was 1.1 for the preintervention group and 1.0 for the postintervention group. The ASA classification for the two groups was the same at 2.5. The two groups were very similar in makeup (See Table 1 below).

Table 1:	Ave Age	Sex F/M	Wound Class					ASA				
			1	2	3	4	Ave	1	2	3	4	Ave
Preintervention	70.9	62%/38%	419	2	2	8	1.1	2	237	179	13	2.5
Postintervention	71.3	62%/38%	359	4	0	2	1.0	7	189	159	10	2.5

In a review of the raw data (Table 2) there were eight (8) post-operative infections in the preintervention group and one (1) postoperative infection in the postintervention group. This translates to a 1.86% infection rate in the preintervention group, compared to a 0.27% infection rate in the postintervention group with a p-value of 0.0376 (Table 3). A p-value less than 0.05 is significant and means the chance of a type 1 error is small.

Table 2:

Unique Identifier	Procedure(s)	Procedure IDs	Pat Age	Sex	Wound Class	ASA Class	SSI Level	Date	Date of Event	POD#	Pathogen
2018-066	HIP REPLACEMENT REVISION TOTAL	121421	82.56	F	1	3		08/20/2018	9/3/2018	15	p. mirabilis
2018-106	HIP FRACTURE- NAIL INSERTION	1215431	76.69	F	1	2		09/30/2018	10/28/2018	28	No Culture
2018-127	KNEE REPLACEMENT TOTAL BILATERAL	1214538	64.09	F	1	3		10/16/2018	11/9/2018	22	MRSA
2018-166	HIP REPLACEMENT REVISION TOTAL	121421	63.74	M	1	2		11/16/2018	12/12/2018	26	S. Aureus
2018-191	KNEE REPLACEMENT TOTAL	1211672	77.88	M	1	2		12/03/2018	12/22/2018	19	No Culture
2018-216	KNEE REPLACEMENT TOTAL	1211672	72.15	F	1	3		12/27/2018	1/25/2019	30	MRSA
2018-266	KNEE REPLACEMENT TOTAL	1211672	73.48	F	1	2		02/05/2019	2/20/2019	16	No Culture
2018-272	KNEE REPLACEMENT REVISION	1213898	69.19	F	1	3		02/13/2019	3/9/2019	25	Pseudomonas
2019-169	HIP FRACTURE- NAIL INSERTION	1215431	95.4	F	2	3		01/04/2020	1/29/2020	26	No Culture

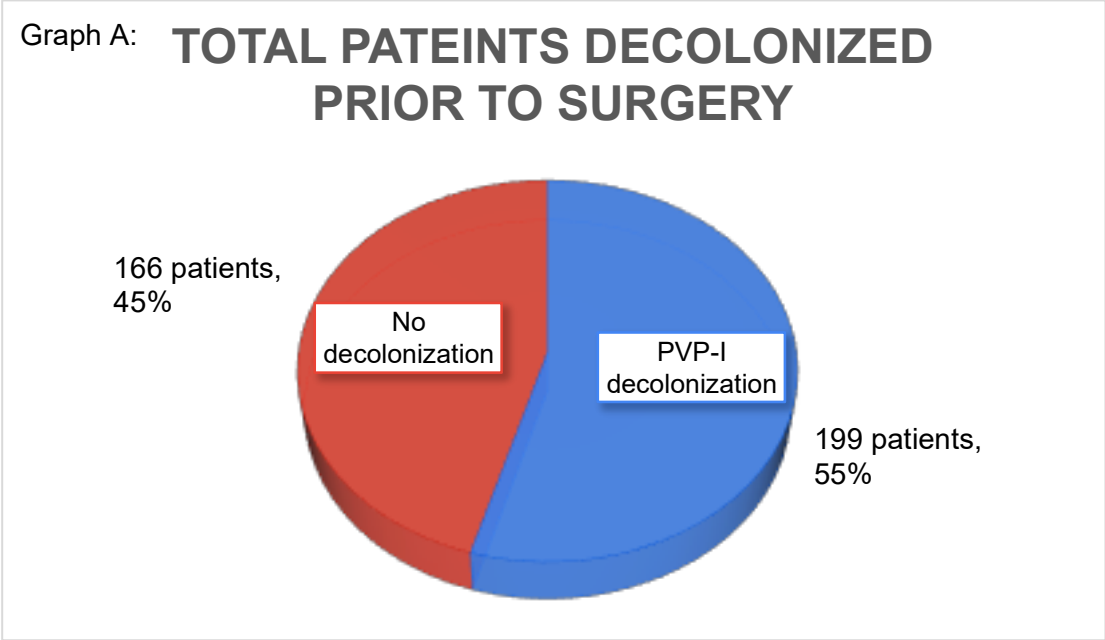
Table 3:

