2016

Methicillin-Resistant Staphylococcus Aureus Infections in the Eight Service Planning Areas of Los Angeles County

Ildiko Roxane Bocskay
Walden University

Walden University

College of Health Sciences

This is to certify that the doctoral dissertation by

Ildiko Bocskay

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

Review Committee
Dr. Frazier Beatty, Committee Chairperson, Public Health Faculty
Dr. Diana Naser, Committee Member, Public Health Faculty
Dr. Scott McDoniel, University Reviewer, Public Health Faculty

Chief Academic Officer
Eric Riedel, Ph.D.

Walden University
2016

Abstract

Methicillin-Resistant Staphylococcus Aureus Infections in the Eight Service Planning Areas of Los Angeles County

by

Ildiko Roxane Bocskay

BSN, Grand Canyon University, 2012

AA, Los Angeles Pierce College, 2011

MBA, DeVry University, 2007

MSc, University of Debrecen, 2001

BSc, Károly Eszterházy Teacher Training College, 1998

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

May 2016

Abstract

Methicillin-resistant staphylococcus aureus (MRSA) has become resistant to antibiotics. The purpose of this quantitative, retrospective cohort study was to examine the relationship between length of hospitalization and invasive MRSA infection rates among different racial and ethnic groups in the 8 service planning areas (SPAs) of Los Angeles County. Cane, O'Connor, and Michie's theoretical domain framework was used. Secondary data from the Healthcare-Associated (HA) Infections Program of the California Department of Public Health were analyzed. For the first research question, a Pearson correlation analysis was conducted to assess the relationships between length of hospitalization and invasive HA-MRSA infection rates and counts. Length of hospital stay was not correlatedwith HA-MRSA infection rates; however, it was strongly and positively correlated with HA-MRSA infection counts. For the second research question, a one-way ANOVA was conducted on the infection count rate data, with SPA as the between-subjects factor. The results were statistically significant, indicating that HA-MRSA infection counts varied among the 8 SPAs. The findings might help medical professionals better understand the risk factors associated with MRSA infections. In doing so, findings may relieve some of the burden on the U.S. health care system and improve the overall quality of life of the patients involved.

Methicillin-Resistant Staphylococcus Aureus Infections in the Eight Service Planning Areas of Los Angeles County

by

Ildiko Roxane Bocskay

BSN, Grand Canyon University, 2012

AA, Los Angeles Pierce College, 2011

MBA, DeVry University, 2007

MSc, University of Debrecen, 2001

BSc, Károly Eszterházy Teacher Training College, 1998

Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

Walden University

May 2016

Dedication

I dedicate my dissertation to my late grandfather, (Tata) Nemes József; my super grandmother, (Mami) Nemes Józsefné Kiczel Irén; my lovely mother, (Anya) Nemes Ildikó Gabriella; and my funny husband, (Férjem) John Alexander Bocskay. I send a special thank you to my grandmother for teaching me how to study and enjoy learning. Mami, you helped me to fall in love with studying! Without your love, support, and encouragement, I would not have been able to pursue my dream of obtaining an advance degree in infectious disease epidemiology, my favorite field of study. You made me who I am today! Thank you very much for your love, prayers, guidance, and support! Szeretlek benneteket! I love you all!

Acknowledgments

I would like to say a special thank you to my wonderful chair, Dr. Frazier Beatty, for supporting me on this journey. My committee member, Dr. Diana Naser, always had positive reflections on my research. My university research reviewer, Dr. Scott McDoniel, always provided thoughtful feedback to improve the final study. My incredible dissertation editor, Barb Elwert, reviewed my writing.

I would like to offer a warm thank you to my elementary school biology teacher, Tóth Gyuláne Ilike, who made me fall in love with biology. I extend warm thanks to my amazing professors at Károly Eszterházy Teacher Training College, Eger, Hungary, and the University of Debrecen, School of Natural Science, Debrecen, Hungary. A special thank you goes to Dr. Béla Lenkey, professor of microbiology, who made microbiology my favorite subject!

In my thanks, I acknowledge my stepfather, Dr. Horváth Gusztáv, pulmonologist, who helped me to prepare study notes to survive the oral defense of plant physiology exam.

I also acknowledge all of my family members and friends in Hungary and in California. I send a special thank you to my best friends, Mata Csaba and Fernando Pena. I want to acknowledge my BSN students at Azusa Pacific University, Azusa and Mount Saint Mary's University, Los Angeles. *"If you study to remember you will forget, but, if you study to understand, you will remember." –Anonymous*

You made me a successful teacher!

I wish to acknowledge Joni Novosel, Dr. Jose Salazar, and Kenneth Archulet for helping me to start my career in a new country. I thank Elaina Ramirez, registered nurse, for giving me help when I needed it. Finally, I want to acknowledge in particular the wonderful family of Aurora Las Encinas Hospital, Pasadena. Psychiatric nursing care rocks!

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction to the Study

Introduction

One of the most common and dangerous bacterial pathogens in the health care setting is Staphylococcus aureus (S. aureus). This bacterium has multiple virulence strains that cause various clinical symptoms and conditions ranging from infections of the skin and soft tissue to death (Heyman, 2008). One strain of the S. aureus bacterium that has developed resistance against the antibiotic methicillin is methicillin-resistant S. aureus (MRSA; Gladwin & Trattler, 2007). MRSA infections that occur in health care settings such as hospitals, dialysis units, and nursing homes are associated with invasive health care-associated MRSA (HA-MRSA) infections (Kjonegaard, Fields, & Peddecord, 2013; Mayo Clinic, 2012).

MRSA nasal colonization results from several factors, including antibiotic usage within 3 to 6 months before admission to hospital, hospitalization within the past 12 months, and transfer from another hospital; male sex and older age are other risk factors (Harbath et al., 2006). MRSA infection rates have manifested racial and ethnic disparities in 323 acute care hospitals in California. Hospitals with increased numbers of patients infected with HA-MRSA mostly work with members of vulnerable populations, such as patients with low levels of education and those who have comorbid conditions (Tehrani et al., 2014). They also often discharge patients to facilities for continuing care (Tehrani et al., 2014).

I conducted a quantitative study to test the association between invasive HA-MRSA infections and length of hospitalization and investigate whether there was an

increased incidence rate of MRSA infection during hospitalization among the eight service planning areas (SPAs) in Los Angeles County. I analyzed secondary data from the California Department of Public Health (CADoPH) for 2011 to 2013. My study might help health care professionals to better understand the risk factors of MRSA infections. In doing so, it might relieve some of the burden on the U.S. health care system and improve the overall quality of life of patients. In Chapter 1, I discuss the background of the study, problem statement, purpose of the study, research questions and hypotheses, theoretical framework, nature of the study, definitions of terms, assumptions, scope and delimitations, limitations, and significance of the study.

Background of the Study

Characteristics of S. Aureus

According to Todar (2012b), S. aureus is a Gram-positive, cluster-forming coccus, nonmotile, and non-spore-forming anaerobe bacterium. Although this coccus mainly colonizes in the arterial nares, it also is commonly found in extranasal sites such as the skin, oral cavity, throat, gastrointestinal tract, umbilicus, groin, and perirectum (Todar, 2012b). It is related to a variety of bacterial strains that can cause clinical symptoms ranging from a single skin lesion to toxic shock syndrome and death (Heyman, 2008).

Staph infections have different pathological manifestations in the human body, two of which are pus-forming infections and toxins. S. aureus frequently generates localized infections at the site of entry because of the active defense mechanism response of the host immune system (Todar, 2012a). Hair follicles, breaks in the skin's protective

layers resulting from needle stick injuries and wounds, and the respiratory tract are considered potential sites of entry for human staph infections (Todar, 2012a). The host's immune system responds to infections with inflammation, swelling, suppurative discharge, fever, malaise, headache, and tissue death (Todar, 2012a).

Potential Sources and Sites of Infection

The pathogenesis of staph diseases produces broad clinical symptoms. S. aureus can colonize on the human skin without damaging the protective layers of the epidermis (Heyman, 2008). Skin irritation and invasive procedures such as peripheral venous access catheter (intravenous line) insertion, surgically created passageways (arteriovenous fistula) for dialysis, and surgical incisions can alter the protective barriers of layers of skin (Heyman, 2008). Breaks in the skin facilitate the migration of this human pathogen into open wounds, which can then lead to localized or severe infections. Primary indications of S. aureus infection include shallow skin lesions such as infections of the eyelid (sties), formation of pus-filled bumps under the skin (boils), inflammatory conditions affecting hair follicles (folliculitis), localized suppurative skin infection of the hair follicles and subcutaneous tissues (furuncles), highly contagious red sores on the skin (impetigo), and the collection of pus in any part of the body (abscesses; Heyman, 2008). Complications of secondary infections include invasive forms of bacterial diseases such as lung abscesses, pneumonia, urinary tract infections (UTIs), osteomyelitis, endocarditis, arthritis, meningitis, toxic shock syndrome, food poisoning, septicemia, and death (Heyman, 2008).

Pathogenesis of S. Aureus

S. aureus is a pathogenic bacterium with virulence factors that can invade immunocompetent and immunocompromised human hosts. This microbe attacks the human immune system by adapting to and resisting innate and adaptive immune responses (Reyes-Robles, Alonzo, & Torres, 2014). Those who experience such bacterial invasion find that their immune systems are compromised and that they have various symptoms of infection. S. aureus produces different kinds of leukotoxins, which are substances that protect pathogens from human leukocytes (e.g., neutrophils). Examples include Panton-Valentine leukocidin (also known as LukSF-PV or PVL), γ-hemolysins (HlgAB and HlgCB), leukocidin AB (LukAB), and leukocidin ED (LukED). Leukotoxins mainly target neutrophils, which are the first responders to microbial infections. They also destroy different immune cells by releasing toxins, whereas HlgAB, HlgCB and LukED destroy red blood cells (Reyes-Robles et al., 2014).

S. aureus secretes LukED as soluble monomers, which can bind chemically with the host cell plasma membrane and target the leukocytes. Leukotoxins have a high affinity to connect with CCR5 (macrophages and dendritic cells); CXCR1; and CXCR2 (neutrophils, monocytes, and natural killer cells) receptors. Once these connections are made, then hetero-octametric pores with stem structures form. These compositions lead to functional pore formations that insert into the host cell plasma membrane and initiate leukocyte death.

S. aureus first attacks the innate immune cells of the host. After the initial S. aureus infection, the adaptive immune system tries to work against the S. aureus bacterial

invasion. Meanwhile, LukED destroys CCR5-positive memory T lymphocytes. This process is termed S. *aureus infection* (Reyes-Robles et al., 2014).

In the early 2000s, scientists identified USA300 isolates of the S. aureus strain type in patients in the United States ranging in age from 1 to 86 years (Tenover & Goering, 2009). Within a brief period of time, this pathogen spread globally. Those who were infected experienced medical problems that ranged from skin and soft tissue infections (SSTIs) to severe bacteremia, necrotizing pneumonia, and osteomyelitis. Biological adaptations and mutations have made this human pathogen a very successful infectious agent. The major characteristics of the microbe are its virulence; its resistance to antimicrobial agents such as methicillin, erythromycin, levofloxacin, mupirocin, and tetracycline; and its reduced susceptibility to vancomycin and daptomycin (Tenover & Goering, 2009).

USA300 is a highly virulent MRSA strain (Planet et al., 2013). The evolutionary success of this clone was based upon the speG gene. Human pathogens with the speG gene can form biofilms, a strategy necessary for bacterial invasion that also increases the connection to the host cells, contributes to antimicrobial resistance, and kills human cells. (This evolutionary advantage has made the MRSA strain USA300 a serious global epidemic (Planet et al., 2013).

According to Even et al. (2009), the virulence of S. aureus is related to virulent genes such as agr and sarA. Considering this relationship, scientists have investigated the biocontrol of virulence expression by changing the microbial environment through the addition of lactic acid bacteria (L. lactis) to test cultures. L. lactis can impair the virulence

expression of S. aureus in the laboratory environment. However, according to Even et al., further research is needed to investigate L. lactis nonantibiotic biocontrol potential to prevent the human pathogenesis of S. aureus.

The colonization of S. aureus depends on environmental stimuli such as cigarette smoke (Kulkarni et al., 2012). Because cigarette smoke, including secondhand smoke, suppresses the immune system and facilitates the formation of staph biofilm, oxidative stress, and the expression of pathogenic virulence. S. aureus bacteria stick to one other inside the nasopharynx, and they compromise fibronectin (i.e., the production of cell-surface protein). Smoking enhances the binding of S. aureus to fibronectin and adherence to human cells. This biological mechanism explains how respiratory infections are caused and how cocci are colonized in the arterial nares (Kulkarni et al., 2012).

Syed, Ghosh, Love, and Boles (2014) indicated that the addition of triclosan as an active ingredient to antibacterial soaps, body washes, toothpaste, cosmetics, and medical equipment can reduce or prevent bacterial contamination. Researchers have been able to easily detect triclosan in bodily fluids and arterial nares because of its presence in numerous personal care products. Syed et al. found that triclosan in nasal secretion can be a predictor of future S. aureus nasal colonization because it intensifies the binding of S. aureus to the proteins of the host cells, which then promotes bacterial colonization in the nose.

Origin of MRSA Infection

In 2012, Prince et al. discovered livestock-associated MRSA clonal complex 398 (MRSA CC398). This clone complex causes very serious human infections. According to

Prince et al., the MRSA CC398 pathogen was well known at the time as methicillin-sensitive S. aureus (MSSA), an infectious clone transmitted via zoonosis from human beings to livestock. Meanwhile, independent genetic events led to tetracycline and methicillin resistance: Excessive antibiotic usage in farm animals promoted resistance to antibiotics and increased potential health risk (Prince et al., 2012).

More recent research has supported a theory about two new emergent clones of MRSA found in livestock, especially in cattle (Spoor et al., 2013). Scientists have identified one of the clones, CC97 (or, bovine S. aureus complex), in patients with MRSA infection. This infectious pathogen was found originally in bovine species, but it has become widespread among human beings. There has been insufficient evidence of the reasons for the host to switch from a bovine species to human beings more than 40 years ago. The CC97 clone has mobile genetic sections that can change the immune reactions of the host by encoding antibacterial resistance. Through this mechanism, the pathogen will survive and spread in host human beings. This adaptive mechanism helps the infectious microbe to establish pathogenesis. As a result, livestock are considered a reservoir for emergent MRSA infections. Active surveillance and infection control measures are necessary in the agricultural sector (Spoor et al., 2013).

