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## **An Educational Module on the Utilization of Chlorhexidine Impregnated Surgical Attire in Operating Room Staff to Decrease Surgical Infections.**

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**An Educational Module on the Utilization of Chlorhexidine Impregnated Surgical Attire in Operating Room Staff to Decrease Surgical Infections.**

A DNP Project Presented to the Faculty of the  
Nicole Wertheim College of Nursing and Health Sciences

Florida International University

In partial fulfillment of the requirements  
For the Degree of Doctor of Nursing Practice

By

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### **Abstract**

Surgical site infections (SSIs) are a significant concern due to the harmful consequences they can cause a patient after a surgical procedure. Surgical site infections rank the highest type of hospital-acquired infections causing adverse patient outcomes by increasing length of stay and increasing morbidity and mortality. Specific surgical procedures have been associated with a higher risk of infection. Orthopedic and abdominal surgeries have the highest risk of post-operative infections. Patients experiencing an SSI can undergo various complications such as additional surgeries, antibiotics, increased length of stay, and even death. There are modifiable and unmodifiable risks that can increase the chance of SSIs in combination with high-risk surgeries. Surgical attire worn by the surgical staff may contribute to the possible contamination of a surgical wound. The healthcare team provides care to all their patients during their shifts without changing attire. The usage of chlorhexidine surgical attire can decrease the incidence of transmitting infections from the healthcare provider to a patient surgical wound. This quality improvement plan tested the knowledge of a group of Certified Registered Nurse Anesthetists (CRNAs). An educational module was presented and their understanding regarding SSIs and chlorhexidine impregnated scrubs was analyzed utilizing a pretest and posttest.

*Keywords:* Surgical site infections (SSI), surgical attire, chlorhexidine impregnated scrubs, antimicrobial impregnated scrubs, home-laundered scrubs, facility-laundered scrubs, uniform contamination, operating room contamination



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## **Introduction**

### **Description of the Problem**

Surgical site infections (SSIs) are a significant concern that can cause detrimental consequences regarding the recovery of a patient after a surgical procedure. Surgical site infections lead to the highest hospital-acquired infections, causing unfavorable patient outcomes by increasing length of stay in the hospital and increasing morbidity and mortality.<sup>1</sup> Results from a survey done by the Centers for Disease Control and Prevention (CDC) concerning healthcare-associated infections (HAI) concluded SSIs are the most common HAI.<sup>2</sup>

### **Background**

Specific surgical procedures have been linked to a higher risk of infection. Orthopedic surgeries hold a high rank in the incidence of post-operative infections. These surgeries require a prosthesis to be implanted into the affected joint that is composed of various ingredients. These implanted devices are composed of plastic, metal, or cement; consequently, foreign material contributes to the high rate of infection. Infection rates for total joint arthroplasty cases can be as high as 2.3%.<sup>1</sup> Abdominal surgery is another example of a type of surgery with an increased incidence of infection and rank high with the occurrence ranging between 4% and 19%.<sup>3</sup>

### **Scope of the Problem**

Undeniably, patients undergoing an SSI can experience a variety of complications, including death. Additional surgeries and antibiotic therapy may be required, along with an increased length of stay in the hospital and a delay in their recovery period. Another adverse effect of SS's is the added costs warranted. These add up to significant additional hospital expenses, with the average cost per infection ranging from approximately \$5,000 to \$13,000.<sup>2</sup> It is predicted that SSIs contribute \$3.5 to \$10 billion annually in health care expenses.<sup>2</sup>

There are various unmodifiable risks related to SSIs, including a variety of comorbidities a patient may have. An ASA class 3 or higher, a BMI greater than 30, diabetes, rheumatoid

arthritis, and immunosuppression may affect the healing process, thus leading to a higher risk of generating an infection.<sup>1</sup> Having two or more of these listed comorbidities can contribute to an even higher risk of infection.<sup>1</sup> Healthcare providers can be aware of these risk factors to help manage these patients, but in actuality, these risks can be modified but not eliminated.

There are modifiable risks that contribute to SSIs, that with the support of the healthcare team can be reduced. Health care providers can aid in the prevention of these risk factors. They can also be contributors to the infiltration of bacteria into a wound due to a knowledge deficit. Fifty-five percent of SSIs can be avoided with the appropriate application of evidence-based strategies.<sup>2</sup> There is no doubt that the surgical team does follow strict hygiene protocols to reduce infections. Regimens need to be followed consistently, and protocols revised frequently, according to new research, to reduce the prevalence of infections.

### **Objectives of the Systematic Review**

Surgical attire may be a contributing factor to the possible contamination of a surgical wound. Surgical attire worn by the surgical team in direct contact with the patient may serve as a route for spreading pathogens. In reality, healthcare workers take care of several patients during their shifts without changing attire. In the surgical ward, the surgical team keeps their same scrubs on during the entire shift, unless the clothing were to get visibly soiled. Surgical attire can serve as a means to communicate antibiotic-resistant pathogenic bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus*, and *Clostridium difficile*.<sup>1</sup> The number of bacteria on healthcare staff uniforms increases with contaminants as shift hours increase.<sup>4</sup>

Sterile uniforms impregnated with chlorhexidine can decrease the incidence of contamination of bacteria to a surgical wound. These sterile, single-use uniforms consist of a packed two-piece garment, where chlorhexidine has been impregnated on the cloth. The preparation consists of submersion in 0.12% chlorhexidine and left to dry in a sterile

environment.<sup>4</sup> A research study published by the Association of Perioperative Registered Nurses (AORN), concluded that 4.4% of antimicrobial-treated scrubs had MRSA, VRE, or multidrug-resistant gram-negative rods compared to 7.8% of non-treated scrubs.<sup>5</sup>

Most surgical departments provide health care providers hospital laundered attire to use in the operating room. Laundering of these scrubs occurs in accredited facilities that follow the guidelines in place by the Healthcare Laundry Accreditation Council. These facilities abide by the OSHA and CDC guidelines.<sup>6</sup> These organizations provide the details pertaining to the necessary temperature required and the type of detergents required to decontaminate the cloth.<sup>6</sup> These methods do not protect the attire from getting contaminated and do not decrease the possibility of spreading the infection to a surgical wound.

Another method of disinfecting surgical scrubs is by home laundering. This method may not be as effective in decontaminating the cloth from bacteria and fungi. Some home laundry machines may not reach the CDC's necessary temperatures, which is 71 degrees Celsius.<sup>6</sup> Most home laundry machines are incapable of removing pathogens due to their water and energy-efficient settings.<sup>6</sup> Also, some household detergents lack the strength that is essential to rid the cloth from the contaminants. To comply with industry standards, facilities must use a bleach-based detergent to disinfect surgical scrubs effectively.<sup>7</sup> A study was done on the home laundered attire of 89 student nurses, where their laundered uniforms were swabbed, and found that 17.3% of the swabs tested positive for methicillin-sensitive *Staphylococcus aureus*.<sup>7</sup> Home laundered scrubs similar to facility laundered scrubs have the possibility of getting contaminated during the work shift and contaminating a surgical wound. Furthermore, home laundered scrubs can harbor bacteria, which can increase the likelihood of contaminating a surgical wound.

One of the leading organizations that develop the standards for operating room attire is the AORN. They provide guidelines that address the proper practice of surgical masks, hair and shoe coverings, scrubs, and cover apparel.<sup>8</sup> This organization provides a guide but emphasizes



following the protocols facilities have in place. They also recommend that scrubs and reusable cloth caps be laundered daily or when visibly soiled. Laundering at home with the appropriate water temperature, sodium hypochlorite, and detergent is permissible if no blood or microbial contamination is present.<sup>8</sup>

### **Gaps in the Literature**

There are gaps in the current knowledge indicating the infection of surgical sites may be acquired from the contaminated surgical attire of the healthcare providers. No definite studies are correlating these infections are transmitted from the clothing of providers to the patient. The data confirms that the scrubs can carry *S. aureus*, methicillin-resistant staphylococcus aureus, and coagulase-negative staphylococci.<sup>6</sup> Although healthcare providers' clothing can harbor many microbes, not much data confirms that surgical site infections were transmitted from provider contact. One case study, though, referring to two neurosurgical patients, confirmed the bacterial contamination of *B cereus* spores were indeed transmitted from bed linens.<sup>6</sup> This gives rise to the possibility that surgical site infections can be transmitted by clothing.

## **Methodology of Literature Review**

### **Search Strategy and Sources**

A detailed search was conducted on several electronic databases, including PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), and EBSCOhost. The search results were limited to articles published from 2015 to 2020 and were in the English language. Search terms included: hospital-acquired infections, surgical site infections, transmitting infections from uniforms, organisms growing on uniforms, high risk for infection surgeries, cost of an SSI, consequences of an SSI, wound contamination from healthcare providers, surgical attire, home laundered scrubs, facility laundered scrubs, hospital uniform laundering guidelines, laundering of surgical scrub uniforms, bacterial load of surgical staff

uniforms, surgical scrub microbes, acquiring infections on surgical attire, chlorhexidine impregnated surgical attire, and antibacterial impregnated surgical attire.