Z-score proportions test	Pre-Intervention	Post- Intervention
Number of Events (Infections- Numerator)	8	1
Number of Trials (Denominator)	431	365
Number of non-events (Trials- Events)	423	364
Proportion	1.86%	0.27%
z- value		2.1037
p-value		0.03572

Secondary findings.

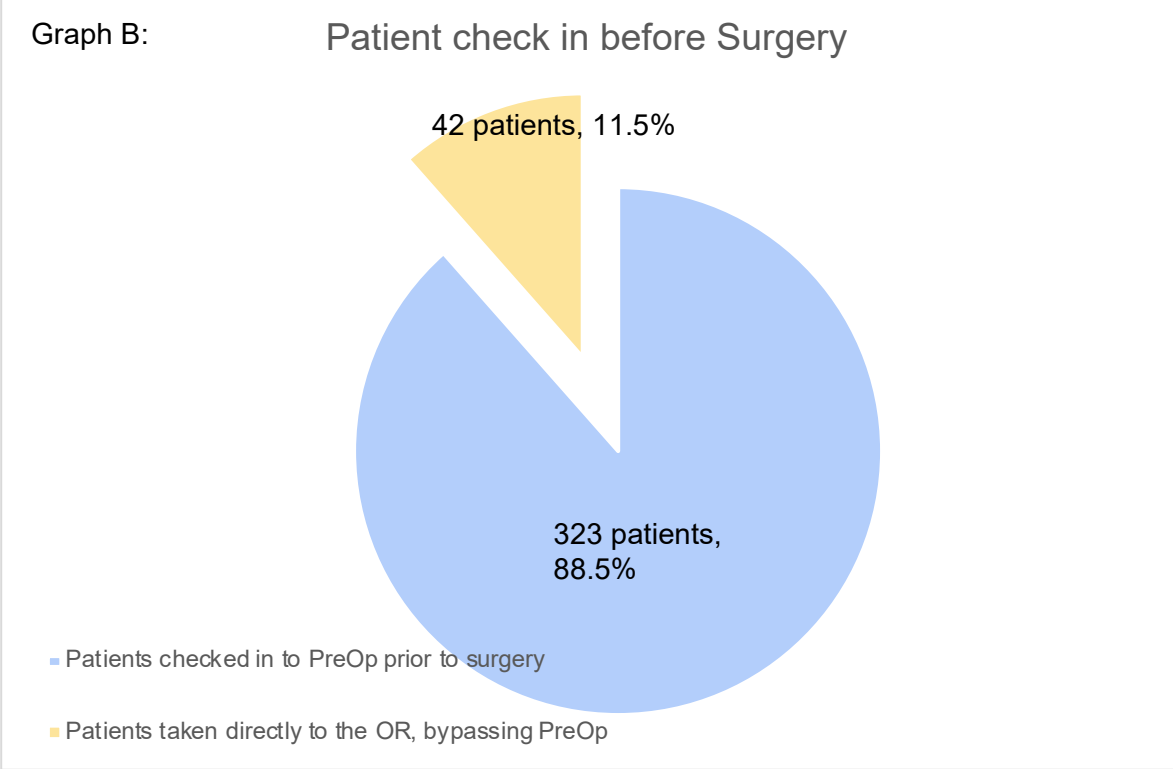
Implementation occurred in July 2019 with data collection range for the intervention group from August 1, 2019, to July 31, 2020. It was expected 80% of the patients undergoing surgery would be decolonized with 10% PVP-I prior to surgery. In the review of the data, 55% of patients were decolonized with PVP-I during the examination period. Out of this, there were two distinct groups: patients that were sent to the preoperative area; patients that bypassed the preoperative area (Graph A).