MRSA can infect not only farm animals but also human beings and their companion animals, including dogs, cats, and horses. Harrison et al. (2014) stated that human beings can infect their pets without host adaptation efforts. Harrison et al. also suggested that companion animals might serve as reservoirs for human infections. The

researchers provided evidence indicating that the use of antibiotics in veterinary medicine has been linked to MRSA infection in human beings.

History of the Disease

Between 1960 and 1968, sporadic MRSA outbreaks occurred in many Western European countries and in Australia (University of Chicago, 2010). The first outbreak of MRSA happened at Boston City Hospital in Massachusetts in 1968. Between 1968 and the mid-1990s, the number of MRSA infections among hospitalized patients and injection drug users increased drastically. In 1997, MRSA was the cause of death of four children in North Dakota and Minnesota. Until 2008, the rates of CA-MRSA infections increased steadily, but the rates of HA-MRSA infections remained stable. In 2001, the USA300 clone was identified as an MRSA virulent factor (University of Chicago, 2010).

The three initial cases of severe S. aureus infection in the 1960s were described as a random genetic accident (McKenna, 2010). This disease-causing bacterium was treated with a beta-lactam antibiotic manufactured by Beecham Research in the United Kingdom in 1959 (Antimicrobe, 2014; McKenna, 2010; University of Chicago, 2010). The proprietary name of this medication in the 1960s was Celbenin, but it currently is known as methicillin (McKenna, 2010).

Despite the use of antibiotics, staph infection rates remained high. Blood culture collections revealed that S. aureus had developed penicillin-sensitive and penicillin-destroying virulence strains, which had increased tolerance and resistance to methicillin (McKenna, 2010). MRSA has the ability to neutralize the effect of antibacterial agents,

alter bacterial survival rates, and promote the multiplication of surviving bacteria (McKenna, 2010). Elaborate.

In an experiment, Barber (1961) selected 18 strains of staph bacteria: Nine were penicillin sensitive, and nine were penicillin destroying. Barber analyzed the ways in which Celbenin could inhibit penicillin-sensitive staphylococci on ditch plates. She found that the staphylococci were resistant to benzylpenicillin. This antibiotic-resistant S. aureus produced penicillinase, an enzyme that inactivated penicillin-like antibiotics. This biochemical mechanism increased Celbenin resistance and benzylpenicillin tolerance. Meanwhile, the bacteria had typical virulent strains. When an increased concentration of was penicillin used, the bacteria's drug tolerance increased (Barber, 1961).

MRSA is a strain of S. aureus that has developed a resistance against the anti-infectives methicillin and nafcillin, which have the trade name Nallpen (Drugs, 2015; Gladwin & Trattler, 2007). The resistance is initiated by a deoxyribonucleic acid (DNA) segment, mecA, which encodes a penicillin-binding protein 2A, and initiates cell wall synthesis by blocking the original penicillin binding protein (Gladwin & Trattler, 2007). The most common antibiotic for the inpatient treatment of MRSA is vancomycin (Brooks, 2012; Jenkins et al., 2014). Vancomycin is a fluoroquinoes antibiotic that inhibits cell wall synthesis (Brooks, 2012). Once patients are discharged from hospital, the discharge therapy regimens include an MRSA-active agent with β-lactam or fluoroquinolone parenteral antibiotics (Jenkins et al., 2014).

According to Schultz, Lowe, Srinivasan, Neilson, and Pugliese (2014), dual treatment against MRSA often is an unnecessary and clinically contraindicated

antimicrobial therapy. The most frequently prescribed medication regimens against MRSA infection are daptomycin and linezolid, vancomycin and daptomycin, and vancomycin and linezolid. Mean days of combination antibiotic therapy ranges from 4 ($M = 4.08$) to 7 ($M = 6.45$) days, suggesting that physicians should prescribe only one antibiotic as an initial treatment of MRSA infections and hospitals should implement single antibiotic stewardship programs to prevent antibiotic resistance and improve patients' health outcomes (Schultz et al., 2014). Mupirocin and chlorhexidine are commonly used preoperatively and in the intensive care unit (ICU) setting to eradicate S. aureus infections (Huang et al., 2013).

Excessive usage of antibiotics creates selective pressure in the microbiological battlefield and makes the surviving bacteria antibiotic resistant. Genetic mutations initiate changes in the codes of bacterial DNA. This one piece of DNA is easily able to migrate into the surrounding bacteria, grow, and multiply with high speed (Centers for Disease Control and Prevention [CDC], 2013).

Type of MRSA Infection

Invasive MRSA infections fall into three categories: HA-MRSA, CA-MRSA, and unknown cause (Kjonegaard et al., 2013; U.S. Department of Health and Human Services [DHHS], 2013). Hospitalized patients are at increased risk of HA-MRSA infection because of the repeated and improper use of antibiotics, medical procedures, complications following surgery, transmission between patients and health care workers, inappropriate disinfection and cleaning procedures, and the use of single-use vials with multiple patients (DHHS, 2013; Kjonegaard et al., 2013). In contrast, CA-MRSA

infections are not associated with hospitalization, surgical procedures or dialysis (New York State Department of Health, 2007). This type of infection is common among people who live in crowded conditions and share contaminated items. Examples include prisoners, athletes, and military recruits. Contamination has been linked to poor hand hygiene (New York State Department of Health, 2007).

Major genetic and microbiologic differences exist between HA-MRSA and CA-MRSA infections (Gorwitz, 2008). Both infections have different virulence factors and different sensitivities to antibiotics. HA-MRSA shows growth in the presence of beta-lactam antibiotics, but CA-MRSA does not (Gorwitz, 2008). The PVL toxin is a common cause of CA-MRSA SSTIs; HA-MRSA infections do not produce this toxin (Epocrates, 2014).

Miller and Diep (2008) highlighted that USA300 is the most common CA-MRSA in the United States. USA300 extranasal colony formation is more common than in non-USA300 MRSA strains (Miller & Diep, 2008). Popovich et al. (2014) asserted that USA300 CA-MRSA colonizes the most often at inguinal and perirectal anatomical sites. This colonization is more common among male than female human beings. They also stated that USA300 CA-MRSA antibiotic resistance is atypical.

Naimi et al. (2003) highlighted the major clinical, microbiological, and demographic differences between HA-MRSA and CA-MRSA infections. For example, they stated that HA-MRSA is a common human pathogen among patients with health care-related risk factors such as surgery; dialysis; history of hospitalization; residence in a long-term care facility within 1 year of the positive MRSA culture collection date; and

insertion of Foley catheter, G-tube, and tracheotomy tube at the time of culture collection. HA-MRSA infections originate in health care settings, whereas CA-MRSA infections present without health care-related risk factors and do not originate in health care settings (Naimi et al., 2003). It is common for HA-MRSA cases to be identified from cultures as early as 2 days after admission to hospital; in CA-MRSA cases, the pathogen identification takes more than 48 hours. HA-MRSA cases most often cause bloodstream infections (BSI), but CA-MRSA cases originate as dermatological conditions that involve damage to skin and soft tissue (Naimi et al., 2003).

HA-MRSA and CA-MRSA infections can cause severe medical conditions and are resistant to beta-lactam or penicillinase-resistant penicillin such as oxacillin (methicillin also is a member of this group; DeLeo, Otto, Kreiswirth, & Chambers, 2010; McKenry, Tessie, & Hogan, 2006). CA-MRSA isolates are susceptible to beta-lactams, ciproflaxin, clindamycin, gentamicin, and trimethoprin-sulfamethazole (Naimi et al., 2003). The average age of HA-MRSA patients is 68 years, but the average age of CA-MRSA patients is 23 years (Naimi et al., 2003). Most HA-MRSA patients are European Americans; most CA-MRSA patients are non-European Americans. HA-MRSA and CA-MRSA patients come from low-income families (Naimi et al., 2003).

I investigated the reasons for the racial and ethnic disparities in MRSA infection rates in Los Angeles County. The outcome of the research could initiate positive social change in understanding the patterns and risk factors of MRSA infections by reducing the incidence and prevalence rates among different racial and ethnic groups. The study will

also guide activities of policy development to implement effective infection control solutions to decrease the cost of infection and improve health outcomes of the patients.

Problem Statement

Since the first outbreak of MRSA infection in Europe in the 1960s, severe S. aureus infections have become more prevalent, and transmission within health care and community settings has been a well-documented global health threat (Klein, Smith, & Laxminarayan, 2007). MRSA caused more than 19,000 deaths and 278,000 hospitalizations in the United States in 2005 (Klein et al., 2007). In 2011, 80,461 severe MRSA infections occurred in the United States (Dantes et al., 2013). The incidence rate of HA-MRSA infection among different racial and ethnic groups has varied, but the reasons often have been misunderstood and have not been assessed (Lewis et al., 2014; Rimawi, Ramsey, Shah, & Cook, 2014). In 2009, California enacted Senate Bill No. 1058, the Medical Facility Infection Control and Prevention Act, or Nile's Law, which requires all acute care hospitals in the state to implement screening, prevention strategies, and the reporting of health care-associated infection (HAI) in an effort to protect patients from MRSA. Patients who have been admitted to intensive care units or burn units, who have received dialysis treatment, or who have been discharged from acute care hospitals within 30 days prior to current hospitalization, or who have been transferred from skilled nursing facilities must be tested for MRSA within 24 hours of admission (CADoPH, 2009). Because the law was not enacted until 2009, there are no adequate data available before 2007.

I conducted a quantitative study to investigate the reasons for the racial and ethnic disparities in MRSA infection rates in Los Angeles County's eight SPAs to address areas of culturally sensitive infection control and health education programs and protocols so that changes or improvements can be made to existing programs in hospitals in Los Angeles. This study could provide information about and offer a viable solution to the problem of racial and ethnic disparities in health care settings. The literature has lacked evidence regarding the ways in which infection control and health education units address culturally sensitive infection control education, thus showing the need for evidence supporting practice. This study has the potential to fill this gap in knowledge.

Purpose of the Study

The purpose of this study was to investigate MRSA infections among different racial groups in Los Angeles County's eight SPAs. Major focuses of the study were to (a) test the possible association between invasive HA-MRSA infections and length of hospitalization, and (b) investigate whether there is an increased incidence rate of MRSA infection during hospitalization among the eight SPAs in Los Angeles County.

In RQ1, the DV is invasive HA-MRSA infection rate; the IV is length of hospitalization; and the covariates are gender, age, race and/or ethnicity, and Los Angeles County's eight SPAs. In RQ2, the DV is MRSA infection rate, and the IV is SPA categorization. Because of patient privacy restrictions, data on actual patients' race and ethnicity were not available, so this comparison could not be made directly. However, examining both the demographic composition of each SPA in Los Angeles County as

well as infection rates in those SPAs allowed me to make an indirect comparison between race/ethnicity and MRSA infection rates.

Research Questions and Hypotheses

The study was guided by two RQs and their corresponding hypotheses:

RQ1: Is there an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs?

H_{01}: There is no association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs.

H_{a1}: There is an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs.

Rationale for RQ1: Prolonged hospitalization, underlying illness or comorbid conditions, exposure to broad-spectrum antibiotics, medical procedures, postoperative complications, presence of invasive device, frequent contact with health care workers and other patients, and inappropriate disinfection and cleaning procedures put patients at increased risk of HA-MRSA infection (DHHS, 2013; Kjonegaard et al., 2013). In 2007, Klevens et al. conducted a population-based surveillance study to investigate invasive MRSA disease. The results indicated that one third of invasive MRSA infections occurred during hospitalization and two thirds were not related to hospitalization. Klevens et al. identified significant differences of invasive MRSA infection among different racial groups.

RQ2: Is there a difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs ?

H_{02}: There is no significant difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs.

H_{a2}: There is a significant difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs.

Rationale for RQ2: Nasal swab cultures are collected on all hospital admissions and unit transfers, and before discharge from the hospital setting to identify MRSA colonization and infection. This laboratory-identified event surveillance helps clinicians to implement evidence-based infection control measures (Evans et al., 2014). Patients with laboratory-confirmed positive nasal samples are at risk of invasive MRSA infections such as SSTIs, pneumonia, central line-associated bloodstream infections, catheter-associated UTIs, and surgical site infections (SSIs; Heyman, 2008; Stenehjem & Rimland, 2013). Squier et al. (2002) stated that positive MRSA nasal and extranasal cultures versus only positive nasal swabs double the risk of MRSA infection. Rimawi et al. (2014) indicated that nasal screening is not an effective way to identify positive oropharyngeal colonization. Rimawi et al. investigated the association between positive MRSA nasal culture and MRSA pneumonia, and they found significant differences in the types of MRSA infections among different racial groups. Robicsek, Suseno, Beumont, Thomson, and Peterson (2008) stated that a negative nasal culture does not mean a completely MRSA-free status. Cosgrove et al. (2003) compared MSSA bacteremia to invasive MRSA bacteremia and found that MRSA bacteremia caused almost twice the mortality rate, lengthened hospital stays, and increased health care costs in comparison to MSSA bacteremia because of its more virulent strain.

Theoretical Framework

I used Cane, O'Connor, and Michie's (2012) theoretical domain framework (TDF), a well-recognized theory that has facilitated the implementation and use of evidence-based practice in the health care setting. The TDF has facilitated changes in the health-related behavior of health care workers and patients that could improve health outcomes and compliance with strategies to control infection in the health care setting. The TDF provides a useful way of identifying barriers to learning and implementing health care guidelines.

The TDF has 14 domains and 84 theoretical constructs, including knowledge, skills, social and professional role and identity, beliefs about capabilities, optimism, beliefs about consequences, reinforcement, intentions, goals, memory, attention and decision processes, environmental context and resources, social influences, emotions and behavioral regulation (Cane et al., 2012). The theory also promotes the active involvement of health care workers, patients and their families and friends, and community members, as appropriate, in all aspects of infection control, thus encouraging self-determination while promoting positive health outcomes and a healthy environment. This conceptual basis is necessary to clarify the knowledge needed to initiate health-related behavioral change across a wide range of clinical situations (Cane et al., 2012). Behavioral change is not easy in the health care setting because organizational and personal factors can influence how health care workers use infection control practices.

Nature of the Study

I used data from 2011 to 2013 from the CADoPH, Healthcare-Associated Infections (HAI) Program. I used secondary data to identify laboratory-confirmed invasive MRSA infections. In Chapter 3, I explain the inclusion and exclusion criteria regarding participation. I used SPSS v.21 to conduct the analysis. In this quantitative study, for RQ1, I used a Pearson correlation analysis between infection rate and length of hospitalization to determine whether increased hospital stays are related to an increased rate of infection, and also whether this association is stronger in certain demographic areas. For RQ2, I conducted a one-way ANOVA on the infection rate, with SPA as the between-subjects factor.

Definitions of Terms

CA-MRSA: MRSA infection that occurs in the community (Mayo Clinic, 2012).