**Table 1.** Database Search Table

<b>Concepts/ Topics</b>	<b>Hospital- acquired infection or Surgical site infections</b>	<b>Surgeries with a high risk of infection/ consequences of surgical site infections</b>	<b>Surgical attire laundering</b>	<b>Surgical staff scrubs</b>	<b>Filters Applied</b>
<b>PubMed</b>	("hospital acquired infections") OR ("surgical site infections") OR ("transmitting infections from uniforms") OR ("organisms growing on uniforms")	("high risk for infection surgeries") OR ("cost of a SSI") OR ("consequences of an SSI") OR ("wound contamination from healthcare providers")	("surgical attire") OR ("home laundered scrubs") OR ("facility laundered scrubs") OR ("hospital uniform laundering guidelines") OR ("laundering of surgical scrub uniforms")	("bacterial load of surgical staff uniforms") OR ("Surgical scrub microbes") OR ("acquiring infections on surgical attire") OR ("chlorhexidine impregnated surgical attire") OR ("antibacterial impregnated surgical attire")	• Peer reviewed filter applied and <b>85 results</b> found
<b>CINAHL</b>	("hospital acquired infections") OR ("surgical site infections") OR ("transmitting	("high risk for infection surgeries") OR ("cost of a SSI") OR ("consequences of an SSI") OR ("wound contamination from healthcare	("surgical attire") OR ("home laundered scrubs") OR ("facility laundered scrubs") OR ("hospital uniform	("bacterial load of surgical staff uniforms") OR ("Surgical scrub microbes")	*Applied peer reviewed, English Filter, 2015-2020, Human Filter, and Journal Article type to get <b>120 results</b>

	infections from uniforms”) OR (“organisms growing on uniforms”)	providers”) OR	laundrying guidelines”) OR (“laundrying of surgical scrub uniforms”)	(“acquirin g infections on surgical attire”) OR (“chlorhexidine impregnated surgical attire”) OR (“anti-bacterial impregnated surgical attire”)	
<b>EBSCOhost</b>	(“hospital acquired infections”) OR (“surgical site infections”) OR (“transmitting infections from uniforms”) OR (“organisms growing on uniforms”)	(“high risk for infection surgeries”) OR (“cost of a SSI”) OR (“consequences of an SSI”) OR (“wound contamination from healthcare providers”)	(“surgical attire”) OR (“home laundered scrubs”) OR (“facility laundered scrubs”) OR (“hospital uniform laundrying guidelines”) OR (“laundrying of surgical scrub uniforms”)	(“bacterial load of surgical staff uniforms”) OR (“Surgical scrub microbes”) OR (“acquirin g infections on surgical attire”) OR (“chlorhexidine impregnated surgical attire”) OR (“anti-bacterial impregnated surgical attire”)	54 results found Filters applied: peer-reviewed, English Filter, 2015-2020, Human Filter, and Journal Article type.

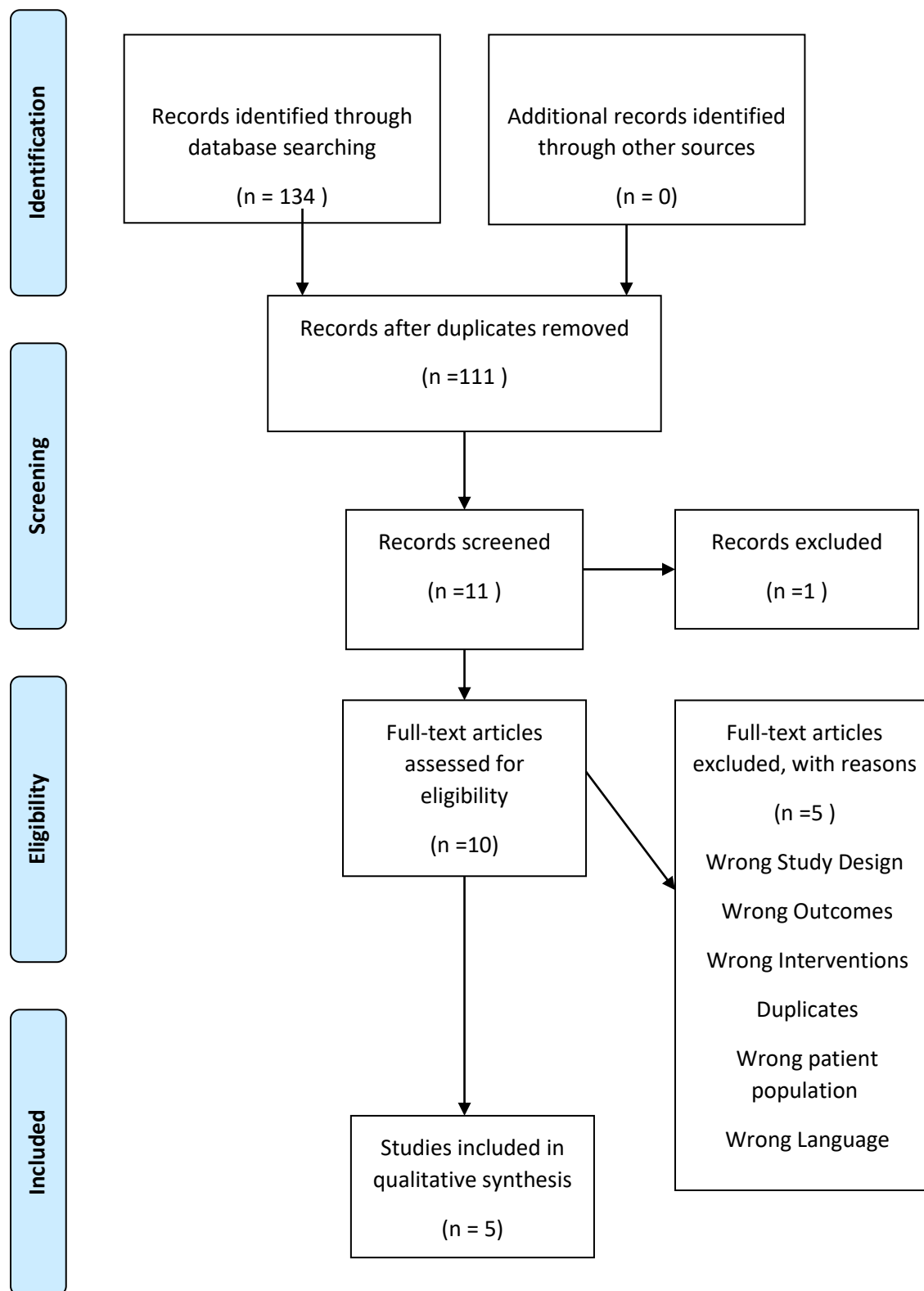
### Study Selection and Screening of Evidence

A systematic review of all relevant research studies was performed. The studies were categorized by chlorhexidine/antimicrobial impregnated attire, hospital laundered scrubs, facility

laundered scrubs, surgical site infections, and contamination of surgical attire. Common reasons for exclusions were studies not done in a hospital setting, non-human subjects, and studies related to an anti-septic skin cleanser, commonly called surgical scrub. The eligible studies with full text were reviewed to ensure they contained the inclusion criteria.

**Table 2.** Inclusion and Exclusion Criteria

<b>Inclusion</b>	<b>Exclusion</b>
Population: <ul style="list-style-type: none"> <li>• Surgical patients</li> <li>• Surgical staff</li> </ul> Interventions: <ul style="list-style-type: none"> <li>• Home laundering scrubs</li> <li>• Facility laundered scrubs</li> <li>• Chlorhexidine impregnated surgical attire</li> </ul> Characteristics: <ul style="list-style-type: none"> <li>• Surgical site infections</li> <li>• Contaminating surgical attire</li> <li>• Contaminating a surgical wound</li> <li>• Consequences of SSIs</li> </ul> Type of study: <ul style="list-style-type: none"> <li>• English language</li> <li>• Randomized controlled trials</li> <li>• Publication date 2015-Present</li> </ul>	Population: <ul style="list-style-type: none"> <li>• Non-surgical staff</li> <li>• Patients with low risk for infection</li> <li>• Patients outside of a hospital setting</li> <li>• Any other subjects other than human</li> </ul> Surgical scrubs – liquid antibacterial scrub utilized to clean patients prior to incision.           Type of study: <ul style="list-style-type: none"> <li>• Non-English</li> <li>• Publication date pre-2015</li> <li>• Meta-analysis</li> <li>• Questionnaire</li> <li>• Dissertations/theses</li> </ul>

**Figure 1.** PRISMA Flow Diagram

## Results of the Literature Review

### Study Characteristics

The evidence used for this review was obtained from a prospective, open comparable trial, a systematic review, a descriptive study, and a literature review. This offers a level I through level VI hierarchy level of evidence-based on the Joanna Briggs Institute.

### Definitions and Outcome

*Surgical site infections (SSI)* – an infection of the skin after surgery, on the body part where the surgery took place.<sup>1</sup>

*Surgical attire* – clothing worn in the restricted areas of the surgery department, including head cover, masks, scrub suit, jacket, and shoes/shoe covers.<sup>4</sup>

*Chlorhexidine impregnated scrubs* – surgical attire with a chlorhexidine coating.<sup>4</sup>

*Antimicrobial impregnated scrubs* – surgical attire with an antimicrobial coating.<sup>4</sup>

*Home-laundered scrubs* – surgical attire that is disinfected and washed at home.<sup>7</sup>

*Facility-laundered scrubs* – surgical scrubs that are disinfected and washed by the healthcare facility.<sup>7</sup>

The PICO was formulated by utilizing the scientific inquiry, which guided the search criteria. From the investigation presented on chlorhexidine impregnated scrubs, the following PICO question was articulated: P (patient population) for patients undergoing surgery, I (intervention) will the use of antimicrobial impregnated scrubs reduce bacterial contamination to surgical patients, C (comparison) compared to health institution laundered surgical scrubs, O (outcome) prevent the occurrence of surgical site infections (SSIs).

