###### MINIMIZING THE RISK OF ORTHOPEDIC SURGICAL SITE INFECTIONS IN THE PEDIATRIC POPULATION: USING EVIDENCE TO INFORM PRACTICE

# Honors Thesis

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By

Alaina Gridley

Dr. Nancy Ebersole

Faculty Advisor

School of Nursing

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**Abstract**

Surgical site infections are some of the most common hospital-acquired infections and are associated with higher rates of morbidity and mortality for patients. Surgical site infections can also increase length of hospital stay for patients and elevate healthcare costs. There is extensive literature exploring risk factors associated with acquiring surgical site infections in adults undergoing orthopedic surgery, however, literature exploring this topic in the pediatric population is limited. Additionally, many interventions and assumed risks within the pediatric population are extrapolated from data collected from adults.

A systematic review of the literature was done using the CINAHL database to identify risk factors associated with acquiring surgical site infections in the pediatric orthopedic patient population and interventions to help mitigate these risks. The result of these studies showed that both weight and nutritional status played a role in predicting the incidences of acquiring a surgical site infection. Additionally, prophylactic antibiotic selection and dosing needs to be specific to both the possible pathogen and the patient. A bundle approach to interventions can help to reduce the rate of surgical site infections, however, strict compliance amongst staff can be difficult to ensure. It is imperative as healthcare professionals that we work to identify associated risk factors for developing surgical site infections within the pediatric population undergoing orthopedic surgery. The identification of these risk factors can guide evidence-based practice to establish interventions that can mitigate these risks and promote health and safety for the pediatric population. *Key words:* [surgical site infections, pediatric, orthopedic surgery]

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**Introduction**

The risk of infection within the healthcare setting is present during any form of invasive surgical procedure, and it is imperative that nurses and other medical staff members implement the best forms of evidence-based practice to reduce this risk. Surgical site infections occur in the location in which surgery was conducted and the “Surgical site infections can sometimes be superficial infections involving the skin only. Other surgical site infections are more serious and can involve tissues under the skin, organs, or implanted material” (CDC, 2019). Surgical site infections account for the largest portion of healthcare associated infection costs nationally and inflict an estimated cost of $20,785 per case (Zimlichman, et al., 2013). In addition to raising healthcare costs, surgical site infections can increase length of hospital stay and are associated with higher rates of morbidity and mortality for patients.

Healthcare associated infections such as surgical site infections are largely preventable. The topic of surgical site infections in the adult population undergoing orthopedic surgery is heavily researched. In contrast, research exploring associated risk factors in the development of surgical site infections in the pediatric population undergoing orthopedic surgery is limited. Additionally, there are many assumed surgical site infection risk factors and preventative interventions within the pediatric orthopedic population that are derived from research from the adult orthopedic population. Strategies that have been found to reduce surgical site infections within the adult orthopedic population have included perioperative oxygenation, glycemic control within the operating room, prophylactic antibiotics, preoperative skin preparation and maintenance of normothermia during the surgical procedure (Schriefer, et al., 2017). Research within the pediatric orthopedic population is essential in order to identify interventions that are mitigating the risk of infection and those that are not. Identification of these interventions can institute positive change in treatment in order to optimize pediatric patient's outcomes.

**Background**

While the incident rate of surgical site infection in the pediatric population is relatively low, 1.8%, surgical site infections still remain a source of preventable harm (Saito, et al., 2013). Surgical site infections can lead to negative patient outcomes such as morbidity which is the condition of suffering from a disease and can even result in mortality (Saito, et al., 2013). Surgical site infections are considered a nosocomial infection meaning that it is an infection acquired within the hospital setting.

Although many types of surgical site infections are preventable, there are core patient variables that can make prevention more challenging. Examples of potential core patient variables that need consideration include patient’s nutritional status or underlying health pathophysiology. Also, the nature of the injury or pathology requiring orthopedic surgical intervention itself can create challenges with prevention. With planned orthopedic surgical intervention, there is more time to evaluate core patient variables and their potential impact on patient recovery. Additionally, there is more time to create a plan of action to counteract core patient variables that can contribute to surgical site infections. However, with traumatic cases that require emergent intervention, challenges present such as limited time to evaluate core patient variables and the risk of a contaminated injury site. In traumatic cases an injury site may be open at the time of injury which can lead to contamination by bacterial organisms from the surrounding environment. Contamination can also occur within the operating room setting both in emergent or planned procedures if there is a major breakdown in sterile technique. Break down in sterile technique results in the introduction of nosocomial organisms which can increase a patient’s risk for acquiring a surgical site infection. Contamination, however, does not always result in surgical site infection development (Gutman, Niemeier & Gilbert, 2019).