Carrier of infection: A human being who is infected with a microbe or a parasite and transmits the infection. There are no signs and symptoms of disease in this stage of infection (*Free Dictionary*, 2015).

Colonization: The first stage of microbial infection (Todar, 2012a).

Contact isolation: Health care personnel and patients' visitors must wear personal protective equipment (PPE) such as gloves and gown to enter to patients' contact precaution rooms in the health care setting. Wearing PPE can prevent the spread of infectious microbes (University of California San Francisco Medical Center Medical Center, 2015).

Health care-associated community-onset MRSA (*HACO-MRSA)*: A phenomenon in which patients are exposed to MRSA in the health care setting but become sick after discharge (CDC, 2012).

Health care-associated MRSA (*HA-MRSA)*: An infection that occurs in health care settings such as hospitals, dialysis units, and nursing homes (Mayo Clinic, 2012).

Health care-associated infection (HAI): An infection related to medical devices such as central lines, urinary catheters, ventilators, or surgical procedures (CDC, 2014).

Hospital-onset MRSA infection (HO-MRSA): MRSA infection that starts with hospitalization (Medina et al., 2013).

Hospital-acquired infection: Viruses, bacteria, or fungi infections in a hospital. The most typical infections are BSI, UTIs, ventilator-associated pneumonia (VAP) and SSIs (Custodio, 2015).

Infection: Microbial multiplication of bacteria, virus, fungi, or parasites that invade the body (MedicineNet, 2012a).

Los Angeles County SPAs: Los Angeles has eight geographic areas that help the Los Angeles County Department of Health (LACDoPH) to provide effective health care needs for the targeted population. SPA1: Antelope Valley, SPA2: San Fernando Valley, SPA3: San Gabriel Valley, SPA4: Metro LA, SPA5: West, SPA6: South, SPA7: East, and SPA8: South Bay (LACDoPH, 2015).

Methicillin: Antibacterial medication or penicillin-family antibiotic (MedicineNet, 2012b).

MRSA: Methicillin-resistant S. aureus (MedicineNet, 2012c).

MSSA: Methicillin-sensitive S. aureus. These bacteria live on the skin and inside the nares. They are harmless unless they enter the bloodstream (Blackpool Teaching Hospitals, 2012).

MRSA-free status: Patient is removed from contact isolation and is medically cleared of infection (Valencia-Rey et al., 2014).

Nasal sampling: Nasal swab procedure or nasal culture collection performed by a trained health care professional (Copan, 2015).

S. aureus: A Gram-positive bacterium that resembles a grape under the microscope (Todar, 2012b).

Assumptions

I assumed that the participants would give truthful answers about their demographic data and health-related problems during admission to hospital. I assumed that all invasive MRSA infections between 2011 and 2013 were laboratory-confirmed cultures. I also assumed that proper infection control measures were being used during the care of MRSA-infected patients. The assumptions were necessary to minimize bias in the data so that the results of the statistical analyses were reliable and generalizable.

Scope and Delimitations

The scope of the study was to (a) determine a possible association between invasive HA-MRSA infections and length of hospitalization, and (b) to investigate whether there is an increased incidence rate of MRSA infection during hospitalization among different racial or ethnic groups in Los Angeles County's eight SPAs. The study was delimited to Los Angeles County. The finding might benefit other culturally diverse

areas in the United States. I designed the study using a quantitative approach, so the following qualitative items were not assessed: (a) In different racial groups, to what extent do culturally sensitive educational activities affect infection control and prevention methods such as hand washing or the wearing of PPE to decrease the dangers of HA-MRSA infections in Los Angeles County's Eight SPAs? and (b) How often do different racial groups with S. aureus infection recognize the importance of infection control measures in preventing bacterial transmission during hospitalization?

Limitations

One limitation of the study was that I used secondary data collected by infection preventionists and submitted to the National Healthcare Safety Network and the CADoPH. Using laboratory-confirmed cases of secondary data limited the generalization of the concept of culturally specific infection control measures in the health care setting in Los Angeles. The lack of sufficient data about racial and ethnic groups' health-related behaviors, extraneous data, demographic scope of data, and geographic limitation (data only from one county) were the limitations of the study. Possible problems with self-reported data, which are considered recall bias (whether intentional of unintentional), could have impeded the proper data evaluation and analysis.

Significance of the Study

I used data from the CADoPH-HAI Program about HA infections in Los Angeles between 2011 and 2013. I determined the possible association between invasive MRSA (laboratory-confirmed) infections and length of hospitalization among different racial and/or ethnic groups in the eight SPAs of Los Angeles County. The study could help to

establish racial and ethnic patterns of S. aureus and MRSA infections in Los Angeles. I analyzed secondary data using the TDF to determine a possible association between exposure to MRSA and disease development based upon demographics.

This study could advance practice and knowledge by providing public health practitioners with new ideas to design and implement culturally sensitive educational activities, including social marketing, webinars, presentation programs in community health education centers, churches and health fairs about infection control and prevention for different racial or ethnic groups, that prevent S. aureus and MRSA infections in the hospital setting in Los Angeles County's eight SPAs. The results could be used to develop culturally sensitive infection control guidelines and influence policy decisions on improving health outcomes and infection control compliance among different racial and ethnic groups, thereby promoting positive social change.

Summary

In Chapter 1, I identified the problem of racial and ethnic disparities in invasive MRSA infection rates in Los Angeles County's eight SPAs. I evaluated variables to identify reasons for differences in MRSA infection rates among the racial and ethnic groups in Los Angeles County's eight SPAs. Chapter 1 highlighted the need to design, develop, and implement culturally sensitive health promotion programs to delivery new knowledge and skills in the hospital setting.

In Chapter 2, I review the TDF, the theoretical foundation of my study. The literature review supports the RQs and hypotheses by focusing on relevant studies related to MRSA infection. I also discuss the procedures.

Chapter 2: Literature Review

Introduction

The purpose of this quantitative study was to investigate MRSA infections among different racial and ethnic groups in Los Angeles County's eight SPAs. In particular, I examined whether invasive HA-MRSA infections were associated with patients' length of hospitalization and whether there was an increased incidence rate of MRSA infection during hospitalization.

Literature Search Strategy

I searched several databases, including PubMed; Medline; CINAHL Simultaneous Search; and Walden University Dissertations, which I accessed via Walden University Library. I also searched databases that held regulatory information, abstracts, conference papers, practice recommendations, brief reports, review articles, clinical trials, and letters to the editors. I also searched various websites, including CDC.gov, ph.lacounty.gov, cdph.ca.gov, ncbi.nlm.nih.gov, asm.org, apic.org, shea-online.org, biomedcentral.com, oxfordjournals.org. I also used Google Scholar and mamma.com search engines. Search terms were Staphylococcus aureus, S. aureus, methicillin-resistant staphylococcus aureus, health care-associated MRSA (HA-MRSA), methicillin-sensitive S. aureus (MSSA), MRSA acquisition, community-acquired MRSA (CA-MRSA), MRSA infection, MRSA morbidity and mortality, infection control, infection prevention in acute care setting and/or hospital setting, infection surveillance, infection monitoring, prevalence rate of MRSA infection, seasonal pattern of MRSA infection, health care-associated infection, decontamination of MRSA, health education, and theoretical domain

framework. The original articles were published between 2010 and 2015, but I also reviewed articles from earlier years to support the study. I selected studies written only in English. All but three articles had been conducted in the United States. I excluded studies from acute psychiatric facilities.

Theoretical Domain Framework

Overview of the Framework

Cane et al.'s (2012) TDF is a well-recognized framework that helps health care professionals to implement and use evidence-based practice to change the health-related behaviors of health care workers and patients to improve health outcomes and comply with infection control protocols in the health care setting. Implementing behavioral changes in the health care setting is not an easy task because of organizational and personal factors (Cane et al., 2012). In the health care setting, a lack of knowledge can negatively influence the use of the most appropriate interventions. For example, knowledge deficits in the pathophysiology of an illness, proper procedures, and intervention strategies can result in poor health outcomes for patients (Cane et al., 2012). I selected the TDF as an interactive measure to access health care workers' behaviors related to infection control prevention as a basis for the development of interventions.

Constructs of the TDF Framework

The TDF promotes the active involvement of health care workers, patients and family members, friends, and community members, as appropriate, in all aspects of infection control. The active involvement of so many parties encourages self-determination and promotes positive health outcomes and a healthy health care

environment. Health care workers and others need this conceptual basis in order to initiate health-related behavioral changes across a wide range of clinical situations (Cane et al., 2012).

The TDF framework has 14 domains of theoretical constructs: knowledge; skills; social and professional role and identity; beliefs about capabilities; optimism; beliefs about consequences; reinforcement; intentions; goals; memory, attention, and decision processes; environmental context and resources; social influences; emotions; behavioral regulation (Cane et al., 2012). The constructs of the TDF can be useful in identifying barriers to learning and difficulties implementing health care guidelines (Cane et al., 2012). Their definitions follow:

Knowledge: Inadequate knowledge is a potential barrier to the implementation of effective infection control measures before, during, and after patient care (Cane et al., 2012).

Skills: Performing any kind of health-related procedures is based upon health care professionals' skill levels (Cane et al., 2012). Being competent in performance is based upon practice and periodic skill assessments. An improper hand hygiene technique, for example, is correctable with skill development, practice sessions, and reinforcement strategies (Cane et al., 2012).

Social and professional role and identity: The domain of social and professional role and identity includes the personality traits, clear self-concepts, and skill levels of health care workers in social and work settings (Cane et al., 2012). This domain sorts tasks based upon professional confidence, professional role, social identity, leadership

skills, and commitment to the organization. Influential leadership also might positively enhance health care workers' organizational commitment and loyalty, both of which determine levels of responsibility and work ethic (Cane et al., 2012). Once health care workers' social and professional roles and identities become known, the workers will support the goals of the health care organizations and will be dedicated to following established rules and protocols (Cane et al., 2012).

Beliefs about capabilities: Beliefs about capabilities are based upon self-confidence, perceived and professional competence, self-efficacy, perceived behavioral control, beliefs, self-esteem, and empowerment (Cane et al., 2012).

Optimism: Optimism is the belief of a health care organization in the most favorable outcome to achieve the desired goals (Cane et al., 2012).

Beliefs about consequences: Beliefs about consequences are one the key concepts of the TDF (Cane et al., 2012). This domain reflects the acceptance of the truth, reality, or validity of behavioral outcomes in the clinical setting. Health care workers might accept or regret behaviors or decisions made in specific clinical situations. If the health outcome is negative, health care workers are responsible for the behaviors or decisions precipitating that outcome (Cane et al., 2012).

Reinforcement: The domain of reinforcement adds support to the desired behavior and helps to support the initial behavioral change process. When rewards are offered as an incentive, the desired behaviors are more likely occur. This reward system supports the implementation of new and improved health care protocols and procedures (Cane et al., 2012).

Intentions: The domain of intentions determines conscious actions and the results.

Goals: Goals symbolize future planning. This domain is based upon the result of such tasks as target setting, goal priority, autonomous and controlled goals, distal and proximal goals, action planning, and implementation intentions. Designing infection control interventions as a controlled goal is one way to enhance health care practice (Cane et al., 2012).

Memory, attention, and decision processes: In this domain, memory, attention, and decision processes contribute to the foundation of knowledge. With effective teaching tools, health educators can control the attention and improve the memory and decision-making processes of health care workers. During health education sessions, health educators must evaluate how much information the participants will retain and how they will use the taught concepts in the health care setting. Cognitive overload and fatigue can negatively impact the attention span (Cane et al., 2012).

Environmental context and resources: The environment context and resources domain focuses on health care workers' situations and/or environments that can discourage or encourage independence, skill development, social competence, and adaptive behaviors. This domain can be used in the analysis of environmental stressors, available resources, organizational culture and climate, salient events and critical incidents, person and environment interactions, and barriers and facilitators (Cane et al., 2012).

Social influences: Social influences can change feelings, thoughts, and behaviors positively and negatively. Social pressure, social conformity, intergroup conflict,

overpowering actions, and alienation can interfere with the implementation of the desired behavioral change process, along with skills development, social competency, and adaptive behaviors. Social support and group identity might empower health care workers to modify their feelings, thoughts, and behaviors positively to achieve the desired behavioral changes (Cane et al., 2012).

Emotions: Human beings can experience emotions that can range from happiness to despair. These complex reaction patterns can increase or decrease motivation, according to Cane et al. (2012). Sadness, depression, anger, stress, fear, anxiety, and burnout are negative emotions that can be triggered by such factors as overwhelming workloads and toxic work environments. Eliminating stress and overcoming negative emotions are possible with assertive communication and cognitive restructuring (Cane et al., 2012).

Behavioral regulation: Behavioral regulation requires self-monitoring, the breaking of certain habits, and action planning (Cane et al., 2012).

TDF is critical to understanding the evidence-based theories and models that help researchers to analyze and predict health care-related behavioral and clinical behavioral change processes (Francis, O'Connor, & Curran, 2012). This framework's conceptual basis includes implementation problems, designing interventions, analyzing and understanding behavioral change based on evidence-based practice (Francis et al., 2012).

Infection Control

In recent years, a decrease in MRSA infections nationwide has been related to adequate knowledge of the origins of the infections, which facilitates the implementation

of effective infection control measures in the health care setting (Evans et al., 2014). Educating health care workers, patients, and visitors about proper hand hygiene; implementing decontamination, disinfection, and cleaning protocols to control MRSA environmental outbreaks; establishing effective risk assessment, prevention, and control strategies; and investigating infection clusters and outbreaks with interventions are dedicated measures meant to prevent MRSA infections (Evans et al., 2014). Decreased rates of true infection of MRSA among S. aureus-colonized patients demonstrate the effectiveness of infection control strategies in the health care setting.

Importance of Education

Education of Health Care Workers

Educating health care workers about hand hygiene behaviors and reinforcing teaching are fundamental to supporting changes in the institutional culture (Evans et al, 2014). Hand hygiene is the most important part of infection control in reducing MRSA transmission. Health care professionals unwittingly transmit infectious organisms because they do not adhere to the recommended and evidence-based infection control practice guidelines.

Seibert, Speroni, Oh, DeVoe, and Jacobson (2014) analyzed the preventive behaviors of health care workers and their commitment to reduce the spread of MRSA. They conducted their study in a mid-Atlantic region of the United States from September to November of 2012. The researchers encouraged all health care workers who participated in direct care to complete the questionnaire. Simultaneously, trained

observers conducted random surveillance of hand washing at direct care settings. Of the 1,200 health care workers, only 276 completed the questionnaire.