### **Risk of Bias**

The limited number of available studies relating SSIs to healthcare providers' attire can create a bias to the study. Two of the randomized studies utilized took place in an intensive care Unit (ICU) setting. The uniforms manipulated in the study were worn by nurses and doctors providing care to patients in an ICU to prevent an HAI. When researching the prevention of SSIs, the setting must be of an operating room to provide better accuracy in the data. Patients hospitalized in the intensive care unit department harbor more infections than operating rooms. ICU patients have a higher incidence of nosocomial infections than patients located in other areas of the hospital.<sup>9</sup> These patients have a higher risk of ventilator-acquired pneumonia, central line-associated bloodstream infections, and urinary tract infections from foley catheters.<sup>9</sup>

## **Discussion of the Literature Review**

### **Summary of Evidence**

A prospective, open comparable, level III trial studied healthcare workers wearing chlorhexidine impregnated surgical attire compared to wearing sterile surgical scrubs and bathing with chlorhexidine wipes to reduce the transmittance of microbes to their patients from their clothing. Ten nurses participated in the study, and 306 cultures were processed.<sup>4</sup> A total of 108 cultures were obtained for the first intervention, which was given a sterile surgical scrub (SSS) to wear at the beginning of the shift.<sup>4</sup> The second intervention also contained 108 cultures, and this group was instructed to take a chlorhexidine bath prior to wearing the SSS.<sup>4</sup> The third group accounted for 90 cultures, and these participants were given a chlorhexidine impregnated surgical scrub to wear without a chlorhexidine bath.<sup>4</sup> The thorax, chest pocket, and abdomen area of the nurse's uniforms were cultured for the first, second, and the third interventions.<sup>4</sup> Seventeen bacterial species were identified and consequently classified as skin microbiota, transient microbiota, and potential pathogens.<sup>4</sup> There was a significant reduction in colony-forming units (CFU) when the first intervention was compared to the second intervention. The first intervention

accounted for a mean of 12.5, where the second intervention resulted in a CFU mean of 3.5.<sup>4</sup> A comparison of the first and third interventions resulted in no significant reduction in CFU.<sup>1</sup> When skin microbiota was examined, the first intervention resulted in higher bacterial load when compared to the second intervention, and no significant difference was noted in the second and third interventions.<sup>4</sup>

There was a notable reduction in *Staphylococcus aureus* between the first and second intervention and the first and third intervention.<sup>4</sup> Gram-negative bacilli were more frequently found in the first intervention attributing to 30 total CFU, with an average probability of 0.27, when the second intervention group formed 9 CFU with an average probability of 0.27 and the third group had 14 CFU with an average probability of 0.12.<sup>4</sup> The bacterial load in uniforms decreased when chlorhexidine was used whether it be by bathing or impregnation of cloth, when compared to SSS without a difference in potential pathogens.<sup>4</sup> There have not been any previous studies regarding health care providers utilizing chlorhexidine apparel. Previous studies are based on bathing patients with chlorhexidine, not staff utilizing chlorhexidine wipes on themselves to diminish the transmission of pathogens. The limitation to this study is the small size and also the lack of a control group. The only risk for harm listed pertained to a skin reaction to chlorhexidine reported by a participant.<sup>4</sup> Chlorhexidine wipes are readily available for staff as well as SSS. Chlorhexidine impregnated scrubs would require proper preparation as they are not yet manufactured.

A prospective, 3-arm blinded randomized Level I trial was conducted to test if antimicrobial impregnated cloth compared to non-impregnated healthcare workers uniforms reduce the contamination of pathogens on the cloth. Forty nurses were enrolled for 3 shifts, where a total of 2,919 cultures were obtained from the environment, and 2,185 cultures were obtained from healthcare providers' clothing.<sup>10</sup> The control included a uniform of a standard cotton polyester material. The material tested in comparison is a silver-alloy embedded or impregnated



with organosilane-based quaternary ammonium, and the other material included a hydrophobic fluoro acrylate copolymer emulsion.<sup>10</sup> Nurses wearing the scrubs were blinded to which type they were wearing. This study took place at two ICUs at Duke University Hospital. Forty nurses participated, which completed a total of 120 shifts.<sup>10</sup> Individually, these nurses cared for 1.4 patients per shift. The study recorded 167 patient encounters for a total of 102 patients.<sup>2</sup>

Statistical calculations were made by using probability when comparing the control with the other antimicrobial impregnated scrubs. The cultures obtained from the patient room included bed rails, beds, and supply carts. 2185 total cultures were obtained from the healthcare providers' clothing.<sup>10</sup> This study utilized a generalized estimating equation (GEE) linear regression model to contrast and compared the amount of contamination between the control and the other scrubs. All the results were logged into a model where different concepts like the type of scrubs and total CFU that were present at the beginning of the shift. Patient characteristics, the presence of drains and tubes, wounds, current infections, mechanical ventilation, and environmental contaminants were all noted.<sup>10</sup> Of the environmental areas tested, bed rails had the highest amount of contamination.<sup>10</sup> Scrub uniform cultures obtained from the control group showed a median CFU increase by 33 on the sleeve, 32 on the pocket, and 25 by the abdomen area.<sup>10</sup> Scrub 1 showed 17 CFU increase by the sleeve, -0.5 by the pocket, and 17 by the abdomen.<sup>10</sup> Scrub 2 showed a 9 CFU median increase, -1 CFU by the pocket, and 4 CFU in the abdominal area of uniform.<sup>10</sup>

This study indicated that the contamination to antimicrobial impregnated scrubs was not reduced compared to the control group scrubs. This study confirms that healthcare providers' clothing becomes frequently contaminated from the patient care environment with significant pathogens. A conclusion to this study may result in the patient environment being the culprit to the contamination of uniforms. The strength of this study is the large number of cultures performed. A limitation may be the small surface area sampled from the cloth of all uniforms, excluding contaminants since only a small portion of each area of the uniform was tested.

This systematic review, Level I of evidence, utilized information from cross-sectional studies, randomized controlled trials, and cohort studies regarding the bacterial contamination of white coats and scrubs worn by healthcare providers. A total of 22 articles were reviewed examining different microbial contaminants, antibiotic resistance found on the bacteria, and the different types of providers with higher contamination rates to their attire.<sup>8</sup> Fabric types, antimicrobial coating on the cloth, laundering frequency, and laundering practices, and disposable scrubs were examined.<sup>8</sup> Each of the variables obtained from the 22 articles was measured separately and organized by percentage. A total of 11 studies regarded microbial contaminants. Treakle et al. found that 23% of white coats were contaminated with *S. aureus*, 18% of which were methicillin-resistant *Staphylococcus aureus* (MRSA).<sup>8</sup> Krueger et al. concluded that 268 of 300 (89%) of resident scrubs were contaminated with bacteria compared to 123 of 300 (41%) unworn scrubs.<sup>8</sup> Similarly, another two studies also showed contamination of *S. aureus* to 17% of worn scrubs and the other at 30% of worn scrubs.<sup>8</sup> Another study determined that nurses caring for patients with wounds had the highest percentage of contamination, where another aspect listed is the type of fabric of the surgical attire worn is a factor in contamination.<sup>8</sup>

Different fabrics studies were cotton, polyester, or a blend of these fabrics. One study found that a blended fabric resulted in a 60% and 36% higher contamination rate than polyester after a work shift.<sup>8</sup> A study by Takashima et al. resulted that wool, polyester, and acrylic are strong carriers of *S aureus* and *P aeruginosa*.<sup>8</sup> Cotton was found to have the least quantity of bacterial contamination.<sup>8</sup> Antimicrobial coating on the fabric of surgical scrubs was also reviewed, and concluded that treated scrubs had bacterial contamination of 4.4% versus 7.8% on non-treated scrubs.<sup>8</sup> Another study by Bearman et al. determined there was a significant reduction in MRSA with treated scrubs.<sup>8</sup> Concerning laundering methods of scrubs, there is higher bacterial contamination on home laundered or unwashed scrubs when compared with hospital laundered or

disposable scrubs. Forty-four percent of home laundered scrubs were contaminated, while none of the facility laundered scrubs had bacteria contamination.<sup>8</sup>

This review also presented data that white coats have a higher contamination percentage than scrubs since white coats are generally washed less frequently and are laundered at home.<sup>8</sup> All the studies in this systematic review prove there is a transfer of bacteria to health care workers' attire during the work shift. Where the evidence lacks is the link of healthcare-associated infections to healthcare providers' attire. There is a definite lack of evidence to confirm that healthcare workers can be the culprits to transfer bacteria from their attire to their patients resulting in a healthcare-associated infection.

The data confirms that healthcare workers carry bacteria in their clothing, so methods should be in place to reduce the transmission. This systematic review examined different aspects and attempted to define the reasoning regarding the contamination of the provider's attire and practices that may increase the number of bacteria. There is a deficiency of studies pertaining to the contamination of healthcare workers' attire directly contaminating the patient. Facilities can utilize this information to create protocols for reducing contamination on healthcare workers' attire to potentially decrease contamination to the patient.