Graph A:



The preoperative unit (PreOp) is open Monday through Friday from 0600 to 1700 each day. All outpatients and patients coming from the medical-surgical floor to the OR are first taken to the preoperative unit within perioperative services where an RN repairs them for surgery. During hours where the PreOp is closed, or if the patient is coming to the OR from the critical care unit (CCU) or the telemetry unit (Tele), then the patient goes direct to the OR. In this workflow, the OR RN, rather than the PreOp RN, checks the patient in for surgery. As the data shows, 323 of the 365 patients, or 88.5%, in the intervention group were check-in through the PreOp, leaving 42 patients that went directly to the OR (See Graph B).

Graph B:



This created two subgroups in the intervention group; patients that went through PreOp and Patients that did not go through PreOp. For patients that went through PreOp prior to surgery, 192, or 494%, of the 323 patients were decolonized. Patients that did not go through PreOp prior to surgery had a 16.7% decolonization rate, 7 out of 35 (See table 4).

Table 4:	PVP-I decolonization	No decolonization	Total	Percentage decolonized
PreOp	192	131	323	59.4%
No PreOp	7	35	42	16.7%
Total	199	166	365	54.5%

Chapter 5

Project summary.

This DNP project review was undertaken to assess the implementation and effectiveness of 10% PVP-I in the reduction of SSI's for patients undergoing orthopedic surgery with Implantations, to include total joint arthroplasty and orthopedic fracture repair surgery. The project initially focused on the impact of 10% PVP-I on MSSA and MRSA infections only. In the literature review phase of the project, it was discovered PVP-I had broader coverage outside of the staphylococcus aureus bacteria strains.

This program review did determine the implementation of PVP-I had a significant impact on SSI's for the population under review. The proportion of SSI's in the preintervention group was 1.86% compared to the postintervention rate of 0.27%. This resulted in a p-value of 0.03572 using a two-proportion z- score, showing a statistically significant change in SSI's. This resulted in seven (7) fewer SSI's in the postintervention group. The facility also saw a decrease in the overall SSI odds ratio from 1.17 in July of 2019 to 1.11 in July of 2020.

A secondary finding noted poor administration of PVP-I in patients undergoing surgery. The facility goal was 80% of all patients undergoing surgery would receive nasal decolonization with PVP-I prior to surgery. The data review showed only 54.5% of the patients overall receiving PVP-I prior to surgery. For patients that bypassed the preoperative area of the facility and went directly to the OR, the compliance rate was 16.7%.

The one patient diagnosed with an SSI in the postintervention group, patient 2019-168 (Table 2), had surgery on a Saturday afternoon, bypassing the preoperative unit, and did not have

documentation of nasal decolonization in the MAR prior to surgery. A review of the nursing workflows to improve compliance may be beneficial in support of nasal decolonization.

Limitations.

Retrospective chart audits and studies offer a wealth of information. However, there are a number of potential pitfalls and barriers to this type of review. All data were collected by the author and allows for possible bias or misinformation. Though data was collected by the author, it was reviewed by members of the medical center's infection prevention department, decreasing the risk of bias or misinformation. All information gathered is part of a terminate medical record that cannot be altered by the author, making verification of data easier.

Retrospective project designs can be prone to misclassification. In the process of verifying automated data a number of discrepancies were noted by the author. This resulted in a more in depth, manual review of the EMP to verify validity of data obtained. Other data analysts were engaged in the verification process as well.

The data collected for this project focused on a single service line, orthopedic surgery with implants, at a single sight community-based medical center, limiting the scope. Expanding the review to all service lines and other facilities would broader the foundation of data and provide further insight into effectiveness.

Future research.

Future research could include more service lines within surgical services and more facilities other than a single-site medical center. This would broaden the number of interventions to give a fuller picture of the impact and effectiveness of PVP-I in the reduction of SSI's.