All participants believed that contact precautions helped to prevent the transmission of MRSA. Many respondents did not know how long MRSA could survive on a surface or in an environment, and that alcohol-based hand sanitizers are the most effective method to eliminate MRSA. Most of the participants (> 90%) considered MRSA a national problem, but only 50% thought that it was a problem in their local areas or hospitals. Support staff (e.g., janitorial staff) were not given adequate information about MRSA, unlike the medical and nursing teams (Seibert et al., 2014).

Approximately 50% of the health care professionals expressed their concern about taking home MRSA infections. Ninety-four percent of medical doctors, almost 89% of nurses, 83% allied health staff, and 45.5% of support staff followed hand hygiene guidelines before and after patient care. Alcohol hand rubs (84.1%) were used more often than soap and water (15.9%). Seibert et al. (2014) identified the most common reasons for not following the recommended hand hygiene guidelines: lack of time to wash hands and then apply gloves and gowns (36.9%), lack of environmental cleanliness (29.1%), heavy workload (27.6%), hard to reach soap and water (11.2%), and communication issues (30.2%). The results emphasized that multidisciplinary educational programs can initiate hand hygiene compliance, increase knowledge and perceptions about disease transmission, and stress the need to follow infection control protocols (Seibert et al., 2014).

There has not been enough focus on the disinfection of physicians' stethoscopes and stethoscope-mediated infection transmission. Longtin et al. (2014) conducted a prospective study in a Swiss university hospital from January 1, 2009, to May 31, 2009, with 83 MRSA-colonized patients from the orthopedic and internal medicine units. Aerobic colony counts (ACCs) and MRSA colony-forming unit (CFU) counts showed a strong positive association between physicians' hands and stethoscopes' MRSA contamination levels. The stethoscopes' tube and diaphragm ACC levels were directly related to the contamination levels of the physicians' fingertips. Stethoscopes are considered vectors in MRSA transmission if they are not cleaned after the physical assessment of each patient (Longtin et al., 2014).

Jessee and Mion (2013) used a survey and a nonparticipant observation study to compare the attitudes, perceptions, and knowledge of medical staff about the importance of contact isolation in a magnet-designated academic medical center and a community medical center (CMC) in the southeastern part of the United States. The academic medical center provided 19 participants, and the CMC provided 32 participants. The majority of respondents were registered nurses. The results showed that 100% of staff members at the center wore gloves and gowns at all times when caring for patients in contact isolation. In the CMC, adherence to the isolation policy was 75%. The health care professionals at the CMC believed that contact precautions added extra time and effort to the nurses' workload.

Jessee and Mion (2013) found that the staff at the CMC were less knowledgeable about the importance of contact isolation. The CMC staff also were older and more

experienced than the staff at the academic medical center, a factor that influenced their perceptions about infection prevention. The results provided insight into the ways in which organizations should assess methods of infection control and motivate health care workers to adhere to contact isolation policies (Jessee & Mion, 2013).

Education of Patients

Istenes, Bingham, Hazelett, Fleming, and Kirk (2013) asserted that there is a significant decrease in patients' hand-washing behavior during hospitalization. Patients' hands contaminated with MRSA have a key role in the transmission of HA-MRSA infection. Istenes et al. conducted a study at the Summa Health System's Akron City Hospital in Ohio to detect the prevalence of infectious bacteria (e.g., MRSA) on patients' hands and determine patients' attitudes and practices toward hand washing. One hundred hand samples were collected from patients who had been admitted to the medical-surgical units. Samples were collected from the patients' dominant hands for collecting microbes for ASTM Standard Tests Method E 1115-10 microbiological analysis. The average age of the patients was 62.4 years, the average length of stay was 6 days, and the sample collection happened 4.3 days after hospital admission.

After the culture specimens had been collected, the eligible patients completed a survey created by Istenes et al. (2013) about their hand hygiene practices at home and in the hospital. The researchers then analyzed the contamination rates using descriptive statistics. The results revealed that the patients' hand-washing behaviors were the same at home and in the hospital setting; however, when the patients were hospitalized, they demonstrated a significant decrease in the frequency of hand washing. For this reason,

39% of the patients' hands were contaminated with infectious microbes at 48 or more hours after admission to the medical surgical ward. Further examination showed that 33% of the participants' hands were exposed to gram-positive bacteria and 11% to gram-negative bacteria. In addition, 14 samples showed MRSA infections (Istenes et al., 2013). The results suggested that the prevalence of bacteria was higher among patients who had been admitted from outside institutions and were subsequently released to outside institutions (Istenes et al., 2013). Unfortunately, Istenes et al. did not analyze ways in which MRSA bacteria on the patients' hands could cause cross-contamination in the health care setting.

According to Chang, Sethi, Stiefel, Candnum, and Donskey (2010), MRSA bacteria from patients' hands can transfer to health care workers' hands. It is difficult to monitor patients' hand hygiene practices and attitudes, so having adequate patient-centered health education programs available can empower patients and make them active participants in their own care. Effective infection control measures will improve patients' health outcomes, shorten hospital stays, and save money.

Ottum et al. (2013) investigated patients' engagement in the prevention of health-care associated infections (HAIs) at the University of Wisconsin's acute care tertiary hospital from July 2011 to October 2011. They prepared questionnaires to survey the patients' awareness, knowledge, and perceptions of the risk factors and infections related to MRSA. For this study, the researchers did not use culture specimens of MRSA. Clinical isolation of the patients 48 hours after hospital admission was used to determine the rate of MRSA infections.

Fifty patients, 22 women and 28 men, were eligible to be active participants in the survey-based MRSA study by Ottum et al. (2013). Twenty-four patients were under the age of 49 years, 13 were ages 50 to 65 years, and 13 patients were older than 65 years. Most of the selected patients (n = 46, 92%) were European American. Fifty-six percent of the participants had experienced hospital-associated infections; 55% had been hospitalized more than five times in their lives. The results indicated that 68% of the participants had a history of MRSA.

Of the 50 participants, only 38 (76%) had heard of MRSA. Participants ages 50 to 65 years (46.2%) were the least educated about MRSA when compared to participants younger than 49 years (83.3%) and those older than 65 years (92.3%). Only 10 of the 50 participants (20%) were aware that the overuse of antibiotics could cause MRSA infections; 19 patients (38%) knew that chronic diseases can increase the chance of MRSA infections. Thirty-five (70%) of the participants stated that staying in hospital or being in a nursing home increased the risk of MRSA infections. Ottum et al. (2013) noted a positive correlation between having knowledge of the risk factors of MRSA infections and a history of hospital-associated infections. The results showed no correlation in knowledge and awareness based upon sex, level of education, and previous history of working in the health care setting or having a family member working in the health care setting (Ottum et al., 2013). Health care education must focus on patients, and educational materials must be tailored to meet patients' existing knowledge, levels of understanding, ages, and cultural backgrounds. The involvement of family members and

friends in health education deepens patients' adherence to proper hand hygiene and medication usage.

Gudnadottir et al. (2013) conducted a study at the University of Wisconsin Hospital to analyze the importance of patients' involvement in infection control and to identify patients' education material preference in the acute tertiary care setting. One hundred adult patients between the ages of 18 and 87 years were recruited to participate in the study in June and July of 2012. The patients were colonized with drug-resistant pathogens and placed on contact isolation. Gudnadottir et al. administered a questionnaire with multiple-choice questions to collect demographic data from the patients on sex, race, ethnicity, level of education, the kinds of antibiotic-resistant organisms that caused infections for them, their knowledge about infectious pathogens, and their preferences in educational material. The data were analyzed using binominal logistic regression.

Gudnadottir et al. (2013) investigated the association between patients' demographic characteristics and their health education preferences as well as the association between patients' demographic characteristics and the type of health care workers from whom the patients preferred to receive information about infectious pathogens. Results showed that although 96% of the participants had heard about drug-resistant pathogens, 11% could not remember receiving health education related to their infections or why they had been hospitalized. Most of the patients indicated having received health information about their infections from a nurse or a physician; 72% of the participants had received verbal information, but only 38.2% had gotten the information in written form or as Internet-based material. Nearly all patients (98%) believed that

learning about multidrug-resistant pathogens was very important or important, and 94% Ninety-four percent of participants agreed in that having adequate knowledge about infections would improve their health and their care.

Most of the participants preferred receiving a combination of written, verbal, and Internet-based educational materials. Seventy percent of the patients favored written materials such as handouts, brochures, and posters; 57% preferred verbal information; and about 50% preferred additional resources such as short videos and Internet-based educational materials. Thirty-two percent of the patients reported wanting to receive information about their diseases from their primary care physicians or infection preventionists. Patients with a college education preferred written material. The male patients chose female health care workers as their preferred health educators, but the female patients focused more on job title, such as infection preventionist (Gudnadottir et al., 2013).

The key to patient-centered infection control is to improve patients' knowledge of drug-resistant infections by providing them with easily understood verbal, written, video, or Internet-based materials. Patient engagement in infection control helps them to make considered and thoughtful decisions about their health issues and care. Reinforcement of the topics also must be integrated into patient education while they are in the health care setting.

Ardizzone, Smolowitz, Kline, Thom, and Larson (2013) conducted a quasi-experimental, pretest-posttest study to investigate the knowledge and perceptions of surgical patients about hand hygiene and the offer of hand hygiene opportunities to

patients by nursing staff, including registered nurses and certified nursing assistants, over a 2-month period. Seventy-two patients and 42 nurses participated in the observational study. Trained volunteers were the observers. Sixty percent of the nursing staff reported that they offered hand hygiene opportunities to patients. On the contrary, 45% of the patients did not get the chance to wash their hands because it had not been offered by the nursing staff. Nineteen percent of the patients believed that the nurses did not think that patients' hand hygiene was important. The patients suggested that hospitals should post more signs about hand hygiene in the bathrooms and provide patients with personal hand sanitizers (Ardizzone et al., 2013).

Education of Patients' Visitors

Educating patients' visitors about contact isolation and hand hygiene will improve patient's safety and decrease the transmission rate of MRSA. Roidad and Khakoo (2014) assessed the attitudes and general knowledge of patients' visitors about contact isolation. The study was conducted at a tertiary care facility in West Virginia University. The participants on contact isolation were either colonized or infected with drug-resistant bacteria such as MRSA or vancomycin-resistant enterococcus. The study targeted the visitors of these patients. All adult, pediatric, and ICUs were included in the study.

Roidad and Khakoo (2014) handed out 137 surveys, but only 36 (26%) visitors answered the surveys completely. Mostly female visitors completed the surveys 92(67%). Of the 36 respondents, 27 (74%) thought that contact isolation is an effective way to prevent the spread of infection, 6 (17%) strongly agreed that contact isolation improves patient care, and 5 (13%) strongly disagreed that contact isolation improves patient care.

A total of 33 (92%) visitors were able to identify why their loved ones or friends had been placed in contact isolation. Only 6 (19%) of the visitors strongly agreed that visitors had to wear PPE such as gloves and gown when visiting patients with MRSA infections. Despite the fact that MRSA is a dangerous infection, 1 (3%) of the participants strongly disagreed and 17 (47%) disagreed with the requirement to wear gloves and gown when visiting patients in contact isolation (Roidad & Khakoo, 2014). Providing health education about infectious diseases and contact isolation is necessary to protect visitors, patients, and health care professionals from unwanted infections. Effective communication initiated by nurses or doctors can positively impact quality of care.

MRSA Infection Prevention and Control

MRSA Screening and Surveillance

Nasal sampling. Nasal cultures for MRSA from anterior nares and nasal septums should be collected on all hospital admissions, in-hospital transfers, and discharges (Evans et al., 2014). Nasal surveillance can help to identify patients' MRSA status and initiate the implementation of proper infection control measures that include contact isolation for patients carrying MRSA and hand hygiene practice guidelines for health care workers (Evans et al., 2014).

California enacted Senate Bill No. 1058, the Medical Facility Infection Control and Prevention Act, or Nile's Law, which mandates that all Californian acute care hospitals implement the screening, prevention, and reporting of HAIs, MRSA infections in particular (CADoPH, 2009). Patients who are admitted to ICUs or burn units, who receive dialysis treatment, who have been discharged from acute care hospitals within 30

days prior to current hospitalizations, or who have been transferred from skilled nursing facilities must be tested for MRSA within 24 hours of admission. The law took effect on January 1, 2009 (CADoPH, 2009). Because the bill is so recent, no adequate data are available about MRSA infections before 2007. Illinois and Maryland also have implemented mandatory active surveillance for MRSA (Weber et al., 2007).

Kjonegaard et al. (2013) conducted a study to test the benefits of California state-mandated MRSA screening in ICUs as well as the effect of contact isolation on the rate of hospital-associated MRSA infections. The participants had been admitted to a 24-bed medical ICU or a 15-bed surgical ICU at a community hospital in southern California. Data collection took place at three different times: preactive surveillance before January 7, 2009, comprehensive active surveillance between January 7 and August 4, 2010, and state-mandated active surveillance between August 7, 2009, and March 4, 2010.

During the preactive surveillance, if a coronary artery bypass patient had an infection with presented signs and symptoms, the doctor needed to order contact isolation and decolonization routines. In contrast, patients with positive MRSA cultures were placed on contact precaution, but without decolonization being ordered. During the comprehensive active surveillance period, patients who had been admitted or transferred to the medical ICU or the surgical ICU were tested for MRSA (Kjonegaard et al., 2013). Polymerase chain reaction (PCR) molecular screening was used to identify these infectious bacteria. Nurses collected samples from the patients' perineal areas and both nares. At the time, the number of samples collected from perineal areas was low, so the

hospital discontinued this protocol. Since the initiation of state-mandated surveillance, all patients who have been admitted to ICUs are screened for MRSA from their nares.

The patients' demographic data and medical records were obtained from electronic medical records (Kjonegaard et al., 2013). A total of 2,938 admission data were used for statistical analysis. The regressive analysis revealed that 955 patients (32.5%) admitted from skilled nursing facilities, assisted living facilities, and board of care facilities had higher rates of MRSA infections than the one patient (3.8%) admitted from the home setting. The researchers pointed out that there was insufficient evidence to state that 100% MRSA screening compliance could have reduced the number of hospital-associated MRSA infections.

Evans et al. (2013) reported on the efforts of the Veteran Health Administration (VHA) Spinal Cord Injury/Disorders (SCI/D) Services in the Department of Veterans Affairs (VA) implemented the MRSA Prevention initiative, begun October 2007 and ended June 2011, to make cultural change to eliminate hospital-associated MRSA infections by using the bundle method (i.e., universal surveillance, nasal culture specimen collection, contact isolation for MRSA-colonized and infected patients, and frequent hand washing). These methods were used in all admissions, transfers, discharges, and days of care in all VA hospitals and SCI/D units. Twenty-two SCI/D units participated in the study nationwide.