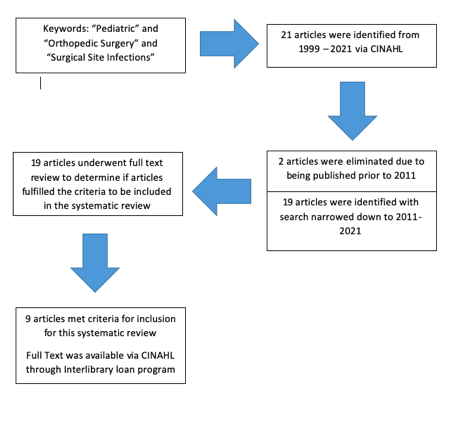
There were 56 million visits to physicians specializing in orthopedic surgery in the United States with 4% of these patients being 15 years old or younger (CDC, 2015). This accounts for over 2.2 million visits from the pediatric population. Additionally, injuries resulting from an accident are one of the most common sources of harm to the pediatric population (CDC, 2019). Unintentional injury as the result of falls for example can result in the need for orthopedic surgery. The pediatric orthopedic population is unique in comparison to the adult population because outcomes of injury or procedures can impact their pending growth as well as their development. Additionally, outcomes within this pediatric population can impact a child’s view of the healthcare setting as a whole for the rest of their life. The promotion of positive experiences within the healthcare setting for the pediatric population can create a trusting relationship that fosters further health promotion as the patient goes through growth and development and reaches adulthood. The pediatric orthopedic population’s care is multifaceted. In addition to pending growth and development, factors also included in care encompass proper implementation of family-centered care as well as effective communication that meets the child’s developmental level. To ensure quality and timely outcomes for the pediatric orthopedic population these dimensions in addition to interventions to mitigate the risk of surgical site infections must be considered.

Exploration of prominent interventions to mitigate the risk of acquiring surgical site infections in the pediatric orthopedic population is needed. Additionally, the identification of risk factors is imperative to establish interventions that can mitigate these risks and promote health and safety for this population. This information needs to be provided in order to prevent the development of surgical site infections and to improve patient centered care for pediatric patients. The aim of this systematic review is to identify associated risk factors in the development of surgical site infections in pediatric patients undergoing orthopedic surgery.

**Methods**

A systematic review of the literature was conducted to identify risk factors associated with acquiring surgical site infections in pediatric patients undergoing orthopedic surgery. Additionally, identified in the search were interventions used to mitigate the risk of acquiring a surgical site infection. The criteria for the articles included within this systematic review required that the articles were published in English in addition to being peer reviewed. Also included within the criteria was the parameters of being published within the years of 2011 to the present year, 2021.

The database Cumulative Index of Nursing and Allied Health Literature (CINAHL) Plus with Full Text was used. A Boolean search was conducted using the key words, “pediatric” and orthopedic surgery” and “surgical site infections”. The search was narrowed down to identify articles that were published between 2011 to 2021.  See Figure 1.



*Figure 1; Keyword article search process.*

**Results**

Nine articles met the criteria for inclusion in this systematic review of the literature with their full text readily available through CINAHL. The full text of these articles was obtained through Salem State University Library Interlibrary Loan system. Within the nine articles, three themes were identified. Both weight and nutritional status played a role in predicting the incidences of acquiring a surgical site infection. Prophylactic antibiotic selection and dosing needs to be specific to both the possible pathogen and the patient. A bundle approach to interventions can help to reduce the rate of surgical site infections, however, strict compliance amongst staff can be difficult to ensure.