With the Covid-19 pandemic, the world has become more familiar with the Coronavirus (CoV) family of viruses. There are currently seven documented coronaviruses in the human population. They are:

- Severe Acute Respiratory Syndrome (SARS or SARS-CoV)
- Middle East Respiratory Syndrome (MERS or MERS-CoV)
- SARS-CoV hCoV-HKU1
- hCoV-OC43
- hCoV-NL63
- hCoV-229E
- SARS- CoV-2 (Covid- 19) (Zhu, et al., 2020)

Though four of the CoVs are non-life threatening and manifest in mild cold or flu type symptoms, SARS, MERS and now Covid- 19 have shown to be deadly in the human population. PVP-I has shown a high potency for virucidal activity against SARs and MERS (Eggers, 2019). Given this information and the magnitude of the Covid- 19 pandemic, further research on the use of PVP-I for the prevention and treatment of Covid- 19 would be beneficial.

HAI's from colonized pathogens such as Staphylococcus aureus, enterococci, gram-negative organisms, and Clostridium difficile are associated with an increased risk of infection (Septimus, 2019). Mupirocin is considered the gold standard for nasal decolonization despite low compliance rates by patients and the increased concern regarding Mupirocin resistant organisms (Humphreys et al., 2016). PVP-I has shown ease of use and is not susceptible to organism resistance. Further investigation into the use for PVP-I nasal decolonization for the prevention of HAI's could provide a low-cost intervention to reduce harm events in the acute care setting.

In addition, SSI's were diagnosed on postoperative day (POD) 15 to 30 in the preintervention group, with the average POD to diagnoses being 22.6 days. The one SSI in the postintervention group was POD 26. This could pose the question on whether the SSI's were caused by a pathogen introduced during surgery or was the SSI related to postoperative wound care?

Dissemination method.

This is a single community-based medical center that is part of a system of 21 hospitals in Northern California. Locally opportunity for discrimination includes staff in-services, presentations for physicians at their service line specific meeting, and the facility's SSI workgroup. In addition, there is a monthly surgical quality and safety committee (SQS) comprised of a multidisciplinary team are well as the operating room committee (ORC) which has representation for surgeons, anesthesia, and the facilities perioperative services leadership team. SQS also reports up to a Regional SQS oversight committee that provides oversight to local medical centers. Regional peer groups for SSI, infection prevention and SQS are additional forums for the dissemination of these results.

Impact of the program.

The summary will cover three areas to determine success and outcome of the nasal decolonization program. These three areas are:

- Success to the patient.
- Successful implementation of a nasal decolonization program.
- Successful impact to the facility.

The patient.

As previously noted, nasal decolonization with 10% PVP-I showed a significant decrease from eight SSI's in preintervention group, or an infection rate of 1.86%, compared to one SSI, or an infection rate of 0.27%, in the postintervention group. This means seven few patients in the 12-month time frame of the postintervention group. This statistical difference did provide for better outcomes and a positive impact for patients undergoing orthopedic surgery.

The program.

Program implementation was also successful, though this review did show gaps in nursing practice that could be improved to provide better patient care. Compliance for the 5-day mupirocin regimen is noted to be as low as 25% nationally (Tsang et al., 2018). Though the compliance rate for PVP-I was lower than expected, at 54.5%, during the postintervention period, this is a significant improvement over that of mupirocin or no intervention at all.

The facility.

Reducing SSI's by seven cases in a 12-month period had a positive financial impact. The cost per nasal decolonization project ranged between $5 and $18 per treatment. That calculates to an annual cost of $6,570 for 356 patients in the 12-month postintervention group. The average cost of an orthopedic SSI was listed at $23,000 to $25,000 per infection. Seven orthopedic patients with a postoperative SSI would have a financial impact of approximately $161,000 (using the low average of $23,000 x 7 patients). A nasal decolonization program, in this case, therefore, shows a potential savings of $154,430 over the course of the year (See Table 5).