During the study, there were a total of 51,627 admissions, transfers, and discharges, and 816,254 patients in days of care. The monthly admission rates were 351 patients. The average age of the patients was 59 years. Ninety-two percent of the patients

were males. The prevalence rates of MRSA positive nasal carriage on SCI/D admission was 38.5%+/-19.1%; the national prevalence rate was 14.2%+/-1.5%. This rate was the reason for the transmission rate of MRSA being low in SCI/D units. Use of the bundle method, along with bathing and decolonization practices in SCI/D units, saw a significant decrease in hospital-associated MRSA infections (Evans et al., 2013).

The VHA implemented an active surveillance system in which all patients admitted to their acute care facilities must be tested for MRSA colonization and infection. They used PCR technology to determine a DNA region, a target sequence, or a gene of MRSA present in the collected sample. This MRSA DNA molecular test can provide a result within 2 hours, which significantly reduces the time related to surveillance testing. Ct is a threshold cycle of Cepheid Xpert MRSA assay commonly used to measure the concentration of MRSA on nasal samples in PCR reactions. This method of surveillance testing was defined by the VHA as MRSA nasal burden.

In 2007, the VHA mandated MRSA bundle in all acute care VA hospitals. All patients were screened for MRSA within 12 to 24 hours of admission by nursing staff, who used Liquid Stuart double swabs to collect test specimens from the patients' nasal mucosa. Fifteen to 36 threshold cycles were considered positive for MRSA. If Ct was more than 24 cycles, the patients' nasal samples had low nasal MRSA burden. If Ct was less or equal to 24 cycles, the nasal samples has high nasal MRSA burden (Stenehjem & Rimland, 2013).

A total of 346 Atlanta veterans from one acute care medical center participated in a retrospective study from October 1, 2007, to February 1, 2008, with a 4-year follow-up. The patients were categorized into three MRSA nasal colonization groups: noncarriers (n = 141), low burden (n = 141) and high burden (n = 64). Fifty-five (39%) of the 141 noncarrriers were African American, 81 (57.4%) were European American, and 5 (3.6%) were from other races. Sixty-seven (47.5%) of the 141 low-burden group were African American, 70 (49.6%) were European American, and 4 (2.9%) were from other races. Thirty (46.9%) of the 64 high-burden group were African American, 34 (53.1%) were European American, and 0 (0%) were from other races. Of the total sample, 185 (53.5%) of the participants were European Americans, 151 (43.9%) were African Americans, and 10 (2.89%) were from other races; 329 (95.1%) were men and 17 (1.05%) were women. The average ages of the participants were 63.4 years for noncarriers, 62.7 years for low burden, and 65.5 for high burden.

Stenehjem and Rimland (2013) used descriptive statistics to look for an association between potential risk factors and colonization status. They also used multivariate logistic regression model to assess the relationship between MRSA nasal colonization burden and subsequent infection. Results showed that 15 (4.3%) noncarrier patients, (64) 18.5% low burden, and 60 (17.2%) high burden developed MRSA infections. Patients with low and high burden had wounds or inserted devices on admission, had been treated with antibiotics within 30 days, had had MRSA infection previously and concurrently, or had been diagnosed with end-stage renal disease (ESRD) or HIV. Inserted devices and ESRD were very common among the patients with high

burden, but three or more comorbid conditions (e.g., diabetes mellitus, coronary artery disease, congestive heart failure, peripheral vascular disease, chronic obstructive pulmonary disease, HIV, advanced liver cancer, active malignancy, smoking) were very common among patients with low burden.

The 4-year follow-up identified 43 subsequent MRSA infections: Six (4.3%) occurred in noncarriers, 26 (18.5%) in low-burden patients, and 11 (17.2%) in high-burden patients. Distribution of the infection was not significant. Mortality rates were more common among low-colonization burden patients (n = 73, 51.8%) and high-colonization burden patients (n = 35, 54.7%) than among noncarriers (n = 48, 34). MRSA nasal colonization is considered a risk factor for MRSA infection. High colonization burden did not increase the chance of infection. One limitation of the study by Stenehjem and Rimland (2013) was the small sample size, making an in-depth investigation into the mortality rates among MRSA-colonized patients difficult.

Kabbani et al. (2013) highlighted that horizontal infection prevention measures (e.g. proper hand hygiene) are key to decreasing the risk of MRSA transmission from colonized to noncolonized patients. For this reason, the Boston VAH Health Care System selected 96 patients from its acute care setting to research nasal and extranasal colonization in patients who shared the same room. A total of 48 pairs participated in the study from September 2011 to September 2012. Six roommate pairs were placed in contact isolation on admission because they had positive nasal cultures for MRSA or had been diagnosed with MRSA previously. Forty-two roommate pairs were admitted to nonprecaution rooms; their MRSA status was unknown. The average age of the

participants was 67 years, and the majority of the participants were European American (n = 94, 97.5%). The average amount of time sharing a room was 1 day. Twenty-two pairs (n = 44, 45.8%) were admitted to the medical-surgical unit.

According to Kabbani et al. (2013), 24 of 82 patients (29%) were colonized with S. aureus at any site on the body: Eight participants had nasal colonization, three had extranasal colonization (groin and perirectal), and 13 had nasal and extanasal colonization. Eight participants were positive for MRSA, seven had at least one extranasal colonization, and two had perirectal colonization. Sixteen patients had MSSA infections. Groin and perirectal areas were identified as the most common extranasal sites for MRSA colonization; the throat was the most common extranasal site for MSSA colonization. The results indicated that patients placed in nonprecaution rooms are highly likely to acquire MSSA from their roommates. The researchers concluded that routine active surveillance focused only nasal screening on admission, making it problematic to identify extranasal colonization on admission, which could result in the risk of transmission in the hospital setting.

Ng, George, Muhammed, Tomassi, and Katz (2012) reported that patients who shared the same rooms for more than 1 day were exposed to the same S. aureus strain. Werthein et al. (2005) argued that MRSA nasal specimens collected at a specific point of time do not show the actual carrier state over longer periods of time. Researchers must focus on understanding the biological mechanism of S. aureus nasal carriage and its relation to infection so that they can improve and strengthen infection control strategies (Wertheim et al, 2005).

Chen and Pass (2013) stated that persistent MRSA and transient MRSA colonization could significantly change health outcomes in the ICU setting. This retrospective cohort study investigated the risk factors for MRSA nasal colonization at the Dallas Veterans Affairs Medical Center MICU from July 2009 to June 2010. During this time, 180 patients had positive nasal swab results on admission to MICU. The average age of the patients were 66.5 years; 178 (98.9%) of the 180 patients were male, and 143 (79.4%) had recently been hospitalized. Univariate analysis revealed that advanced age, diabetes mellitus, acute renal failure, congestive heart failure, and surgery were the major risk factors for MRSA colonization. In contract, the multivariate analysis identified diabetes mellitus and congestive heart failure as predictive risk factors of MRSA nasal colonization. Chen and Pass did not find any association between MRSA colonization and the incidence of HA-MRSA infections, increased length of stay in ICU, and inpatient mortality.

Rimawi et al. (2014) found a significant and strong correlation between MRSA nasal sampling and S. aureus pneumonia in MICU. From March 2010 to March 2013, 275 individuals participated in the retrospective chart review study. Of the 275 patients, 165 (60%) tested positive for MRSA pneumonia, and 110 (40%) tested positive for MSSA pneumonia. Per the study, 91 of the 165 patients (55%) with MRSA pneumonia had negative nasal cultures, and 108 of 110 patients (98%) with MSSA pneumonia had negative nasal cultures on admission to MICU. The study did not support the hypothesis that a positive nasal MRSA culture could cause pneumonia, but the results did highlight

that nasal screening is not effective in identifying positive oropharyngeal colonizations (Rimawi et al., 2014).

Squier et al. (2002) emphasized that patients with nasal carriage and extranasal MRSA colonization had twice the risk of MRSA infection than patients with only positive MRSA nasal cultures in ICU and liver transplant units. The sample comprised 204 participants; 52 of the patients (25.5%) were positive MRSA carriers in nasal and rectal areas, 44 (21.6%) were nasal carriers only, 7 (3.4%) were rectal carriers, and 101 (49.5%) were noncarriers. The results revealed that patients who were nasal and rectal carriers had a significantly higher risk of S. aureus infections than patients with either nasal or rectal carriage only. Pulsed-field gel electrophoresis confirmed that nasal and rectal isolates were clonally identical in patients with positive S. aureus cultures (Squier et al., 2002).

According to Harbath et al. (2006), certain risk factors are associated with MRSA colonization and nasal carriage. These risk factors are antibiotic usage within 3 to 6 months prior to admission to hospital, hospitalization within the past 12 months, male sex, older age, and transfer from another hospital (Harbath et al., 2006). Torres and Sampathkumar (2013) conducted a study at St. Mary Hospital in Rochester, MN to develop a risk factor score to identify patients with MRSA colonization and nasal carriage at the time of admission to hospital. The researchers used derivation and validation studies to evaluate MRSA risk factors.

The derivation study used electronic record data from 496 patients in March 2008. The following risk factors were used in the derivation study: hospital transfer, chronic

hemodialysis, long-term in-dwelling device, immunocompromised status, use of antibiotics in the past 3 months, resident in a nursing home, hospitalization in the past year, and skin infection/condition. Using the multivariable logistic model, Torres and Sampathkumar (2013) identified four risk factors that were significantly associated with MRSA colonization (i.e., chronic skin condition or active skin infection, nursing home residence, hospitalization within the year prior to admission, and diabetes mellitus). The risk factor score model was a useful tool to foretell MRSA colonization by using sensitivity and specificity scores (71% vs. 83%).

The prospective validation study took place from May 2011 to June 2011 (Torres & Sampathkumar, 2013). Of the 1,462 patients, data for only 991 patients were eligible for inclusion in the study. Results showed that the nursing home residents had the highest rates of MRSA colonization (Torres & Sampathkumar, 2013).

Although most published articles praised the success of universal screening for MRSA infections, Glick et al. (2014) questioned the effectiveness of active culture specimen collections. They asked whether hospitals should do active MRSA surveillance on all patients (i.e., universal screening) or only on patients admitted to ICUs or having major surgical procedures. They found in their review of the literature that universal screening decreased the number of hospital-associated MRSA infections.

Othman, Fishbain, and Khatib (2013) found that cardiovascular implantable electronic devices might play a role in the case of S. aureus bacteremia (SAB). Othman et al. identified these devices as risk factors because they are "potential source of transient bacteremia and seeding of cardiac device" (p. 377). Baddour et al. (2010) confirmed that

S. aureus infection is one of the most common bacteremia after the implantation of cardiovascular implantable electronic devices even through antibiotics administered preoperatively. Controversially, a previous study by Chamis et al. (2001) stated that SAB was very high among patients who received permanent pacemakers or implantable cardioverter defibrillators. Although it seemed that cardiac devices caused SAB, the researchers emphasized that cardiac devices were not the initial source of infection. RQ1 was designed to analyze the relationship between positive nasal culture and invasive HA-MRSA among hospitalized patients from different racial and ethnic groups in Los Angeles County's eight SPAs.

Oral and perioral sampling. McCormack et al. (2015) highlighted in their retrospective cohort study the SAB commonly found in oral and perioral cultures. They emphasized that S. aureus found in the oral cavity has a major role in the spread of S. aureus to other body sites via cross-infection. They reviewed 11,312 laboratory records from January 1998 to December 2007 from an oral microbiology lab in Glasgow. A total of 1,986 (18%) of the 11,312 specimens contained S. aureus isolates: 1,772 (90%) of the 1,986 specimens were MSSA, and 204 (10%) were MRSA positive. Another 567 (33%) of the 1,782 MSSA specimens were found in oral rinse, 384 (22%) in angle-of-mouth swabs, and 199 (11%) in tongue swabs. Fifty-two (25%) of the 204 MRSA specimens were found in tongue swabs, 32 (16%) in oral rinse and hard plate swabs, and 26 (13%) in angle-of-mouth swabs. The most common oral conditions related to MSSA infection were angular cheilitis (333, 19%); suspected candidal infection (182, 10%); and cysts and implants (176, 9.9%). The most common oral conditions related to MRSA infection were

suspected candidal infection (39, 19%); cysts and implants (24, 12%); and angular cheilitis (17, 8%). McCormack et al. recommended that a prospective surveillance study be conducted to assess cross-transmission, identify oral infections, and investigate the antibiotic prescribing habits of dentists.

Decontamination and Disinfection

Hospital-acquired infections in the ICU setting are commonly related to improperly cleaned medical devices. Gold and Hitchins (2013) agreed that the fundamental purpose of infection control is to improve training in cleaning and disinfection, as well as the proper selection of cleaning, disinfection, and sterilization agents. Gold and Hitchins found that not all commercially available disinfectant wipes are effective in removing blood or bacteria from the exterior surfaces of reusable medical equipment. Ineffective cleaning and inappropriately selected cleaning wipes do not eliminate biofilm formation on medical devices. These medical devices serve as reservoirs for future bacterial infection.

Gold and Hitchins (2013) selected six cleaning wipes to test the disinfection properties of these commercial cleansers. They used adenosine triphospate (ATP) bioluminescence assay to evaluate the cleanliness of medical equipments after cleaning them with different medical wipes. None of the six selected cleaning wipes removed blood soil and bacterial contamination 100%. The most effective cleaning wipe had sodium hypochlorine as an active ingredient. Gold and Hitchins recommended that all hospitals check the active ingredients of disinfectants, wipe designs, and wipe wetness before purchasing. They also suggested that improper staff training, difficult-to-clean

surfaces, and noncompliance with manufacturers' instruction are very serious issues of HAIs.

Luick et al. (2013) noted that hospitals' environmental services must follow strict cleaning and disinfection guidelines to prevent microbial transmission among patients and health care workers. Over a period of 2 months, they randomly tested 250 environmental surfaces that had been contaminated on purpose with aerobic culture. Before the terminal cleaning, Luick et al. marked different objects in the patients' rooms with fluorescent dye marker. They compared visual inspection, fluorescent maker, and ATP bioluminescene assay system to monitor and measure surface cleanliness. Of the 250 surfaces, 214 (86%) were considered clean after visual inspection. After cleaning, 232 surfaces were considered clean by visual inspection. These surfaces were evaluated with ATP bioluminescene assay; only 191 (76%) of the surfaces were considered clean after terminal cleaning. When fluorescent maker was used, there were similar results. The study illustrated that ATP assay is the best method to assess and monitor cleaning and disinfecting procedures in the health care setting (Luick et al., 2013).