**Weight and Nutritional Status**

Weight and nutritional status play a role in predicting the incidences of acquiring a surgical site infection within the pediatric orthopedic population (Ceis, et al. 2012; Blackwood, et al., 2017; Schriefer, et al., 2017). In the pediatric population, body mass index or BMI is divided into four categories underweight, healthy weight, overweight and obese. The CDC defines underweight as less than the 5th percentile, healthy weight as the 5th through 84th percentile, overweight as the 85th though the 94th percentile and obese as equal or greater than the 95th percentile. The BMI percentile of a child is obtained through a graph system and is interpreted relative to children of the same age and gender (CDC, 2021).

The risk of developing surgical site infection is increased in children who are overweight or obese based on the BMI criteria established by the CDC (Blackwood, et al., 2017). Children who were overweight or obese were most likely to develop a superficial incisional infection (Blackwood, et al., 2017). Additionally, these surgical site infections occurred despite the implementations of prevention guidelines including prophylactic antibiotics and maintaining normothermia within the operating setting (Blackwood, et al., 2017). This suggests that additional intervention is needed to manage the independent risk factor of an increased BMI.

The risk of developing a surgical site infection increased in children who are underweight and malnourished (Ceis, et al. 2012; Blackwood, et al., 2017). Due to poor nutritional status pediatric patients can be at risk for impaired wound healing. Additionally, the immune system of children who are underweight may be unable to produce a sufficient response to fight off infection due to poor nutritional status (Ceis, et al. 2012). Nutritional screening and treatment prior to surgery can help to mitigate this risk within the pediatric orthopedic population (Schriefer, et al., 2017).

**Prophylactic Antibiotic Selection**

Prophylactic antibiotic selection and dosing needs to be specific to both the possible pathogen and the patient. There are many challenges present that can make this difficult to achieve (Ceis, et al. 2012; Ballard, et al. 2012; Schriefer, et al., 2017; Jones, Shepherd, Robinson & Khandekar, 2018)

Staphylococcus aureus is the most common causative agent in orthopedic surgical site infection development for the pediatric population. (Ceis, et al. 2012; Jones, Shepherd, Robinson & Khandekar, 2018). Infections due to staphylococcus aureus can be due to its presence on the skin in normal flora (Jones, Shepherd, Robinson & Khandekar, 2018). To mitigate this risk within pediatric orthopedic surgery cefazolin must be dosed adequately for the child’s weight (Ceis, et al. 2012; Schriefer, et al., 2017)

In many successful bundled interventions to reduce surgical site infections, patients have received nasal swabs to screen for methicillin resistant staphylococcus aureus (Ballard, et al. 2012; Schriefer, et al., 2017). In children who screened positive for methicillin resistant staphylococcus aureus, adjustments in the antibiotic prophylactic regimen have been made to include vancomycin to reduce the risk of acquiring a surgical site infection (Ballard, et al. 2012; Schriefer, et al., 2017.)

For minimally invasive procedures prophylactic antibiotics are not needed. Reducing incidences of drug resistance supports withholding prophylactic antibiotics in minimally invasive procedures (Formaini, Jacob, Willis, & Kean, 2012).

While prophylactic antibiotics can help to mitigate the risk of infection there are challenges during an orthopedic surgical procedure that can lessen an antibiotics effect. A pediatric orthopedic surgical procedure that is prolonged was found to be an associated risk factor for surgical site infections within two articles (Ceis, et al. 2012; Jones, Shepherd, Robinson & Khandekar, 2018). A longer surgical procedure results in an increased blood loss. Amount of blood loss matters because antibiotics are lost with the blood causing a decrease in the serum concentration within the body (Ceis, et al. 2012). In order to provide proper prophylaxis, antibiotic dosing must be adjusted for longer orthopedic surgical procedures and for increased blood loss.