A descriptive, level VI study was conducted to determine the level of contamination of surgical scrubs prior to entering the operating room. Surgeons, upon entering, were given a questionnaire regarding where they had been and their activities before entering the surgical suite. Following the questionnaire, one single swab was taken from the front pocket of their hospital-issued scrubs. This study takes place in a 1,000-bed hospital located in Jerusalem, Israel. This hospital provides facility laundered scrubs to their employees and prohibits wearing these scrubs outside of their facility. Eleven samples were taken as a control from clean uniforms. A total of 133 surgeon scrubs were sampled, and of the 133 samples, 77% of these surgeons stated they had been in another operating room prior.<sup>6</sup>

Another group, 41% of the surgeons entering, stated they had participated in other clinical activities.<sup>6</sup> The third group, 33%, specified they had taken part in other non-medical functions in the hospital.<sup>6</sup> Culture results of the control and study groups showed no significant statistical difference between the two. Thirteen percent contamination of the control group versus 9% of the study group.<sup>6</sup> In relation to where these surgeons had been before entering the operating room, the ones that had participated in other medical activities before entering had the highest bacterial load contamination.<sup>6</sup>

This study specified that when the replacement of scrubs is frequent (at least every 4 hours), it decreases the bacterial load. Surgical scrubs should be changed frequently in the operating room to reduce the amount of contamination on the clothing. This article indicated that an alternative to reducing bacteria would be a frequent change in scrubs when entering the operating room. Healthcare facilities would have benefitted if the different medical procedures prior to entering the operating room were identified and which of those would pose the highest risk for contamination. Also, the control group, the facility laundered scrubs, should be tested and protocol reviewed as to the reason for the significant amount of contamination identified. Suppose the subjects that wore these control scrubs contaminated them upon dressing themselves. In that case, further testing should be conducted on the hygiene of the skin of healthcare workers upon entering the hospital.

With level V evidence, this literature review evaluates home laundered and facility laundered surgical scrubs and the potential to transmit bacteria and potentially cause a surgical site infection (SSI). The database search on this review included terms like SSI, home laundering, bacteria prevention, hospital laundered, and surgical scrubs.<sup>7</sup> Seventy-five total articles were reviewed, of which 30 met the criteria. Two of these articles were randomized controlled trials (RCT's), 10 were literature reviews, 18 were considered experimental studies, 4 were case reports, 1 was a cross-sectional survey, and 3 articles were expert opinions.<sup>7</sup>

The information further reviewed included the transmission of bacteria from surgical attire and the relationship between SSIs and scrub uniforms. Also observed were the difference between home laundered and facility laundered scrubs and the recommendations for decontamination of surgical scrubs. Each of the criteria was examined, and the results from these studies were presented by the percentage rate of occurrence. The majority of articles reviewed confirmed the bacterial-carrying capacity of hospital worker uniforms that accumulated throughout the workday.<sup>7</sup> Further data was gathered suggesting that bacterial load increases as hours of work increase, suggesting the contamination occurs by patient contact.

### **Limitations of the Systematic Review**

Even though the evidence in countless articles suggests providers carry bacteria in their uniforms, the direct correlation to SSI is lacking. There is evidence of one case report where contaminated facility laundered scrubs resulted in two post-operative patients acquiring *Bacillus cereus* after neurological surgery.<sup>7</sup> Evidence reviewed regarding home or facility laundered scrubs indicate no change in SSI to either. There is a lack of evidence suggesting facility laundered scrubs are more effectively decontaminated than home laundered scrubs. Whichever the two means of decontaminating the surgical scrubs, the methods should be precise, and recommendations should be uniform regarding temperature, drying processes, and storage.

### **Recommendations for Future Research**

Medical facilities can review the data and determine what is feasible to their institution regarding providing facility laundered scrubs or the possibility of reducing their budget by allowing their employees to launder their uniforms. Any facility that chooses to provide their healthcare team the choice to launder their clothing should closely monitor any increases in the incidence of SSIs and continuously compare their incidence of SSI with similar facilities that utilize facility laundered scrubs.

## **Conclusion of Literature Review**

Surgical attire impregnated in chlorhexidine, utilized by staff in direct contact with patients having a high-risk surgical procedure, can reduce SSI. It could reduce morbidity and mortality for these high-risk procedures where the infection is a high possibility. Using this single-use, chlorhexidine impregnated surgical attire can minimize contamination from provider to patient and decrease the chances of an SSI. This addition of infection control protection and the rest of the established protocols to minimize infection can prove beneficial to patients with non-modifiable risk factors. Other circumstances where an extra step towards infection control would be beneficial are surgical procedures with a higher chance of developing surgical site infections. The operating room staff would identify potential risk factors and adopt a facility regulation to require all staff involved in these surgical procedures to wear the disposable chlorhexidine impregnated scrubs. This change in practice would serve as an additional hygiene practice mode to prevent the terrible complication of infection and improve patient outcomes.

## **Methodology of the Quality Improvement**

### **Setting**

The setting for this educational project is based out of a university in Miami-Dade County, Florida. Prior nurse anesthesia alumni will be contacted via email to obtain their responses anonymously. For both undergraduate and graduate, the enrolled student population at Florida International University is predominantly Hispanic and African American.

### **Recruitment and Participants**

Following the approval by the Human Research Subject Office at Florida International University (FIU), a total of 65 FIU alumni CRNAs were communicated via Qualtrics using their emails from the university database. The sample size varied based on age, ethnicity, gender, and a range of years working in the profession. There were also a variety of CRNAs with different

levels of educational degrees. Even though surgical site infections are of interest to many different disciplines in the surgical department, this study evaluated the knowledge of CRNAs.

### **Intervention and Procedures**

The instrument that was utilized is an anonymous pretest and posttest Appendix E. The participants were provided a pretest to test baseline knowledge. Taking a test prior to learning allows for improved retention of the material.<sup>11</sup> The educational session was in the form of a PowerPoint presentation containing the information from the literature review. Following the pretest, a link to the presentation was available. The PowerPoint was incorporated into the Qualtrics survey. Following the presentation, surveyors were directed to the posttest, which concludes the educational survey. Anesthesia providers hold vital roles in the prevention of SSIs such as administration of prophylactic antibiotics and maintaining aseptic technique during procedures.<sup>12</sup> It is imperative to continue to provide knowledge to this healthcare discipline.

### **Protection of Human Subjects**

CRNAs receiving the survey received a unique code identifier to keep their survey and data anonymous. The data collected from the pretest and posttest were stored in a password-protected laptop that contains a spyware program. These procedures assured the data remained protected.

### **Data Collection**

The overall objective of the education session was to educate CRNAs on the possible contamination of pathogens via surgical attire. It also included the data supporting the various options on how different aspects of cleaning the apparel can decrease the chances of surgical site infections in the vulnerable surgical population.

The questionnaire was administered via the Qualtrics program prior to and following the educational PowerPoint. Qualtrics is a web-based program for creating and distributing surveys.

It can be used on any internet-connected computer and is widely utilized for academic and market research. Surveys can be customized to the researcher's needs relating to the topic investigated. Qualtrics can create quizzes and calculate scores based on the responses. It also has built-in email distribution capabilities that can send emails with the surveys, reminder emails, and thank you emails to those who have responded. The pre and posttest did not contain any identifiers to preserve anonymity. The questions were formulated to evaluate the CRNAs' knowledge regarding proper cleansing of surgical attire and different methods that can be used to decrease the pathogens on surgical attire. The question set consisted of 10 multiple-choice questions. The primary investigator completed these questions based on the current evidence found in the research.

### **Measurement and Analysis**

The data results were viewed in the results section of the Qualtrics program. The number of responses was categorized by percentage to compare and contrast the pre- and posttest surveys. The results from the pre- and posttest questions were compared to determine if there was an improvement in knowledge of the CRNAs participating. An improvement in the posttest scores would presume the PowerPoint was instructional.

## **Results of Quality Improvement**

### **Pretest and Posttest Sample**

The survey consisted of 13 questions on the pretest and 8 questions on the posttest. A different variety of questions were provided, including multiple-choice, true or false, and questions utilizing the Likert scale. The Likert scale is considered one of the most essential and commonly used tools in various types of research.<sup>13</sup>

### **Pretest Knowledge**

The pretest consisted of six demographic questions in multiple-choice, which included the participants' age, sex, ethnicity, position, education, and years working.



### Prettest Demographics

**Table 3.** Title

Demographic	n (%)
Total Participants	5 (100%)
<b>Gender</b>	
Male	2 (40%)
Female	3 (60%)
<b>Ethnicity</b>	
Hispanic	4 (80%)
African American	1 (20%)
<b>Position</b>	
CRNA	3 (60%)
Faculty	2 (40%)
<b>Educational Degree</b>	
Doctoral	4 (80%)
Masters	1 (20%)
<b>Years working</b>	
1-2 years	1 (20%)
3-5 years	1 (20%)
Over 10 years	3 (60%)

Table 3 demonstrates the responses with a percent value. The demographic questions were only asked on the pretest. The first question pertained to gender. Sixty percent of the participants were female, and 40% were male. The median age for the participants was 44 years of age. Of the 5 participants, 80% stated they were Hispanic, and 20% were African American. Employment position was the following survey question included in demographics. This survey question allowed participants to type in their answers. Sixty percent of the participants were employed as CRNA's, and 40% stated they were faculty. The next demographic question inquired about the level of academic education. Eighty percent of the participants stated they had a

doctoral degree and 20% a Master's degree. The last demographic question asked about the number of years working in the profession. Twenty percent answered they worked between 1 and 2 years, 20% answered between 3 and 5 years, and 60% stated over 10 years.