Engelbreacht et al. (2013) highlighted that disinfectants with quaternary ammonium ingredients show decreased effectiveness when in contact with cotton and microfiber towels. The use of high-performance liquid chromatography showed that this binding decreased the effectiveness and activity of hospital cleaners. When reusable cotton towels were used with quaternary ammonium, the concentration level of the active ingredient was only 85.3%. The study demonstrated that cotton towels cannot be

combined with quaternary ammonium for cleaning purposes in the hospital setting (Engelbreacht et al., 2013).

Neely and Maley (2000) stated that S. aureus is viable on cotton towels for 19 to 21 days, on polyester for 1 to 56 days, and on polyethylene plastic for 22 to 90 days. These bacteria also can survive on hospital fabrics, lab suits, scrubs, hospital drapes, and so on (Neely & Maley, 2000). Oller and Michell (2008) investigated cell viability on cotton towels. They found that S. aureus stays viable on cotton towels for at least 48 hours after hand contact transmission. Although they used detergents and water to clean the towels, Oller and Michell found that S. aureus was viable even after washing. The towels contained 10^5 CFUs, which can be a direct or an indirect infection source in the health care setting. The researchers also reported that bleach was a more effective disinfectant than detergents and water and that thick and more absorbent towels, more so than less absorbent towels, were reservoirs for bacteria.

Sifuentes, Gerba, Weart, Engelbrecht, and Koenig (2013) emphasized that assessing hospitals' cleaning practices such as in-house laundry services or central laundry services are an essential part of infection control practices. Ten hospitals participated in their study. Eight of the hospitals reported using cotton towels, and two reported using microfiber towels. In all 10 hospitals, after laundering, 93% of the cleaning towels still had viable microbes. The result indicated that cleaning towels might have a possible role in HAIs (Sifuentes et al., 2013).

D'Antonio, Rihs, Stout, and Yu (2013) found that computer keyboards act as fomites and can transfer infectious organisms from one person to another. They also

noted that keyboard surfaces can carry MRSA and contribute to HAIs. D'Antonio et al. evaluated Biosafe HM4100 antimicrobial polymer, from which they produced keyboard covers and assessed the efficiency of polyurethane material containing HM4100. The results revealed that antimicrobial polymer computer keyboard covers were effective in reducing bacterial viability and decreased potential contact transmission.

Kiedrowski, Perisetti, Loock, Kaaitsa, and Guerrero (2013) emphasized that modern electrical technology such as the use of iPads in the health care setting is increasing. They used 20 iPads to evaluate cleaning methods related to bacterial contamination. They found that three of the 20 iPads were contaminated with S. aureus. The researchers tested alcohol, bleach, and moistened cloths to remove viable microbes form the surfaces of the iPads. All there cleaning wipes were effective in removing MRSA. Currently, there are no infection control guidelines available for iPad disinfection (Kiedrowski et al., 2013).

Campos-Murguia, Leon-Lara, Munoz, Macias, and Alvarez (2014) agreed that stethoscopes must be cleaned regularly with antiseptics and must be included in the disinfection protocol. The researchers cultured 112 stethoscopes from various hospital settings, such as children and adult wards. Forty-eight (47%) of the 112 stethoscopes had biofilms with 50 pathogenic microbes. Forty-three (86%) of those 48 stethoscopes were contaminated with S. aureus, 18 of which (42%) had been infected with MRSA. Campos-Murguia et al. recommended using 70% alcohol, chlorhexidine, or triclosan as cleaning agents for stethoscopes before and after patient care.

Inappropriately cleaned filtering face piece respirators (FFRs) can contribute to infection and the spread of diseases (Heimbuch et al., 2014). The researchers contaminated three FFRs with aerosols of mucin and viable S. aureus and then used three different cleaning wipes (i.e., hypochlorite, benzalkonium chloride, and nonantimicrobial wipes) to test the effectiveness of the disinfection. None of the antimicrobial wipes was effective enough to clean the product. Heimbuch et al. (2014) concluded that reusable FFRs and the cleaning protocols will require FDA-approved National Institute for Occupational Safety and Health (NIOSH) certification.

Infection prevention mainly focuses on hand hygiene and the use of disposable gloves in the health care setting. Moore, Dunnill, and Wilson (2013) suggested that the type of glove that health care workers use could influence MRSA transmission Because glove material and glove hydrophobicity are considered the two most significant factors in microbial transfer among patients, health care workers, and the environment. Moore et al. tested seven types of glove material: latex, latex with low protein content, latex with very low protein content, nitrile plus accelerators, nitrile without chemical accelerators, nitrile, and vinyl. Three high-touch surfaces, namely, a storage trolley drawer, a bed rail, and a silicone-coated computer keyboard were tested.

In the cross-contamination assay, Moore et al. (2013) analyzed the transfer of MRSA bacterial suspension from a contaminated glove to a clean and dry environmental surface as well as the transfer of MRSA from a contaminated surface to a disposable glove. The results showed that the nitrile glove with accelerators had the lowest MRSA transfer rate ($p < 0.05$) in comparison to latex and vinyl gloves, regardless of the test

surface. The latex and vinyl gloves had the highest MRSA transfer rates related to the protein content and hydrophobicity of the gloves (Moore et al., 2013).

Few researchers have focused on S. aureus colonization, transmission, and infection in the household environment. Eells et al. (2014) noted that USA300 MRSA isolates were found persistently on household items such as landline phones, bathroom door handles, toilets, hairbrushes, bathroom sink handles, toys, refrigerator door handles, television remote controls, kitchen counters, and kitchen sink handles 3 months after skin infections. These household items continue to be persistent reservoirs for S. aureus microbes and put household members at risk of infection. Patients in the longitudinal cohort study by Eells et al. came from the Harbor University of California Los Angeles Medical Center and University Chicago Medical Center. The study took place from August 2008 to June 2010. The eligibility criteria included index subjects with positive S. aureus isolates on their skin confirmed by microbiological sampling and one or more household members related to the participants willing to join the study. A total of 346 households (n = 1,148 participants), 170 in Los Angeles and 176 in Chicago households, participated in the study.

During the investigation, Eells et al. (2014) collected and obtained culture samples from the surfaces of different household items at the time of enrollment and again 3 months later. Four different S. aureus isolates were identified from the participants' households: MRSA, USA300 MRSA, Pantone-Valentine Leukocidin, and SCCmec type IV. The results confirmed that the index subject's S. aureus infection strain remained on more than 50% of the household items after 3 months. At the time of

enrollment, 49% (n = 170) of the households had one or more objects contaminated with S. aureus, 23% (n = 80) with MRSA, and 33% (n = 133) with MSSA. After 3 months, 51% (n = 154) of the households had one or more objects contaminated with S. aureus, 26% (n = 78) with MRSA, and 31% (n = 97) with MSSA. The researchers found more S. aureus contamination in the Los Angeles households (n = 97, 57%) than in Chicago households (n = 72, 41%; p = .007). Similar trends were noted 3 months later (56% vs. 44%; p = .07).

At the time of enrollment, landline phone (20%), bathroom door handles (17%), and toilets (17%) had the highest contamination rates. At the 3-month follow-up, there were similar contamination trends. At the time of enrollment, the nonindex subjects' favorite toys (11%) had a higher prevalence rate of S. aureus contamination than that of the index subjects' favorite toys (8%). At 3 months, the household members' favorite toys (10%) had the highest prevalence rate of MRSA contamination, followed by bathroom door handle (9%) and toilets (9%). Eells et al. (2014) suggested that environmental decontamination can be an important part of infection control to decrease S. aureus colonization in the community setting.

Infection Prevention

Reducing MRSA in health care facilities requires collaboration among governmental agencies, health care facilities, health care workers, patients, and patients' visitors. MRSA infection control and prevention strategies must be based upon evidence-based interventions that include active surveillance, hand hygiene and contact isolation protocols, and changes in the behaviors of health care workers (Kralovic et al., 2013).

Calfee et al. (2014) developed comprehensive guidelines to prevent MRSA infections in acute care hospitals. The guidelines recommended that the detection of MRSA infection must be based upon laboratory-identified event surveillance, which includes laboratory data, dates of admission of patients to hospital, and inpatient locations. Calfee et al. also recommended clinical surveillance to classify MRSA types and strains. The infection prevention guidelines also advised that all acute care hospitals conduct risk assessments and implement evidence-based monitoring systems to prevent MRSA infections and transmission in the hospital setting.

Calfee et al. (2014) emphasized that implementing an alert system is beneficial in identifying intrafacility-transferred and readmitted MRSA-colonized patients and patients with MRSA infections. MRSA decolonization protocol therapy is essential for adult ICU MRSA-infected patients with daily chlorhexidine bathing and with or without mupirocin intranasal applications. Infection control measures and strategies are effective only if compliance levels are assessed and evaluated on a regular basis (Calfee et al., 2014).

From 2008 to 2010, 49 acute care general hospitals in California participated in the California Healthcare-Associated Infection Prevention Initiative (CHAIPI; Halpin et al., 2013). The selected hospitals received $20,000 grants to implement evidence-based infection control practice to improve patients' safety and reduce HAI rates from MRSA infections, catheter-associated UTIs, central line-associated bloodstream infections (CLABSIs), and SSIs in California. Another 149 hospitals were part of the cohort, but they did not participate in the CHAIPI. Halpin et al. (2013) compared these hospitals' survey data with those from the CHAIPI hospitals. The results indicated that the CHAIPI

hospitals had improved their compliance with evidence-based practices to prevent HAI. There was no statistical difference in the reduction of HAI rates between CHAIPI and non-CHAIPI hospitals (Halpin et al., 2013).

S. aureus-caused BSIs are extremely high in outpatient hemodialysis centers. Because of this access-related BSI, the CDC Hemodialysis Bloodstream Infection Prevention Collaborative was implemented in a 12-bed outpatient hemodialysis center in Atlantic City. Lindberg et al. (2013) explained that engaging health care workers in infection prevention will increase their adherence rate to proper infection prevention.

Wright et al. (2013) highlighted that CLABSIs can be prevented by decontaminating the central hubs. They analyzed the effectiveness of disinfection cap with 70% alcohol in preventing intraluminal bacterial infections such as MRSA. Use of the disinfection cup saw the CLABSI rate decrease by 49% in the three participating hospitals; however, when the intervention was over, the CLABSI rates continued to increase. The results had a significant impact on the infection control practices at the hospitals, and disinfection cap became a standard protocol for patients with central catheters (Wright et al., 2013).

Pope, Dellit, Owens, and Hooton's (2009) survey focused on antimicrobial stewardship program (ASPs) in hospitals in the United States. They found that only 48% of the hospitals had implemented ASPs. Wagner et al. (2014) evaluated ASPs in a systematic review of articles from 2000 to 2013 in the Medline and Cochrane Library databases to assess the ways in which ASP interventions were implemented and report on the outcomes. The results indicated that the ASP programs definitely improved

prescribed antibiotic usage and microbial outcomes without any negative impact on patients' health. Wagner et al. recommended that ASP implementation should be a priority at all health care facilities because antibacterial resistance is becoming a broad and alarming problem in inpatient care. The key is to slow the spread of antibiotic-resistant microbes and prevent adverse reactions of prescribed antibiotics (Wagner et al., 2014). I designed RQ2 to evaluate the incidence rates of MRSA infections among different racial and ethnic groups during hospitalization.

Prevalence of MRSA

Since the first outbreak of MRSA infections in Europe in the 1960s, severe S. aureus infections have become more prevalent, and transmission within the health care and community settings has become a global health threat (Klein et al., 2007). MRSA caused more than 19,000 deaths and 278,000 hospitalizations in 2005 in the United States (Klein et al., 2007). More recently, 80,461 severe MRSA infections occurred in the United States in 2011 (Dantes et al., 2013).

The CDC (2012), with the assistance of the National Center for Health Statistics, surveyed 19,393,677 people to investigate invasive MRSA epidemiological classifications, demographic characteristics, and disease and mortality rates in California, Colorado, Connecticut, Georgia, Maryland, Minnesota, New York, and Oregon. The CDC reported that 3,780 patients had HA-MRSA infections, or 19.5 cases per 100,000 population, in 2011. Five hundred and thirty-two of those 3,780 patients died from HA-MRSA infections, or 2.7 cases per 100,000 population. Eight hundred and sixty-eight patients had HO-MRSA infections, or 4.5 cases per 100,000 population. One hundred and

eighty-two of the 868 patients died from invasive HO-MRSA infections, or 0.9 cases per 100,000 population. A total of 2,912 patients had HACO-MRSA infections, or 15.0 cases per 100,000 population. Three hundred and fifty patients died from invasive HACO-MRSA infections, or 1.8 cases per 100,000 population. A total of 1,010 patients had CA-MRSA infections, or 5.2 cases per 100,000 population. One hundred patients died from CA-invasive MRSA infections, or 0.5 cases per 100,000 population.

In 4,872 cases, the patients' races were reported as follows: 2,743 European Americans, 1,542 African Americans, and 126 Other. The CA-, HACO-, and HO-invasive MRSA rates were the highest among patients older than 65 years. The national estimate and adjusted overall mortality rate was 3.62 per 100,000 population in 2011 (CDC, 2012).

According to Klein, Sun, Smith, and Laxminarayan (2013), in 2009, 697,248 (95% Cl [633, 338, 761,159]) hospitalizations related to S. aureus occurred the United States. The hospitalization rate was 17.68 (95% Cl [16.06, 1930]) per 1,000 hospitalizations. In 2009, the most common S. aureus infections were carbuncles (painful cluster of boils), furuncles (boils), cellulitis (SSTIs), and abscesses (painful lumps with pus and debris collection; Klein et al., 2013; WebMD, 2014). Seven percent of infections were caused by implanted devices or drafts, 6% by postsurgical infections, 5% by diabetes mellitus, and 3% by osteomyelitis. The rate of HA-MRSA pneumonia among patients older than 65 years was 1.15 per 1,000 hospitalizations during the winter due to flu season (Klein et al., 2013).

Klevens et al. (2007) used a population-based surveillance study to investigate invasive MRSA disease in nine communities in the United States from July 2004 to December 2005. They participated in the Active Bacterial Core Surveillance and Emerging Infections Program Network. The rate of invasive HO-MRSA infection among men was 10.1 per 100,000 incidents and 7.9 per 100,000 incidents among women. The rate of HO-invasive MRSA infection among European Americans was 8.1 per 100,000 incidents, 16.6 per 100,000 incidents among African Americans, and 3.3 per 100,000 incidents among others.

The rate of death related to invasive HO-MRSA among European Americans was 2.4 per 100,000 incidences, 3.7 per 100,000 incidences among African Americans, and 1.2 per 100,000 incidences among others. The rates of the disease were the highest among African American males older than 65 years. Results showed that 85% of invasive MRSA infections were health care related, with 33% occurring during hospitalization and 66% occurring outside the hospital setting (Klevens et al., 2007).