Table 5:		
Cost of an infection (low ave) per patient	$	23,000.00
Number of patients		7
Total Cost of an SSI	$	161,000.00
Cost of the intervention (High Ave) per patient	$	18.00
Number of patients		365
Total cost of intervention	$	6,570.00
Savings (annual)	**$**	**154,430.00**

Implementation of PVP-I did show decease in the facility SSI odds ratio, though this decrease was not statistically significant. The odds ratio for the preintervention timeframe was 1.17 compared to the odds ratio of 1.11 for the postintervention time period.

Conclusion.

Though the facility did not see a significant change in their SSI odds ratio, the nasal decolonization program was successfully implemented, the number of SSI's were reduced and there was a potential financial savings associated with the intervention. Though more study is needed, this implementation has shown a positive impact on patient care and is another step in reducing total patient harm.

References

ASA Physical Status Classification System. (2020, December 13). American Society for Anesthesiologists. Retrieved March 29, 2021, from https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

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

Copanitsanou, P. (2020). Recognising and preventing surgical site infection after orthopaedic surgery. *International Journal of Orthopaedic and Trauma Nursing*, *37*, 100751. https://doi.org/10.1016/j.ijotn.2019.100751

Darouiche, R. (2019, January 19). *Surgical Site Infections*. Infectious Disease Advisor. Retrieved December 14, 2020, from https://www.infectiousdiseaseadvisor.com/author/rabih-darouiche-dsm/

Demetriou, C., Hu, L., Smith, T. O., & Hing, C. B. (2019). Hawthorne effect on surgical studies. *ANZ Journal of Surgery*, *89*(12), 1567–1576. Retrieved January 18, 2021, from https://doi.org/10.1111/ans.15475

Descriptive and Inferential Statistics. (2018). Laerd Statistics. Retrieved January 18, 2021, from https://statistics.laerd.com/statistical-guides/descriptive-inferential-statistics.php

Dietz, N., Sharma, M., Adams, S., Alhourani, A., Ugiliweneza, B., Wang, D., Nuño, M., Drazin, D., & Boakye, M. (2019). Enhanced recovery after surgery (eras) for spine surgery: A

systematic review. *World Neurosurgery*, *130*, 415–426. https://doi.org/10.1016/j.wneu.2019.06.181

DNP Essentials. (n.d.). AACN. https://www.aacnnursing.org/DNP/DNP-Essentials

Drake, K. (2011). Scip core measures. *Nursing Management (Springhouse)*, *42*(5), 24–30. https://doi.org/10.1097/01.numa.0000396344.54830.0d

Eggers, M. (2019). Infectious disease management and control with povidone iodine. *Infectious Diseases and Therapy*, *8*(4), 581–593. https://doi.org/10.1007/s40121-019-00260-x

Elshafie, S. S., Landreau, P., & Popovic, N. (2018). Preoperative screening and decolonization protocol for methicillin – resistant staphylococcus aureus, methicillin – resistant staphylococcus epidermidis and methicillin sensitive staphylococcus aureus prevents orthopedic surgical site infections. *Microbiology & Infectious Diseases*, *2*(2). https://doi.org/10.33425/2639-9458.1031

Fresno. (n.d.). Kaiser Permanente. Retrieved February 15, 2021, from https://fresno.kaiserpermanente.org/about-us/

George, S., Leasure, A., & Horstmanshof, D. (2016). Effectiveness of decolonization with chlorhexidine and mupirocin in reducing surgical site infections. *Dimensions of Critical Care Nursing*, *35*(4), 204–222. https://doi.org/10.1097/dcc.0000000000000192

Hamasaki, T., Bretz, F., LaVange, L. M., Müller, P., Pennello, G., & Pinheiro, J. C. (2021). Editorial: Roles of hypothesis testing, p-values and decision making in biopharmaceutical research. *Statistics in Biopharmaceutical Research*, *13*(1), 1–5. Retrieved March 7, 2021, from https://doi.org/10.1080/19466315.2021.1874803

Haun, J. N., Patel, N. R., Lind, J. D., & Antinori, N. (2015). Large-Scale Survey Findings Inform Patients' Experiences in Using Secure Messaging to Engage in Patient-Provider