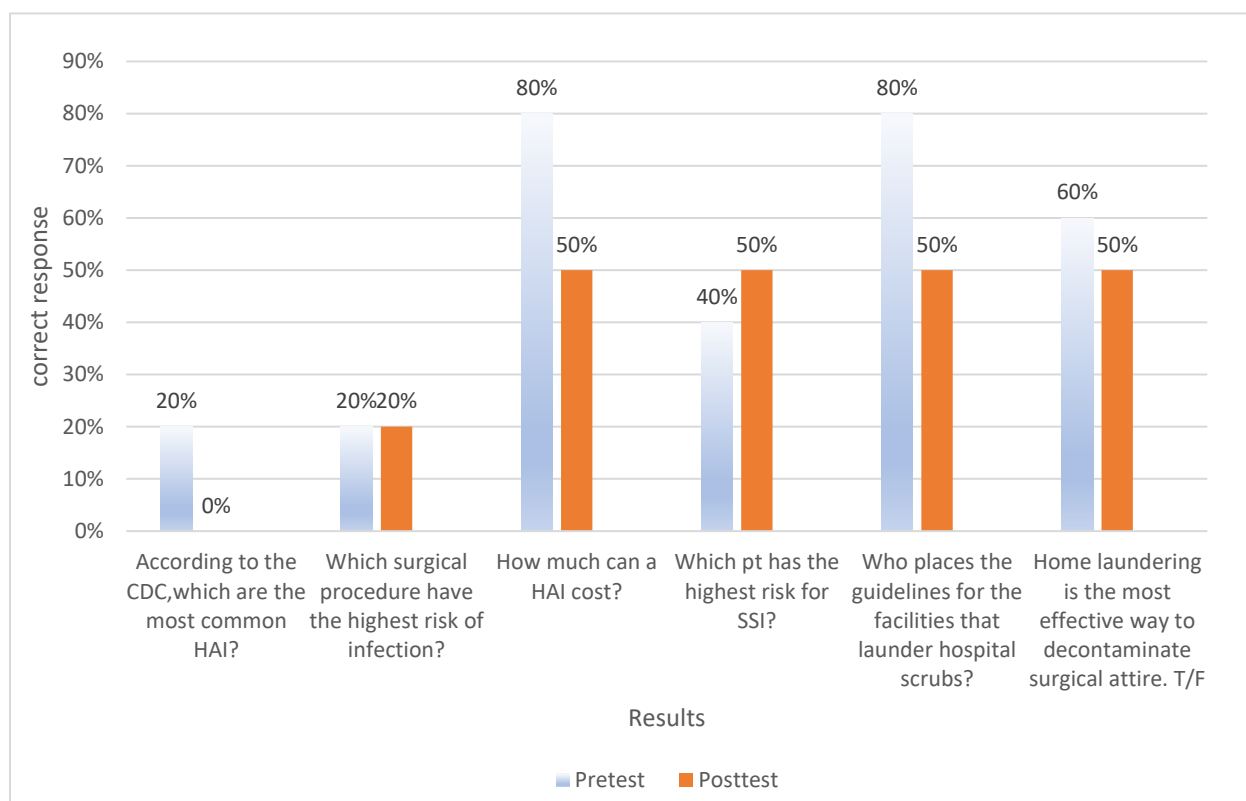
Included in the pretest questionnaire inquired upon the practitioner's current mode of handling their surgical attire. Table 4 demonstrates that more than half the participants confirmed that home laundering was their current method of handling their scrubs.

**Table 4.** Current Mode of Handling Scrubs

Mode	n (%)
Home laundering	3 (60%)
Hospital laundered	2 (40%)

### **Posttest Knowledge**

To test knowledge following the instructional PowerPoint, seven of the pretest questions were repeated in the posttest. Figure 2 demonstrates a side-by-side comparison of the pre- and posttest question results from the CRNA participants.

**Figure 2.** Pretest and Posttest Results

The first question on the posttest was "According to the CDC, which is the most common type of SSI?" The pretest showed 20% chose the correct answer, and when the same question was asked in the posttest, none of the answers were correct. The same scenario, where the percent of correct choices in the pretest were higher than the posttest, occurred on three other answer choices. These four questions showed there was no improvement in knowledge, and the results were worse.

The question in the posttest, "Which surgical procedure has the highest risk of infection?" on the pretest showed 20% chose the correct answer, and the posttest reflected the same. The only question that showed improvement in knowledge was the one referring to which patient that was most at risk for SSIs, where there was a 10% improvement. Additionally, this same question had only four responses, indicating that one participant did not answer; hence, the percentage was 50%.

Additionally, two questions were included in the posttest utilizing Likert scales. The first question asked how likely they were to use the antimicrobial impregnated surgical attire (Table 5). Seventy-five percent responded they were extremely likely, and 25% stated they were somewhat unlikely.

**Table 5.** Question 9 Posttest Results

How likely are you to use antimicrobial impregnated surgical attire?	Posttest
Extremely likely	75%
Somewhat likely	0%
Neither likely or unlikely	0%
Somewhat unlikely	25%
Extremely unlikely	0%

The last question utilizing the Likert scale asked how likely they were to recommend the product (Table 6); also, 75% indicated they were extremely likely, and 25% responded they were somewhat unlikely.

**Table 6.** Question 10 Posttest Results

How likely are you to recommend surgical attire?	Posttest
Extremely likely	75%
Somewhat likely	0%
Neither likely nor unlikely	0%
Somewhat unlikely	25%
Extremely unlikely	0%

### **Perspective of Use in Practice**

Preventing SSIs is the responsibility not only of the surgeon but the entire surgical team involved in the patient's care. CRNAs hold responsibilities directly related to reducing the probabilities of SSIs. CRNAs are a component of this group and hold an essential role in the prevention of SSIs. An anesthetist or anesthesiologist usually administers prophylactic antibiotics prior to the surgeon performing the incision and timed to maintain coverage throughout the length of surgery.<sup>12</sup> CRNAs also monitor the patient's temperature to avoid hypothermia. Normothermia

prevents surgical site infections, and documentation is a component of the Physician Quality Reporting System, which monitors compliance.<sup>12</sup>

The prevention of transmitting a microbe from CRNAs' apparel would be another measure to prevent infections. Educating this healthcare discipline on the occurrence of SSIs, ways of transmission, and modalities on how to prevent it was the objective of the survey. There are guidelines in place published by the American Association of Nurse Anesthetists (AANA) that address the handling of surgical attire but recommend following the facility's policy where they are employed.<sup>14</sup> All means of infection prevention would aid in preventing SSIs to provide quality service; therefore, providing knowledge is essential.

### **Discussion of Quality Improvement**

#### **Limitations**

Limitations for the project include the limited number of responses from the emailed surveys. Presenting the data with the PowerPoint in a classroom-type setting or perhaps with a group of CRNAs in the hospital, the pre- and posttests will be more accessible to CRNAs and possibly be more compelled to fill them out. Research conducted by Nulty consistently showed respondents have greater response rates when filling out surveys in person instead of online.<sup>15</sup> Another limitation and inconsistency with the results were that not every question was completed. This inconsistency did not allow for an accurate measure when comparing pre to posttest.

Further limitations regarding sending emails are the possibility of the subject scanning quickly through the PowerPoint, thus not receiving any knowledge. The results indicated that the majority of questions did not receive the correct response on the posttest. There was only one question where the posttest percentage improved.

### **Future Implications for Advanced Nursing Practice**

The topic of hospital-acquired infections is a significant concern for the health industry, which involves a variety of disciplines synergistically and continuously attempting to improve outcomes. Many protocols are in place to reduce the chances of surgical site infections. The critical factor is maintaining sterility in the operating room. Reducing the number of bacteria that could be contaminated in the incision is crucial. Thus, there are specific branches to maintaining sterility that has been overlooked.

The lack of evidence pertains to how uniforms contaminated with bacteria can, in turn, contaminate surgical site infections. For the most part, healthcare providers in the operating room change into a hospital laundered or home laundered surgical attire at the beginning of their shift. Aside from the surgeons, surgical assistants, and operating room technicians, no other healthcare worker providing care for the patient changes their attire between patient encounters. Antimicrobial impregnated surgical attire would be of value since it would have the potential to carry and transmit fewer bacteria.

There is a lack of randomized controlled trials concerning the transmission of pathogens from healthcare providers. Researchers from a university in Israel conducted a randomized control trial that coated hospital textiles with metal oxide nanoparticles that contain antibacterial properties.<sup>16</sup> These fabrics were those of patient gowns, sheets, and pillow covers.<sup>16</sup> The results were positive, and researchers are now collaborating with producers in the textile industry to conduct further studies and improve the quality of the product.<sup>17</sup> Even though this cloth is not worn by hospital personnel, these studies can prove that fabric can harbor microbes, and an antibacterial impregnation on hospital staff attire can decrease the spread of infections.

### **Conclusion**

Surgical site infections continue to be a nuisance for healthcare despite numerous protocols and adjustments in infection control measures throughout the years. These hospital-

acquired infections can extend the length of stay, increase costs, and increase the chances of morbidity and mortality. It is clear which patients and which surgeries increase chances of SSIs due to numerous studies. More studies should aim at strategies protecting patients more susceptible to infections where all the caregivers should be considered a means to spread pathogens. If this information is transparent, different strategies more intense than the standard need to be in place to protect this vulnerable group.