Bakullari et al. (2014) used the Medicare Patient Safety Monitoring System (MPSMS) to evaluate HAIs among racial and ethnic groups in the United States from January 2009 to December 2011. There were 76,833 MRSA infections in the United States during this 3-year period; 51 were HA-sterile-site MRSA. Interestingly, the MRSA definition in the MPSMS included only blood and spinal fluid infections. Among European Americans, there were 32 HA-sterile-site MRSA infections, 11 among African Americans, five among Hispanic Americans, and three among Asian American patients. The results suggested that language barriers between health care professionals and

patients could be a contributing factor in HAIs (Bakullari et al., 2014). MRSA-caused SSTIs were a well-documented health problem in the United States at the end of 20th century. From 2004 to 2008, MRSA infections were the most significant cause of purulent SSTI in U.S. emergency departments related to MRSA susceptibility to non-β lactam parental antibiotics (Talan et al., 2011).

Ellis et al. (2014) analyzed the prevalence rate of nasal colonization and strain in an observation study among U.S. Army soldiers undergoing infantry training in a study from May 2010 to January 2012 as a prospective, cluster-randomized trial at Fort Benning, Georgia. A total of 1,203 (4%) of the 30,209 male soldiers had SSTIs and participated in the study. Of these 1,203 trainees, 508(42%) had laboratory-conformed S. aureus SSTIs; 290 (57%) of the 508 participants had MRSA SSTIs, and 218 (43%) had MSSA SSTIs.

Ellis et al. (2014) did not collect race and ethnicity data for all trainees because only 114 participants of the 290 MRSA SSTI enrollees had available data about race and ethnicity. Ninety-one of the 114 participants were non-Hispanic European Americans, 12 were Hispanic Americans, seven were non-Hispanic African Americans, and four were non-Hispanic Other Americans. Only 92 participants of the 218 MSSA SSTI enrollees had available data about race and ethnicity, with 77 the 218 participants being non-Hispanic European Americans, 10 being Hispanic Americans, two being non-Hispanic African Americans, and three being non-Hispanic Other Americans. The average age of the participants was 19 years.

Comparing the clinical symptoms, 141 (49%) of the participants had MRSA-caused abscesses ($p < .01$), and 65 (30%) had MSSA-caused abscesses; 61 (21%) had MRSA-caused cellulitis ($p < .02$), and 65 (30%) had MSSA-caused cellulitis. Anterior nasal swab cultures were collected within 1 day of the signs and symptoms of SSTI from 466 (92%) of the 508 participants and within 3 days for 15 of the 508 participants. S. aureus nasal colonization and same-time positive SSTIs were found among 357 of the 508 trainees. A total of 118 (41%) of 290 trainees with MRSA SSTIs had positive MRSA nasal cultures; 25 (12%) of 218 MSSA SSTIs had positive MRSA nasal cultures. The 92 (32% of 290) trainees with MRSA SSTIs had positive MSSA nasal cultures; 122 (56%) of 218 participants with MSSA SSTIs had positive MSSA nasal culture. The results revealed that USA300 MRSA nasal colonization and MRSA SSTIs were not common but that bacteria found in nares and wounds could be important in determining the development of a disease (Ellis et al., 2014).

Drug-resistant MRSA infections are becoming a problem among nursing home residents. A wide range of clinical complications are related to positive MRSA cultures, including bloodborne infections, pneumonia, SSTIs, and so on. Nursing home residents are highly likely to be exposed to MRSA infections because of their chronic medical conditions, diabetes, long-term use of indwelling catheters, and physical inactivity. Research scientists from University of California Irvine investigate the frequency of MRSA nasal carriage among nursing home residents in 22 nursing homes in Orange Country in California between October 2008 and May 2011. They collected 3,433 nasal swab samples from the elderly residents. Results showed that residents in 20 of the 22

nursing homes were carriers of MRSA. They found that 824 (24%) of 3,433 residents were MRSA positive: 266 (17%) of 1,549 were positive for MRSA on admission to their respective facilities; and 558 (30%) of 1,884 were positive for MRSA at point prevalence screening. Of the 824 positive MRSA tests, 208 (25%) were CA-MRSA. Murphy et al. (2013) asserted that CA-MRSA was more common among residents under the age of 65 years, residents who were Hispanic Americans, and residents diagnosed with diabetes mellitus.

Nelson, Stevens, Jones, Samore, and Rubin (2015) conducted a retrospective cohort study to analyze the long-term effect of HA-MRSA infection and mortality after discharge from the hospital. The participants' data were selected from U.S. Department of Veterans Affairs facilities from October 2007 to September 2010. Positive MRSA cultures were identified from electronic microbiology reports; 3,599 (1%) of the total 369,743 patients had positive MRSA cultures. The MRSA infection incidence rate was 0.83 infections per 1,000 patients. These 3,599 patients were followed until their deaths or for 365 days after discharge from a hospital. A total of 2,433 (67.6%) of the 3,599 patients were European American, 759 (21.1%) were African American, 11(0.3%) were Asian American, 25 (0.7%) were Native American, 212 (5.9%) were Hispanic American, and 162 (4.5%) were Unknown. In addition, 3,455 (96%) of the MRSA positive patients were male and 144 (4%) female. The multivariable Cox proportional hazards model revealed that patients with HA-MRSA were 49% more likely to die than MRSA-free status patients, and patients with MRSA colonization had a 41% increased risk of death.

Nelson et al. argued that infection prevention must focus on decreasing MRSA transmission and assessing the long-term outcomes of the infection (Nelson et al., 2015).

In their prospective cross-sectional study, Datta et al. (2014) analyzed the protective effect of MSSA carriage against MRSA in 26 nursing homes between October 2008 and May 2011 in Orange Country in California. The researchers collected 1,661 admission samples and 2,145 point prevalence samples from nursing home residents. The median age of the residents younger than 65 years old was 14 (number of residents in the 26 nursing homes who met this criterion ranged from 0-75). The median age of the residents older than 85 years old was 25 (range = 2-72 residents). The median number of male residents was 42 (range = 21-67). The median number of Hispanic American residents was 17 (range = 1-38) and non-European American was 16 (range = 1-88). The median number of residents who had diabetes was 27 (range = 11-59), skin lesions was 72 (range = 4-100), poor locomotion was 60 (range = 14-89) and fecal incontinence was 44 (rang = 5-91). The MRSA median admission prevalence rate for the 26 nursing homes was 16%; MSSA was 11%.

At the same time, the MRSA median point prevalence rate was 27% versus a rate of 14% for MSSA among the residents of the 26 nursing homes. In conclusion, Datta et al. (2014) stated, “There was no significant correlation between MRSA and MSSA prevalence upon nursing home admission, but there was a significant inverse correlation when comparing MRSA point prevalence to MSSA point prevalence” (p. 1260). The inverse association supported the hypothesis that MSSA carriage might protect against MRSA in nursing homes (Datta et al., 2014).

Tehrani et al. (2014) published a retrospective cohort study to determine facility-level characteristics related to HA-MRSA infection in 323 California acute care hospitals by using *International Classification of Disease* diagnostic and procedure data between January 1, 2009, and December 31, 2010, to ascertain the cases of HA-MRSA during admission and hospitalization associated with pneumonia and septicemia and/or 30 days after discharge from hospital. The median number of male patients was 38.6 (range in the number of residents who met this criterion in the 323 hospitals = 36.1-43.2. The highest median age of the patients between 18 and 44 years was 27.7 (range = 21.0-33.1), 75 to 84 years of age was 15.6 (range = 12.7-18.6) and 65 to 74 years of age was 14.9 (range = 13.1-16.8). The median 3- to 4-day hospital stay of the total of 5,530,181 hospitalizations in 323 California hospitals for the 2-year period was 41.8 (range = 38.2-45.1). The median racial characteristics were as follows: 75.8 (range = 53.3-88.8) of all patients were European American, 0.2 (range = 0.1-0.5) were African American, 4.6 (range = 1.8-10.6) were Asian American, 18.9 (rang = 10.0-33.1) were Hispanic American, and 15.9 (range = 7.1-31.1) were Other. The median comorbid conditions were as follows: 19.3 (range = 15.6-25.0) of inpatients had fluid and electrolyte disorders, 16.6 (range = 13.5-20.4) had diabetes, 10.8 (range = 7.8-14.3) had renal failure, 3.1 (range = 2.5-4.0) had liver disease, and 1.8 (range = 1.2-2.4) had metastatic cancer.

The results of Tehrani et al.'s (2014) study were as follows: There was a median 16 (range = 0-102) HA-MRSA infections per 10,000 admissions. Hospitals with higher number of patients with comorbid conditions, low levels of education, and discharge to facilities other than home had higher HA-MRSA infection risks. Tehrani et al. concluded

that modifiable prevention strategies related to hospital performance can influence patient care.

For more than 20 years, the number of patients diagnosed with pneumonia caused by MRSA strains has continued to increase in U.S. hospitals. Between 20% and 40% of all pneumonia patients have been diagnosed with hospital-associated pneumonia (HAP), VAP, and health care-associated pneumonia (HCAP) related to MRSA infections (Rubenstein, Kollef, & Nathwani, 2008). From 2008 to 2012, the incidence of HCAP due to MRSA increased among patients admitted to the 24 hospitals in the Duke Infection Control Outreach Network in the southeastern United States.

This fact prompted Lewis et al. (2014) to conduct a retrospective cohort study using surveillance data to investigate seasonal and annual incidence rates and outcomes of HCAP due to MRSA. A total of 1,048 patients were diagnosed with HCAP due to MRSA during the 5-year period. A total of 234 of 1,048 patients had HAP due to MRSA. The median age of the patients was 68 (range = 58-78), and 45 of them were older than 80 years of age. Eighty-nine of the 234 patients were female, and 121 were male. A total of 814 of 1,048 patients had HCAP due to MRSA. The median age of the patients was 74 (range = 61-83), and 267 of them were older than 80 years of age. Three hundred and eleven of the 814 patients were female, and 323 was male. No racial data were assessed. The surveillance data revealed that the annual incidence rate of HCAP due to MRSA was 11.3 cases per 100,000 patient days (95% Cl) in 2008; 2009 saw 14.6 cases per 100,000 patient days, 18.5 cases per 100,000 patient days in 2009, 17.5 cases per 100,000 patient days in 2010, and 15.5 cases per 100,000 patient days in 2012. The collected data clearly

showed an increased incidence rate between 2008 and 2012. The surveillance data showed seasonal differences of HCAP due to MRSA. From December to February, the incidence rate was the highest at 15.4 cases per 100,000 patient days; from June to August, the incidence rate was the lowest at 11.1 cases per 100,000 patient days. The incidence rate was 12.4 cases per 100,000 patient days from March to May and the incidence rate was 12.3 cases per 100,000 patient days From September to November. Two hundred and forty of the 1,048 patients with HCAP died from MRSA infection: 76 had HAP related to MRSA, and 164 had HCAP related to MRSA. Lewis et al. (2014) mentioned that further investigation should be conducted to assess mortality as a consequence of health care-related MRSA pneumonia as a public health concern.

Rimawi et al. (2014) summarized the findings of their retrospective chart review about S. aureus pneumonia in intensive care units. They reviewed data from March 2010 to March 2013 from a tertiary care hospital in North Carolina. The respiratory cultures of 387 patients were positive for S. aureus, but only 275 cultures met the clinical criteria for pneumonia. One hundred and sixty-five of the 275 patients had MRSA pneumonia: the mean age of the patients was 56.7 years; 71 (43%) were male, and 94 (57%) were female. Seventy-one (43%) of the patients with MRSA pneumonia were European American, 92(56%) were African American, and 2(1%) were Hispanic American. One hundred and forty-two (86%) of the patients had HCAP, and 23 (14%) had CA pneumonia. Seventy-four (45%) of the patients had positive nasal screening, and 91(55%) had negative nasal screening. One hundred and ten of the 275 patients had MSSA pneumonia: the mean age of the patients was 54.8 years; 64 were males (58%), and 46 (42%) were female. Forty-

six (42%) of the patients with MSSA pneumonia were European American, 63 (57%) were African American, and 1 (1%) was Hispanic American. One hundred and ninety-four (85%) of the patients had HCAP, and 16 (15%) had CA pneumonia. Two (2%) patients had positive nasal screenings, and 108 (98%) had negative nasal screenings. The researchers noted that 55% of the patients with MRSA pneumonia had negative nasal cultures and 98% of the patients with MSSA pneumonia had negative nasal cultures on admission to MICU.

Rimawi et al. (2014) also analyzed racial and ethnic disparities in MRSA and MSSA infections. They found that the African American patients had the highest incidence rates of MRSA and MSSA pneumonia; the lowest rates were among Hispanic Americans. The findings suggest that doctors should not initiate anti-MRSA therapy based upon negative nasal swabs (Rimawi et al., 2014). Robicsek et al. (2008) emphasized that in a case of negative MRSA nasal screening, ruling out MRSA disease does not mean that patients have an MRSA-free status.

Inpatient patients with MRSA positive nasal swabs or laboratory-confirmed MRSA infection are placed on contact isolation per hospital policy. Not many standard discontinuation policies exist because of the "absence of national guidance" (Shenoy, Hsu, Noubary, Hooper, & Walensky, 2012, p. 852). Shenoy et al. (2012) surveyed 2,580 institutions in the United States to assess their institutional discontinuation policies. They identified 48 different institutional policies among the surveyed facilities.

Valencia-Rey et al. (2014) retrospectively investigated the discontinuation policy of the Veteran Affairs Boston Health Care System between October 2007 and April 2013.

They investigated MRSA-free status after removing patients from contact isolation. A sample of 351 patients joined the study. The average age of the patients was 68 years; 327 participants were European Americans, and 343 were men. Two hundred and fifteen participants had hypertension, 130 had diabetes, and 51 had cancer as a comorbid condition; 94 of the 351 patients had an indwelling device (e.g., Foley catheter, central line, gastrostomy tube, or tracheotomy). Valencia-Rey et al. stated that 249 (71%) of the 351 participants stayed MRSA-free but 102 (29%) of 351 were reinfected with MRSA. MRSA-free status was not associated with antibiotic use at the time of discontinuation of contact isolation. Valencia-Rey et al. recommended that institutions simplify clearance policies and criteria to decrease the number of days of contact isolation.