Communication and Self-Care Management: A Quantitative Assessment. *Journal of Medical Internet Research*, *17 (12)*. https://doi.org/10.2196/jmir.5152

Herman, T. F., & Bordoni, B. (2020, April 14). *Wound Classification*. NCBI. Retrieved March 29, 2021, from https://www.ncbi.nlm.nih.gov/books/NBK554456/

Huang, S. S., Singh, R., McKinnell, J. A., Park, S., Gombosev, A., Eells, S. J., Gillen, D. L., Kim, D., Rashid, S., Macias-Gil, R., Bolaris, M. A., Tjoa, T., Cao, C., Hong, S. S., Lequieu, J., Cui, E., Chang, J., He, J., Evans, K.,...Miller, L. G. (2019). Decolonization to reduce postdischarge infection risk among mrsa carriers. *New England Journal of Medicine*, *380*(7), 638–650. https://doi.org/10.1056/nejmoa1716771

Humphreys, H., Becker, K., Dohmen, P., Petrosillo, N., Spencer, M., van Rijen, M., Wechsler-Fördös, A., Pujol, M., Dubouix, A., & Garau, J. (2016). Staphylococcus aureus and surgical site infections: Benefits of screening and decolonization before surgery. *Journal of Hospital Infection*, *94*(3), 295–304. https://doi.org/10.1016/j.jhin.2016.06.011

Kent, S. E., Schneider, G. B., Hollenbeck, B. L., & Vlad, S. C. (2019). Risk factors for staphylococcus aureus colonization in a presurgical orthopedic population. *American Journal of Infection Control*, *47*(8), 902–905. https://doi.org/10.1016/j.ajic.2019.02.008

Kerbel, Y. E., Sunkerneni, A. R., Kirchner, G. J., Prodromo, J. P., & Moretti, V. M. (2018). The cost-effectiveness of preoperative staphylococcus aureus screening and decolonization in total joint arthroplasty. *The Journal of Arthroplasty*, *33*(7), S191–S195. https://doi.org/10.1016/j.arth.2018.01.032

Pelfort, X., Romero, A., Brugués, M., García, A., Gil, S., & Marrón, A. (2019). Reduction of periprosthetic staphylococcus aureus infection by preoperative screening and

decolonization of nasal carriers undergoing total knee arthroplasty. *Acta Orthopaedica et Traumatologica Turcica*, *53*(6), 426–431. https://doi.org/10.1016/j.aott.2019.08.014

Peng, H., Wang, L., Zhai, J., Weng, X., Feng, B., & Wang, W. (2018). Effectiveness of preoperative decolonization with nasal povidone iodine in chinese patients undergoing elective orthopedic surgery: A prospective cross-sectional study. *Brazilian Journal of Medical and Biological Research*, *51*(2). https://doi.org/10.1590/1414-431x20176736

Rezapoor, M., Nicholson, T., Tabatabaee, R., Chen, A. F., Maltenfort, M. G., & Parvizi, J. (2017). Povidone-iodine–based solutions for decolonization of nasal staphylococcus aureus : A randomized, prospective, placebo-controlled study. *The Journal of Arthroplasty*, *32*(9), 2815–2819. https://doi.org/10.1016/j.arth.2017.04.039

Rohrer, F., Nötzli, H., Risch, L., Bodmer, T., Cottagnoud, P., Hermann, T., Limacher, A., Fankhauser, N., Wagner, K., & Brügger, J. (2020). Does preoperative decolonization reduce surgical site infections in elective orthopaedic surgery? a prospective randomized controlled trial. *Clinical Orthopaedics & Related Research*, *478*(8), 1790–1800. https://doi.org/10.1097/corr.0000000000001152

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

Septimus, E. J. (2019). Nasal decolonization: What antimicrobials are most effective prior to surgery? *American Journal of Infection Control*, *47*, A53–A57. https://doi.org/10.1016/j.ajic.2019.02.028

Septimus, E. J., & Schweizer, M. L. (2016). Decolonization in prevention of health care-associated infections. *Clinical Microbiology Reviews*, *29*(2), 201–222. https://doi.org/10.1128/cmr.00049-15