**Bundle Approach to Interventions**

A care bundle or a bundle approach to interventions within healthcare is a structural process of implementing a collection of interventions into care with the goal to improve patient outcomes. Three studies have concluded that implementation of bundled interventions can have a meaningful impact on decreasing pediatric orthopedic surgical site infections (Ballard, et al., 2012; Schriefer, et al., 2017; Vandenberg, et al., 2018). Hospitals often adopt bundle approaches during quality improvement projects. The first step to establishing this system is evaluating the current level of pediatric orthopedic surgical site infections within the hospital facility. This allows for a baseline to be established in which future results can be compared. Additionally, this process involves research into current evidence-based practice and requires collaboration of multiple disciplines within the hospital setting to decide about interventions they will implement within their facility. This multiple disciplinary approach allows collaboration and teamwork amongst the health care team. With proper surveillance in addition to a dedicated multidisciplinary team, meaningful reduction in surgical site infections within the pediatric orthopedic population can occur (Schriefer, et al., 2017).

Implementation of bundled interventions within a quality improvement project must involve consistent auditing of adherence as compliance is important. Compliance rate amongst patients and the healthcare team is a major factor in determining the outcome of the bundled interventions (Schriefer, et al., 2017). To promote compliance amongst staff, leadership within the facility must ensure that expectations and proper interventions are correctly communicated. This may require staff to receive extra educational hours or even in-service training. Additionally, children and their parents must receive proper teaching in order to ensure compliance of interventions. Other challenges to implementation of bundles may include the time it takes for a hospital to acquire new resources that they have not previously had (Schriefer, et al., 2017).

Within the pediatric orthopedic population there has been success in mitigating the risk of infection through the implementation of bundles. Previous successful bundles have integrated a wide variety of interventions. Interventions that have been found within the successful bundles have included some form of prophylactic antibiotic regimen with specific dosing parameters, nutritional status evaluation, preoperative skin preparation, wound culturing as well as screening for methicillin resistant staphylococcus aureus (Ballard, et al., 2012; Schriefer, et al., 2017; Vandenberg, et al., 2018).

**Discussion**

The research shows that meaningful reduction in surgical site infections within the pediatric population can be achieved, however, there are numerous challenges. The healthcare team must make the proper selection of antibiotics for patients, considering possible pathogens. Additionally, considerations must be made for prolonged surgery time within the operating room as this can lead to increased blood loss resulting in depletion of the serum antibiotic concentration. Antibiotic dosing must be adjusted for increased blood loss.

Children who are overweight or obese have an increased risk of developing a surgical site infection. Antibiotic dosing must consider a child’s weight. However, even with proper antibiotic dosing surgical site infections can still occur. Additionally, children who are underweight or malnourished also experience an increased risk for developing surgical site infections. Nutritional screening may be able to be completed prior to surgery to reveal deficiencies that can be fixed with medical intervention, however, this is time sensitive depending on the orthopedic surgical procedure.

Implementation of a bundled approach to interventions can reduce pediatric orthopedic surgical site infections within a facility. This approach allows for collaboration and teamwork amongst the healthcare team. However, success of the bundled approach to interventions relies on compliance from staff, patients and their families. Proper education and communication of expectations must be made in order to promote compliance from all. Additionally, auditing and regular meetings can help to ensure compliance.

**Limitations**

Determining risk factors and interventions for surgical site infections within the pediatric population has many limitations. Within this systematic review, one of the limitations was the use of one database, CINAHL Plus with Full Text, to gather research. Additional limitations included limited research results that focused on orthopedic surgical site infections within the pediatric population.

**Conclusions**

It is our duty as healthcare professionals to prevent the potential devastating effects of surgical site infections and promote patient safety by improving care. Outcomes of surgery within the pediatric population can shape a child’s view of the healthcare system. It is imperative that we promote positive experiences to not only foster growth and development but to foster further health promotion as the child grows and reaches their adulthood. There is still a need for more research within this topic to further help to mitigate the risk of morbidity and mortality related to pediatric orthopedic surgical site infections.

This evidence provides direction for nurses and other healthcare professionals in caring for the pediatric orthopedic population. Weight and nutritional status are important factors that can contribute to a child’s risk of developing a surgical site infection. Prophylactic antibiotics and a bundled approach to interventions can help to reduce the risk of surgical site infections. However, even with proper implementation surgical site infections within the pediatric population can still occur. More research to identify associated risk factors and interventions to mitigate these risk factors is essential to provide further health promotion. It is imperative that nurses and other medical staff members implement proper preventative measures to decrease the incidences of surgical site infections in order to promote safe, high quality patient care.

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