Based on the evidence presented in this literature review, several recommendations can be concluded to decrease the number of surgical site infections. Many of these studies have focused on the contamination of hospital providers' uniforms during their work shifts. Other evidence has examined the difference in laundering techniques and how different methods can decrease bacterial loads on uniforms. A combination of all these practices, along with extra vigilance among patients with a high probability of obtaining an HAI, can reduce the opportunities of surgical site infection.

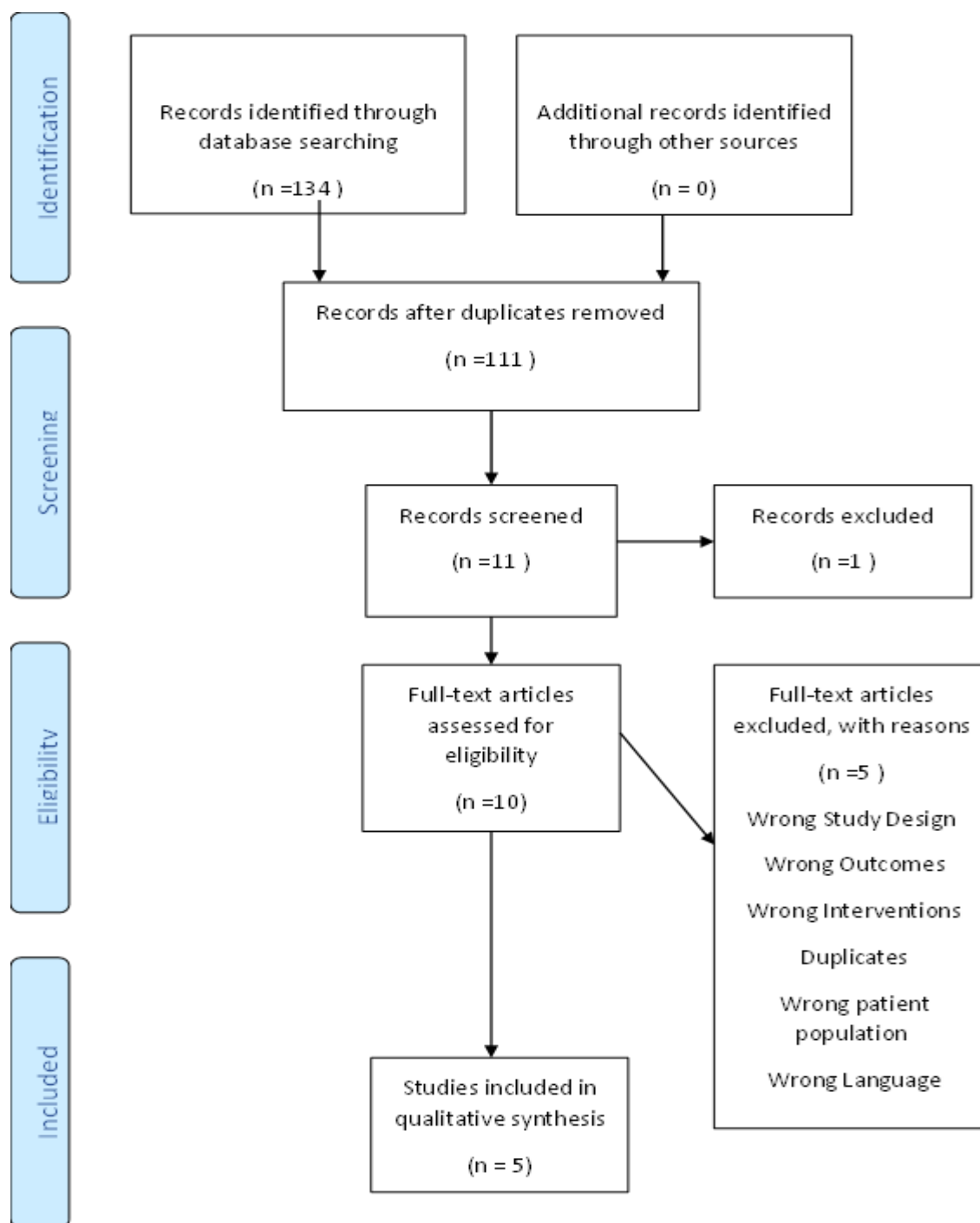
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### Appendix A: PRISMA Flow Diagram



## Appendix B: Matrix Table

Citation and Theme of the article	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/ Level
4. Salazar-Vargas K, Padilla-Orozco M, Garza-González E, Camacho-Ortiz A. Chlorhexidine impregnated surgical scrubs and whole-body wash for reducing colonization of health care personnel. <i>Am J Infect Control</i> . 2020;48(10):1216-1219  Healthcare givers wearing chlorhexidine impregnated surgical attire compared to wearing sterile surgical scrubs and bathing with chlorhexidine wipes to reduce the transmittance of microbes in their clothing to their patients.	A prospective, open comparative trial. Three different methods of antimicrobials were compared.	10 nurses participated in the study. 306 cultures processed. 108 first intervention, 108 for the second intervention and 90 for the third intervention.	The first group was given a sterile surgical scrub (SSS) to wear at the beginning of the shift. The second group was instructed to take a chlorhexidine bath prior to wearing the SSS. The third intervention participants were given a chlorhexidine impregnated surgical scrub to wear without a chlorhexidine bath.	The thorax, chest pocket, and abdomen area of the nurse's uniforms were cultured for the first, second and third interventions. 17 bacterial species were identified as skin microbiota, transient microbiota and potential pathogens.	There was a significant reduction in colony-forming units (CFU) when the first intervention was compared to second intervention 1st (SSS) mean 12.5 range 0-118 vs. 2nd intervention at CFU mean 3.5 range 0-22. Comparing 1st and 3rd interventions. 3rd intervention CFU mean 3 range 0-39. When comparing 2nd and 3rd interventions, no significant reduction in the CFU was observed.	Referring to skin microbiota- 1st intervention bacterial loads were higher compared to the 2nd intervention. No difference between 2nd and 3rd intervention. Lower bacterial loads were found in the chlorhexidine groups. Reduction in staph between 1st and 2nd intervention and the 1st and 3rd intervention. Gram-negative bacilli were more frequently found in the 1st (30 total CFU, average 0.27, range 0-7 intervention when compared	The bacterial load in uniforms decreased when chlorhexidine was used. (bathing or impregnation when compared to SSS. No difference in potential pathogens.	Strength: no previous studies on the results of staff wearing chlorhexidine apparel. Previously studies are patients bathed with chlorhexidine not staff utilizing chlorhexidine wipes to diminish the transmission of pathogens. Limitations: small study, no control group (no chlorhexidine or SSS). Risk of harm: The only risk for harm listed was a skin reaction to chlorhexidine. Feasibility of use: Chlorhexidine wipes are readily available for staff, so is SSS. Chlorhexidine impregnated scrubs would have to be prepared in the facility. It is not yet

<p>10. Anderson DJ, Addison R, Lokhnygina Y, Warren B, Sharma-Kunkel B, Rojas LJ, Rudin SD, Lewis SS, Moehring RW, Weber DJ, Rutala WA, Bonomo RA, Fowler VG, Sexton DJ; CDC Prevention Epicenters Program. The antimicrobial scrub contamination and transmission (ASCOT) trial: A three-arm, blinded, randomized controlled trial with crossover design to determine the efficacy of antimicrobial-impregnated scrubs in preventing healthcare provider contamination. <i>Infect Control Hosp Epidemiol.</i> 2017 Oct;38(10):1147-1154. DOI: 10.1017/ice.2017.181. Epub 2017 Aug 29. PMID: 28847326. Two different antimicrobial impregnated scrubs and a control scrub without antimicrobial</p>	<p>Prospective blinded randomized trial. 3-arm RCT of two types of antimicrobial impregnated clothing: standard HCP clothing: 40 nurses were enrolled, and for 3 shifts. 2919 cultures from the environment and 2185 from HCP clothing. The control was a standard cotton polyester material. Compared to silver-</p>	<p>This study took place at two ICU's at Duke University Hospital. 102 total patients with 40 nurses, 120 individual 12 hour ICU shifts. 1.4 patients per shift per nurse.</p>	<p>167 patient encounters. Total 2919 cultures were obtained from the patient room including bed rails, beds, supply carts. 2185 total cultures obtained from the HCP clothing.</p>	<p>This study utilized a generalized estimating equation GEE linear regression model to contrast and compare the amount of contamination between the control and the other scrubs. Logged into a model were different concepts like type of scrubs, total CFU in the start of the shift. Randomization, patient characteristics. The presence of drains and tubes, wound, current infections, mechanical ventilation and environmental contaminants. Statistical</p>	<p>Contamination was not reduced on chlorhexidine impregnated scrubs.</p>	<p>to the 2nd (9 CFU, average 0.27 range 0-7) and 3rd (CFU 14, average 0.12, range 0-3) intervention group.</p> <p>Total of 2185 cultures during 120 shifts. Of the environmental areas tested, bed rails had the highest amount of contamination. Scrub cultures obtained from the control group showed a median CFU increase by 33 on the sleeve, 32 on the pocket and 25 by the abdomen area.</p>	<p>manufactured.</p> <p>Strength: Large amount of cultures performed. Limitations may include the surface area sampled from the cloth of all uniforms tested may have failed to demonstrate the true amount of contamination. Only a small portion of each area of uniform was tested.</p>
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impregnation were analyzed and microbes were compared.	alloy embedded. Or impregnated with an organosilane-based quaternary ammonium and hydrophobic fluoroacrylate copolymer emulsion. Nurses wearing the scrubs were blinded to which type they were wearing.	calculations were made by using probability when comparing the control with the other antimicrobial impregnated scrubs.	Scrub 1 showed 17 CFU increase by the sleeve, -0.5 by the pocket, and 17 by the abdomen. Scrub 2 showed a 9 CFU median increase, -1 pocket and 4 abdominal area of uniform.			
8. Goyal S, Khot SC, Ramachandran V, Shah KP, Musher DM. Bacterial contamination of medical providers' white coats and surgical scrubs: A systematic review. <i>Am J Infect Control.</i> 2019;47(8):994-1001. doi:10.1016/j.ajic.2019.01.012 Bacterial contamination from white coats and scrubs.	22 articles are looked at in this review of bacterial contamination of white coats and surgical scrubs worn by health care providers.	Variables examined are different microbial contaminants, antibiotic resistance found on the bacteria, types	Each of the variables obtained from the 22 articles were	Microbial contaminants, 11 studies were looked at (Treakle et al.) found that 23% of white coats were contaminated with <i>S. Aureus</i> , 18% of which were MRSA. Krueger et al. 268 of 300 (89%) of resident scrubs were contaminated with	There is a definite lack of evidence to confirm that healthcare workers can be the culprits to transfer bacteria from their attire to their patients resulting in a healthcare	Strength: This systematic review examined different aspects looking at providers' clothing contamination and practices that may increase the number of bacteria. Limitations: There is a deficiency of studies pertaining