Solomkin, J. S., Mazuski, J., Blanchard, J. C., Itani, K. M., Ricks, P., Dellinger, E., Allen, G., Kelz, R., Reinke, C. E., & Berríos-Torres, S. I. (2017). Introduction to the centers for disease control and prevention and the healthcare infection control practices advisory committee guideline for the prevention of surgical site infections. *Surgical Infections*, *18*(4), 385–393. https://doi.org/10.1089/sur.2017.075

Sporer, S. M., Rogers, T., & Abella, L. (2016). Methicillin-resistant and methicillin-sensitive staphylococcus aureus screening and decolonization to reduce surgical site infection in elective total joint arthroplasty. *The Journal of Arthroplasty*, *31*(9), 144–147. https://doi.org/10.1016/j.arth.2016.05.019

Stambough, J. B., Nam, D., Warren, D. K., Keeney, J. A., Clohisy, J. C., Barrack, R. L., & Nunley, R. M. (2017). Decreased hospital costs and surgical site infection incidence with a universal decolonization protocol in primary total joint arthroplasty. *The Journal of Arthroplasty*, *32*(3), 728–734.e1. https://doi.org/10.1016/j.arth.2016.09.041

Sullivan, E., Gupta, A., & Cook, C. H. (2017). Cost and consequences of surgical site infections: A call to arms. *Surgical Infections*, *18*(4), 451–454. https://doi.org/10.1089/sur.2017.072

Surgical Site Infection. (n.d.). CDC. Retrieved December 5, 2020, from https://www.cdc.gov/hai/ssi/ssi.html

Surgical Site Infections (SSI) - Surveillance and Resources. (n.d.). The Joint Commission. Retrieved November 22, 2020, from

https://www.jointcommission.org/standards/standard-faqs/office-based-surgery/national-patient-safety-goals-npsg/000002155/

Tableau. (n.d.). Tableau. https://www.tableau.com/products

Tang, J., Hui, J., Ma, J., & Mingquan, C. (2020). Nasal decolonization of staphylococcus aureus and the risk of surgical site infection after surgery: A meta-analysis. *Annals of Clinical Microbiology and Antimicrobials*, *19*(1). https://doi.org/10.1186/s12941-020-00376-w

Tansarli, G. S., LeBlanc, L., Auld, D. B., & Chapin, K. C. (2020). Diagnostic accuracy of presurgical staphylococcus aureus pcr assay compared with culture and post-pcr implementation surgical site infection rates. *The Journal of Molecular Diagnostics*, *22*(8), 1063–1069. https://doi.org/10.1016/j.jmoldx.2020.05.003

Tartaglia, A., & Matos, M. (2020). Second victim: After all, what is this? *Einstein (São Paulo)*, *18*. Retrieved January 3, 2021, from https://doi.org/10.31744/einstein_journal/2020ed5619

Tsang, S. J., McHugh, M. P., Guerendiain, D., Gwynne, P., Boyd, J., Laurenson, I. F., Templeton, K. E., Lewis, S., Simpson, A. W., & Walsh, T. S. (2018). Evaluation of staphylococcus aureus eradication therapy in orthopaedic surgery. *Journal of Medical Microbiology*, *67*(6), 893–901. https://doi.org/10.1099/jmm.0.000731

Zhu, X., Sun, X., Zeng, Y., Feng, W., Li, J., Zeng, J., & Zeng, Y. (2020). Can nasal staphylococcus aureus screening and decolonization prior to elective total joint arthroplasty reduce surgical site and prosthesis-related infections? a systematic review and meta-analysis. *Journal of Orthopaedic Surgery and Research*, *15*(1). https://doi.org/10.1186/s13018-020-01601-0

Zhu, Z., Lian, X., Su, X., Wu, W., Marraro, G. A., & Zeng, Y. (2020). From sars and mers to covid-19: A brief summary and comparison of severe acute respiratory infections caused by three highly pathogenic human coronaviruses. *Respiratory Research*, *21*(1). https://doi.org/10.1186/s12931-020-01479-w