<p>Systematic review utilizing information from cross-sectional studies, randomized controlled trials and cohort studies.</p>	<p>of providers with the higher rates of contamination to their attire. Fabric type, antimicrobial coating on the cloth, laundering frequency and laundering practices disposable scrubs.</p>	<p>measured separately and organized by percentage.</p>	<p>bacteria compared to 123 of 300 41% unworn scrubs. Similarly, another two studies also showed a contamination of Staph aureus 17% of worn scrubs and the other at 30 % of worn scrubs. Another study determined that nurses caring for patients with wounds had the highest percentage of contamination. Another aspect listed is the type of fabric of the surgical attire worn. Different fabrics studies were cotton, polyester or a blend of these fabrics. One study found that blend fabric had a were 60% and 36% higher than polyester after a work shift. A study by Takashima et al resulted</p>	<p>Data showed that white coats have a higher percentage of contamination than scrubs which white coats are generally washed less frequent and are laundered at home. All the studies in this systematic review does prove there is a transfer of bacteria to health care workers attire during the work shift. Where the evidence lacks is the link of health care associated infections to healthcare providers</p>	<p>associated infection. The data does confirm healthcare workers carry bacteria in their clothing and so methods should be in place to reduce the transmission</p>	<p>to the contamination of healthcare workers attire directly to the patient. Feasibility of use: Facilities can utilize this information to create protocols for the reduction of contamination on healthcare workers attire.</p>
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that wool, polyester and acrylic are strong carriers of S aureus and P aeruginosa. Cotton was found to have the least of these bacteria. Antimicrobial coating on the fabric of surgical scrubs was studied and concluded that treated scrubs had a bacterial contamination of 4.4% versus 7.8% on non-treated scrubs. Another study by Bearman et al concluded a significant reduction in MRSA with treated scrubs. In regard to laundering methods of scrubs, there is a higher bacterial contamination on home laundered or unwashed scrubs when compared with hospital laundered or disposable attire.

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<p>8. Ilibman Arzi Y, Assous MV, Livnat K, Yinnon AM, Wiener-Well Y. Bacterial contamination of surgical scrubs in the operating theater. <i>Am J Infect Control.</i> 2020;48(1):56 -60. doi:10.1016/j. ajic.2019.06.0 22 Contaminatio n of surgical scrubs obtained while in the facility prior to entering the OR.</p>	<p>scrubs. 44 % of home laundered scrubs were contaminat ed while none of the facility laundered scrubs had bacteria contaminati on.</p>
	<p>Culture results of the control and study group showed no significant statistical difference between the two. 13% contaminati on of study group versus 9% of the study group. In terms regarding where these surgeons had been prior to entering the operating room, the ones that had participated in other medical activities prior to entering 41, had higher bacterial load contaminati on 34.</p>



7. Vera CM. Laundering methods for reusable surgical scrubs: A literature review. AANA J. 2016;84(4):246-252. Literature review	A descriptive study where surgeons upon entering the operating room were given a questionnaire regarding where they had been and their activities prior to	in a 1000 bed hospital located in Jerusalem, Israel. This hospital provides facility laundered scrubs to their employees and prohibits wearing these scrubs outside of their facility.	Independent variable: Cultures obtained for a bacterial contaminant in the attire along with the activity of this provider. 11 samples were taken as a control from clean uniforms.	133 surgeons' scrubs were sampled and 11 control samples. Of the 133 samples, 77% of these surgeons stated they had been in the operating rooms. 41% prior to entering had taken part in other clinical activities. And 33% had taken part in other non medical functions in the hospital.	The majority of article reviewed confirmed the bacterial-carrying capacity of hospital worker uniforms that accumulated throughout the workday. Further data was gathered suggesting the bacterial load	When replacement of scrubs is frequent (at least every 4 hours) decreases the bacterial load.	Surgical scrubs should be changed frequently in the operating room to reduce to amount of contamination on the clothing.	This article indicated an alternative to the reduction in bacteria which is the frequent change in scrubs when entering the operating room. Weakness: Identify the different medical procedures prior to entering the operating room and which of these pose the highest risk for contamination. More testing of the control group. These facility laundered scrubs should be tested and protocol reviewed as to the reason for contamination. If the subjects that wore these control scrubs contaminated them upon dressing themselves, then further testing should be conducted on the hygiene of
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<p>regarding home laundered or facility laundered surgical scrubs and the potential to transmit bacteria and cause a SSI.</p>	<p>entering. Following the questionaire one single swab was taken from the front pocket of their hospital issued scrubs.</p>	<p>75 total articles were reviewed, of which 30 met the criteria. 2 of these articles were RCT, 10 were literature reviews. 18 were considered experimental studies, 4 of them were case reports, 1 was a cross-sectional survey and 3 articles were expert opinions.</p>	<p>Information further reviewed included the transmission of bacteria from surgical attire, the relationship between SSI and scrub uniforms. Also, the difference between home laundered and facility laundered scrubs and the recommendatio</p>	<p>Each of the criteria were examined and the results from these studies were presented by</p>	<p>increases as hours of work increase, suggesting the contamination occurs by patient contact. Even though the evidence in countless articles suggest providers carry bacteria in their uniforms, the direct correlation to SSI is lacking. There is evidence of one case report where contaminated facility laundered scrubs resulted in two post-operative patients acquiring <i>Bacillus cereus</i>. Evidence reviewed regarding home or facility laundered scrubs indicate no change in SSI to either.</p>	<p>Whichever of the two means of decontaminating the surgical scrubs, the methods should be clear and recommendations should be uniform throughout regarding temperature, drying methods, and the storage.</p>	<p>the skin of healthcare workers upon entering the hospital. Feasibility of use: It is appropriate and feasible for scrubs to require changing every 4 hours or between surgical cases.</p>	<p>Strength: This article indicated an alternative to the reduction in bacteria which is the frequent change in scrubs when entering the operating room. Weakness: Identify the different medical procedures prior to entering the operating room and which of these pose the highest risk for contamination. More testing of the control group. These facility-laundered scrubs should be</p>
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**Appendix C: IRB Exemption Letter**

Office of Research Integrity  
Research Compliance, MARC 414

**MEMORANDUM**

**To:** Dr. Yasmine Campbell  
**CC:** Karina Fraga  
**From:** Elizabeth Juhasz, Ph.D., IRB Coordinator *EJ*  
**Date:** April 8, 2021  
**Protocol Title:** "An educational module on the utilization of chlorhexidine impregnated surgical attire in operating room staff to decrease surgical infections."

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The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

**IRB Protocol Exemption #:** IRB-21-0148      **IRB Exemption Date:** 04/08/21  
**TOPAZ Reference #:** 110230

As a requirement of IRB Exemption you are required to:

- 1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
- 2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
- 3) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

**Special Conditions:** N/A

For further information, you may visit the IRB website at <http://research.fiu.edu/irb>.

EJ

## Appendix D: QI Project Consent



### CONSENT TO PARTICIPATE IN A QUALITY IMPROVEMENT PROJECT

“The utilization of antimicrobial impregnated surgical attire in operating room staff to decrease surgical infections.”

#### **PURPOSE OF THE PROJECT**

You are being asked to be in a quality improvement project. The goal of this project is to decrease surgical site infections by utilizing chlorhexidine impregnated attire. Certified Registered Nurse Anesthetists will review guidelines that could be implemented in the operating room to reduce surgical site infections.

#### **DURATION OF THE PROJECT**

Your participation will require about 20 minutes of your time.

#### **PROCEDURES**

If you agree to be in the project, we will ask you to do the following things:

#### **RISKS AND/OR DISCOMFORTS**

There are no foreseeable risks with you for participating in this project.

#### **BENEFITS**

The following benefits may be associated with your participation in this project: An increase in knowledge regarding surgical attire and the reduction of surgical site infections, which will assist you as a practitioner to provide excellent care to surgical patients by reducing their incidence of infection. The overall objective of the program is to increase the quality of healthcare delivery, improve the health indicator of our patients, and increase patient engagement.

#### **ALTERNATIVES**

There are no known alternatives available to you other than not taking part in this project. However, if you like to receive the educational material given to the participants in this project, it will be provided to you at no cost

#### **CONFIDENTIALITY**

The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, we might publish, we will not include any information that will make it possible to identify you as a participant. Records will be stored securely, and only the project team will have access to the records.

#### **COMPENSATION & COSTS**

There is no cost or payment to you for receiving the health education and/or participating in this project.

**RIGHT TO DECLINE OR WITHDRAW**

Your participation in this project is voluntary. You are free to participate in the project or withdraw your consent at any time during the project. Your withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove you without your consent at such time that they feel it is in the best interest.

**RESEARCHER CONTACT INFORMATION**

If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact Karina Fraga. at [kfrag010@fiu.edu](mailto:kfrag010@fiu.edu) or Dr. Jorge Valdes at 305-348-7729, [jvalde@fiu.edu](mailto:jvalde@fiu.edu).

**IRB CONTACT INFORMATION**

If you would like to talk with someone about your rights of being a subject in this project or about ethical issues with this project, you may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at [ori@fiu.edu](mailto:ori@fiu.edu).

**PARTICIPANT AGREEMENT**

I consent by participating in the survey. I have read the information in this consent form and agree to participate in this project

## Appendix E: QI Project Survey



### Pretest and Posttest Questionnaire:

#### Antimicrobial Impregnated Surgical Attire to Reduce Surgical Site Infections

##### INTRODUCTION

The primary aim of this QI project is to improve the knowledge of CRNA's on the possibilities of surgical site contamination from a provider's surgical attire in order to decrease the incidence of surgical site infections.

Please answer the question below to the best of your ability. The questions are either in multiple-choice or true/false format and are meant to measure knowledge and perceptions on surgical site infections contaminated by provider's attire.

##### PERSONAL INFORMATION

Gender: Male                      Female                      Other\_\_\_\_\_

1. Age: \_\_\_\_\_

2. Ethnicity:

Hispanic              Caucasian              African American              Asian              Other\_\_\_\_\_

3. Position/Title: \_\_\_\_\_

4. Level of Education: Associates                      Bachelors                      Masters                      Other  
\_\_\_\_\_

5. How many years have you been an anesthesia provider?  
Over 10              5-10 years                      2-5 years                      1-2 years

##### QUESTIONNAIRE

**1. According to the CDC, which are the most common health care-associated infections:**

- a. Catheter-associated bloodstream infections
- b. Surgical site infection
- c. Catheter-associated urinary tract infections
- d. Pneumonia

**2. Which surgical procedures have the highest risk of infection?**

- a. Open heart surgery
  - b. Shoulder surgery
  - c. Abdominal surgery
  - d. Craniectomy
- 3. How much can an infection cost?**
- a. 5,000-13,000
  - b. 500-1,000
  - c. 1,000-3,000
  - d. hospitals don't pay for infections
  - e. All the above
- 4. Which patient has the highest risk to obtaining a surgical site infection?**
- a. ASA 2, rheumatoid arthritis
  - b. BMI 25, 89 year old female
  - c. trauma, GCS 5
  - d. ASA 3, diabetes
- 5. Who places the guidelines for the facilities that launder hospital scrubs?**
- a. Healthcare Laundry Accreditation Council
  - b. American Nurses Association
  - c. Infectious Disease Society of America
  - d. Society for Healthcare Epidemiology of America
- 6. What is a critical component assessed when laundering scrubs?**
- a. Number of days clothing has been soiled.
  - b. Number of surgeries involved in with those scrubs.
  - c. Temperature of water utilized when washing the scrubs.
  - d. Scrubs soiled with blood.
- 7. Home laundering is the most effective way to decontaminate surgical attire.**  
True or False
- 8. What is your current mode of handling your surgical attire?**
- a. Home laundering
  - b. Utilizing the hospital laundered scrubs
  - c. Utilizing disposable scrubs
- 9. How likely are you to use antimicrobial impregnated surgical attire?**
- a. Most likely
  - b. Somewhat likely
  - c. Somewhat unlikely
  - d. Most unlikely
- 10. How likely are you to recommend antimicrobial surgical attire?:**
- a. Most likely
  - b. Somewhat likely
  - c. Somewhat unlikely
  - d. Most unlikely



## Appendix F: Educational Module

**FIU**

“The utilization of antimicrobial impregnated surgical attire in operating room staff to decrease surgical infections.”

Karina Zaldivar

FLORIDA INTERNATIONAL UNIVERSITY

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### Learning Objectives

- Present data on surgical site infections
- Discuss patients at risk for surgical site infections
- Discuss the process of home laundering scrubs
- Discuss the process of facility laundered scrubs
- Discuss the features of Chlorhexidine impregnated surgical attire

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### Background of Problem

- According to the CDC, surgical site infections lead the highest HAI.<sup>1</sup>
- SSI's increase length of stay in the hospital and morbidity and mortality.<sup>2</sup>
- Abdominal surgeries hold the highest incidence of SSI between 4-19%.<sup>3</sup>
- The average cost per infection ranges from \$5,000-\$13,000.<sup>1</sup>
- Risk factors related to SSI (ASA class, BMI greater than 30, diabetes, rheumatoid arthritis and immunosuppression)<sup>2</sup>
- Surgical attire can serve as a means to communicate antibiotic-resistant pathogenic bacteria, including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococcus*, and *Clostridium difficile*.<sup>2</sup>

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### Home laundering of scrubs

- A case study done on surgical wound contamination, found that an anesthesia provider contaminated the sternal wound during 3 surgeries with *G. bronchialis*, and it was traced back to the home washing machine.<sup>4</sup>
- The CDC recommends water temperature of 71 degrees Celsius and a bleach-based detergent.<sup>4</sup>
- Home washing machines typically achieve 60 degrees Celsius for an average of 35 minutes.<sup>4</sup>

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### Hospital laundered surgical attire

- Regulated by the Healthcare Laundry Accreditation Council abiding with OSHA and CDC guidelines<sup>5</sup>
- Not enough studies/evidence suggesting facility laundered scrubs are more effectively decontaminated than home laundered scrubs.
- This requires employees to adhere to policy and remove scrubs prior to departure of the hospital.

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### Chlorhexidine impregnated surgical attire

- Chlorhexidine is utilized to wipe patient prior to surgery to reduce microbes on the skin.
- Sterile, single use uniforms<sup>6</sup>
- Packaged as a two-piece garment<sup>6</sup>
- The cloth is submerged in 0.12% chlorhexidine and left to dry in a sterile environment<sup>6</sup>
- 4.4% of antimicrobial-treated scrubs had MRSA, VRE, or multidrug resistant gram-negative rods compared to 7.8% of nontreated scrubs<sup>6</sup>
- Reduces the contamination on the cloth as opposed to decontaminating the cloth after it's already been contaminated
- Not yet manufactured by a company

## Practice Changes

- Vigilance among the surgical team regarding surgical cases that contain a high risk of infection.
- Infection control protocols/recommendations in the OR concerning attire.
- Providing anesthesia providers with current infection rates in the operating room.
- Removing scrubs when visibly soiled or after providing care to an infected patient.
- Utilizing antimicrobial impregnated attire for surgeries with a high risk of attaining infection.
- More studies correlating whether surgical infections were caused by a provider's attire.

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## In Conclusion...

- Surgical site infections can increase cost for the hospital by increasing length of stay and costly antibiotic treatments.
- Patients are at risk for death if a surgical wound is infected.
- Home laundering is a probability if the proper detergents and water temperature is utilized.
- Facility laundered scrubs offer better results than home laundered but is an added cost to the hospital.
- Chlorhexidine impregnated surgical attire reduces the contamination of microbes on the cloth.
- Home laundered and facility laundered modalities remove contamination from cloth, as opposed to antimicrobial impregnated which reduces the chances of contamination.

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2. Harold RE, Butler BA, Linsplot J, Lau III, Lawton CD, Manning D. Multifaceted aseptic protocol decreases surgical site infections following hip arthroplasty. *Hip Int* 2018;28(2):182-188. doi:10.5301/hipint.5000551
3. Matz D, Tentenberg S, Wencierz A, Soysal SD, Heilmann O. Do antibacterial skin sutures reduce surgical site infections after elective open abdominal surgery? - Study protocol of a prospective, randomized controlled single center trial. *Trials*. 2019;20(1):N.PAG. doi:10.1186/s13063-019-3492-3
4. Vera CM. Laundering Methods for Reusable Surgical Scrubs: A Literature Review. *AANA J*. 2016;84(4):246-252.

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5. Implementing best practices for surgical attire laundering. *AORN J*. 2015;102(5):P7-P9. doi:10.1016/S0001-2092(15)00910-2
6. Anderson DJ, Addison R, Lokhnygina Y, Warren B, Sharma-Kuinkel B, Rojas LJ, Rudin SD, Lewis SS, Moehring RW, Weber DJ, Rutala WA, Bonomo RA, Fowler VG, Sexton DJ, CDC Prevention Epicenters Program. The antimicrobial scrub contamination and transmission (ASCOT) trial: A three-arm, blinded, randomized controlled trial with crossover design to determine the efficacy of antimicrobial-impregnated scrubs in preventing healthcare provider contamination. *Infect Control Hosp Epidemiol*. 2017 Oct;38(10):1147-1154. doi: 10.1017/icc.2017.181. *Epub* 2017 Aug 29. PMID: 28847326.

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