MRSA Infection Demographic in Los Angeles

According to the LACDoPH (2012), African Americans and European Americans had the highest rates of severe S. aureus infections at 0.5 cases per 100,000 and 0.4 cases per 100,000, respectively, in 2008. Hispanic Americans had the lowest rate of severe S. aureus infections at 0.1 cases per 100,000 in Los Angeles County's eight SPAs in 2008. The surveillance data for 2012 did not identify any changes in the rates since 2005; SPAs 1, 3, and 5 had the highest rates of invasive S. aureus infection in 2008 and no rate changes in 2012. In contrast, SPA2's invasive S. aureus infection rate decreased from 0.2 cases per 100,000 in 2008 to 0.0 cases per 100.000 in 2012. S. aureus infection rates peaked during November in 2010, but the outbreak of severe S. aureus infections was the highest in January and October of 2012 (LACDoPH, 2012).

Summary and Conclusion

MRSA is one of the most prevalent and persistent infectious pathogens in the health care setting. Hand hygiene is the most important infection control practice in the health care setting that has an essential role in minimizing MRSA transmission and the occurrence of invasive MRSA infections (Kabbani et al., 2013). In this chapter, the comprehensive literature review included analyzing TDF related to the health-related behaviors of health care workers, patients, and patients' visitors to assess the need for more comprehensive health education to prevent the transmission of MRSA in the hospital setting. Having adequate knowledge, the appropriate resources, and the most effective infection control and prevention measures will decrease the incidence of MRSA infections (Evans et al., 2014). In Chapter 3, I describe the research design and methodology connected to the RQs, variables, target population, sampling inclusion and exclusion criteria and ethical consideration of the research.

Chapter 3: Research Method

Introduction

The purpose of this quantitative, retrospective cohort study was to investigate MRSA infection rates among Los Angeles County's eight SPAs. I assessed the demographic composition of each SPA to make inferences about the possible role of race and ethnicity in MRSA infections. Specifically, I provided descriptive statistics of the demographic features of each SPA in Los Angeles County. Next, I looked for a possible association between invasive HA-MRSA infections and length of hospitalization in each of the eight SPAs in Los Angeles County. Finally, I assessed differences in the rate of invasive MRSA among Los Angeles County's eight SPAs; I then used the demographic information for each SPA to make inferences about the possible role of race and ethnicity in MRSA infections. In Chapter 3, I explain the research design and method, and I discuss the ways in which I answered the RQs. Chapter 3 also includes details about the sample selection and size, eligibility criteria, secondary data collection and approval processes, and ethical considerations.

Research Design and Methodology

A quantitative, retrospective cohort study was appropriate to investigate MRSA acquisition among the eight SPAs in Los Angeles County. Nelson et al. (2015) stated that a retrospective cohort study on a large data set is effective to conduct a proper analysis of historical data. The reported infection control surveillance data were on a microbe and its antibiotic susceptibility (Nelson et al., 2015). Byrd et al. (2009) found that using secondary data from a health service organization can help to determine MRSA and

MSSA-associated infections and diagnoses among the selected racial or ethnic groups. These data also provided demographic information and time periods for comparison. An observational, prospective cohort, interventional study design was not a proper approach to analyze secondary data because of the difficulty in setting up baseline and follow-up periods (Medeiros et al., 2015). Reviewing a variety of research designs and methods can create a pathway to increase the possibility to find answers to the proposed RQs.

I obtained the secondary data from the CADoPH-HAI Program to identify HAIs reported between 2011 and 2013 in Los Angeles County. I used historical data to (a) test the possible association between invasive HA-MRSA infections and length of hospitalization and (b) assess differences in invasive MRSA cases among Los Angeles County's eight SPAs. Time and resource constraints include not having access to all variables, something that could have impeded the proper analysis and evaluation of the data.

Description of the Target Population

The data in this retrospective study were from male and female patients older than 18 years of age who were admitted to hospitals in Los Angeles County with MRSA infections between 2011 and 2013. Because of federal privacy regulations, no identifying information on the patients was available. The data reported were not on individual patient data, but rather, aggregate information by health care facility each year (i.e., rate count of MRSA infection for each facility).

Sampling Inclusion and Exclusion Criteria

To be included in the reported rate counts, criteria stipulate that at some time between 2011 and 2013, the participants had to be older than 18 years of age, had to have laboratory-confirmed and reported positive MRSA nasal cultures or laboratory-confirmed and reported positive extranasal cultures, were hospitalized, had to have HA-MRSA infection, and were residents of one of Los Angeles County's eight SPAs. Exclusion criteria were younger than 18 years of age and laboratory-confirmed and reported CA-MRSA infection. Laboratory-confirmed MRSA cases are reported by infection prevention practitioners to the National Healthcare Safety Network and the CADoPH. Gaining access to the data set required permission from the CADoPH.

Data Analysis Plan

Descriptive Statistics of Population

The first part of the data analysis plan was to obtain and present the descriptive demographic composition of each SPA in Los Angeles County between 2011 and 2013.

Research Question 1

I developed RQ1 to determine a possible association between invasive HA-MRSA infections and length of hospitalization in each of Los Angeles County's eight SPAs (see Table 1).

RQ1: Is there an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs?

H_{01}: There is no association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs.

H_{a1}: There is an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs.

Table 1

RQ1 Variables

Variable type	Name of variable	Definition
DV	HA-MRSA infection rate	Development of HA-MRSA infection between 2011 and 2013
IV	Length of hospitalization	How long patient stayed in hospital

To assess RQ1, I conducted a Pearson correlation analysis between infection rate and length of hospitalization for each of the eight SPAs in Los Angeles County. This analysis allowed me to assess whether increased hospital stays are related to increased rates of infection and whether this association is stronger in certain demographic areas.

Research Question 2

I developed RQ2 to investigate whether there is an increased incidence rate of MRSA infection during hospitalization among the eight SPAs in Los Angeles County. I tested the null and alternate hypotheses for RQ2 to examine whether there is an increased or a decreased incidence of MRSA infection during hospitalization among Los Angeles County's eight SPAs (see Table 2).

RQ2: Is there a difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs ?

H_{02}: There is no significant difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs.

H_{a2}: There is a significant difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs.

Table 2

RQ2 Variables

Variable type	Name of variable	Definition
DV	MRSA infection rate	Development of MRSA infection between 2011 and 2013
IV	SPA categorization	Demographic area of infection in Los Angeles County categorized by SPA (1-8)

To assess RQ2, I conducted a one-way ANOVA on the infection rate data, with SPA as the between-subjects factor. If the analysis indicated a significant overall difference, I conducted post hoc tests to determine which SPAs are significantly different from the others on MRSA infection rates. I presented descriptive statistics to articulate these differences.

Using the demographic data for each SPA presented in the first stage of the analysis allowed me to make inferences about the possible relationship between MRSA infection rates and certain racial and ethnic groups. Because of patient privacy restrictions, data on actual patients' race and ethnicity were not available, prohibiting a direct comparison. However, examining the demographic composition of each SPA in Los Angeles County and the infection rates in those eight SPAs allowed me to make an indirect comparison between race and ethnicity and MRSA infection rates.

Sample Size

I used annual morbidity data sets from 2011 to 2013 from the CADoPH-HAI's Program. I used secondary data to identify laboratory-confirmed MRSA infections. In standard research, determining the most appropriate sample size depends on the study design, desired power, and alpha. Estimating the sample size is based upon the least 80% power. However, in this study, I examined rate count data based upon the number of

reporting health care facilities. Thus, the number of hospitals in Los Angeles County determined my sample size, making a sample size calculation irrelevant to this design. There are approximately 100 hospitals in Los Angeles County, so across the 3 years that were sampled (2011-2013), I anticipated a total of 300 data points. There were no anticipated issues with internal validity because I did not collect the data. The only possible problem with external validity could have been geographical limitation, which might have threatened generalizability and reproductivity (reliability) because the results might have been different in other counties or other parts of United States.

Ethical Procedures

I submitted my study proposal to Walden University's Institutional Review Board (IRB) for approval. After gaining approval from the IRB to conduct the study (IRB approval #10-21-15-0131857), I obtained access to the annual morbidity data sets from the CADoPH-HAI Program. I saved the secondary data set on a USB drive and stored them in a locked safe. Five years after the study is completed and published, I will delete all data and electronic files, and I will destroy all print documentation. I will apply the general ethical considerations of confidentiality, respect, beneficence, and justice to the study. No informed consent was required to analyze secondary data. Assessing the data set required permission only from the CADoPH.

Summary

I designed this quantitative, retrospective cohort study to (a) test the possible association between invasive HA-MRSA infections and length of hospitalization and

(b) assess differences in invasive MRSA cases among Los Angeles County's eight SPAs. I used this information to make indirect inferences about the possible relationship between MRSA infection and racial and ethnic groups. I used laboratory-confirmed MRSA cases to understand the patterns and risk factors of infections. For RQ1, I conducted a Pearson correlation analysis, and for RQ2, I conducted a one-way ANOVA with post hoc tests. Included in Chapter 4 is a detailed analysis of the secondary data and the findings derived from the analysis.

Data Management

I obtained population demographic data from 2014 from the LACDoPH. I obtained data on HA-MRSA infection count and rates from Los Angeles County hospitals for the 2011, 2012, and 2013 calendar years. I used the hospital facility name to categorize each case into an SPA, and I compiled the data from the 3 years into a single file. I then transferred the data to SPSS v.21 for analysis. I removed cases with missing data, including those in which the SPA could not be identified, prior to conducting the analysis.

Chapter 4: Results

Introduction

The purpose of this quantitative study was to investigate MRSA infections among different racial groups in Los Angeles County's eight SPAs. The major focus of the study was to test the possible association between invasive HA-MRSA infections and length of hospitalization and investigate whether there is an increased incidence rate of MRSA infection during hospitalization among the eight SPAs in Los Angeles County.

In RQ1, the DV was invasive HA-MRSA infection rate, and the IV was length of hospitalization. In RQ2, the DV was MRSA infection rate, and the IV was SPA categorization. Because of patient privacy restrictions, data on actual patients' race and ethnicity were not available, so I could not make this comparison directly. However, examining the demographic composition of each SPA in Los Angeles County as well as the infection rates in those SPAs allowed me to make an indirect comparison between race and ethnicity and MRSA infection incidents.

I obtained population demographic data for 2014 from the LACDoPH. I obtained the data on HA-MRSA infection counts and rates from Los Angeles County hospitals for the 2011, 2012, and 2013 calendar years. The name of each facility was used to categorize each case into an SPA, and data from the 3 years were compiled into a single file. I then transferred the data into SPSS v.21 for analysis. I removed cases with missing data, including those in which the SPA could not be identified, prior to analysis.

Descriptive Statistics

Los Angeles County has eight SPAs. SPA1 is the Antelope Valley and serves the communities of Acton, Agua Dulce, Gorman, Lake Hughes, Lake Los Angeles, Lancaster, Littlerock, Palmdale, and Quartz Hill. SPA2 is the San Fernando Valley and serves the communities of Burbank, Calabasas, Canoga Park, Canyon Country, Encino, Glendale, La Cañada-Flintridge, San Fernando, Sherman Oaks, Sun Valley, Van Nuys, and Woodland Hills. SPA3 is the San Gabriel Valley and serves the communities of Alhambra, Altadena, Arcadia, Azusa, Baldwin Park, Claremont, Covina, Diamond Bar, Duarte, El Monte, Glendora, Irwindale, Monrovia, Monterey Park, Pasadena, Pomona, San Dimas, San Gabriel, San Marino, Temple City, Walnut, and West Covina. SPA4 is Metro LA and serves the communities of Boyle Heights, Central City, Downtown LA, Echo Park, El Sereno, Hollywood, Mid-City Wilshire, Monterey Hills, Mount Washington, Silverlake, West Hollywood, and Westlake. SPA5 is the West and serves the communities of Beverly Hills, Brentwood, Culver City, Malibu, Pacific Palisades, Playa del Rey, Santa Monica, and Venice. SPA6 is the south and serves the communities of Athens, Compton, Crenshaw, Florence, Hyde Park, Lynwood, Paramount, and Watts. SPA7 is the east and serves the communities of Artesia, Bell, Bellflower, Bell Gardens, Cerritos, City of Commerce, City Terrace, Cudahy, Downey, East Los Angeles, Hawaiian Gardens, Huntington Park, La Habra Heights, Lakewood, La Mirada, Los Nietos, Maywood, Montebello, Norwalk, Pico Rivera, Santa Fe Springs, Signal Hill, South Gate, Vernon, Walnut Park, and Whittier. SPA8 is South Bay and serves the communities of Athens, Avalon, Carson, Catalina Island, El Segundo, Gardena, Harbor

City, Hawthorne, Inglewood, Lawndale, Lennox, Long Beach, Hermosa Beach, Manhattan Beach, Palos Verdes Estates, Rancho Dominguez, Rancho Palos Verdes, Redondo Beach, Rolling Hills, Rolling Hills Estates, San Pedro, and Wilmington. A list of hospitals in each SPA is presented in Table 3.

Table 3

Hospitals and Medical Facilities in Each SPA

SPA	Hospitals/Medical facilities
SPA1	Antelope Valley Hospital Medical Center, Palmdale Regional Medical Center/Lancaster Community Hospital
SPA2	Encino Hospital Medical Center, Glendale Adventist, Medical Center, Glendale Memorial Hospital, Henry Mayo Newhall Memorial Hospital, Kaiser Permanente - Woodland Hills, Kaiser Permanente Hospital - Panorama City, Mission Community Hospital, Los Angeles Co Olive View-UCLA Medical Center - Sylmar, Motion Picture & Television Hospital, Northridge Hospital Medical Center, Olive View - UCLA Medical Center, Pacifica Hospital of the Valley, Providence Holy Cross Medical Center, Providence Saint Joseph Medical Center, Providence Tarzana Regional Medical Centers, Sherman Oaks Hospital, Southern California Hospital at Hollywood, USC Verdugo Hills Hospital, Valley Presbyterian Hospital, West Hills Hospital and Medical Center
SPA3	Alhambra Hospital Medical Center, Casa Colina Hospital, Citrus Valley Medical Center-Intercommunity Campus, Citrus Valley Medical Center-Queen of the Valley, City of Hope National Medical Center, Doctor's Hospital of West Covina, East Valley Hospital Medical Center - Glendora, Foothill Presbyterian Hospital, Garfield Medical Center, Glendora Community Hospital, Greater El Monte Community Hospital, Huntington Memorial Hospital, Kaiser Permanente Baldwin Park Medical Center, Kindred Hospital of Baldwin Park, Kindred Hospital San Gabriel Valley, Lanterman Developmental State Hospital, Methodist Hospital of Southern California, Monrovia Memorial Hospital, Monterey Park Hospital, Pomona Valley Hospital Medical Center, San Dimas Community Hospital, San Gabriel Valley Medical Center
SPA4	Barlow Respiratory Hospital, California Hospital Medical Center, Cedars Sinai Medical Center, Children's Hospital Los Angeles, Good Samaritan Hospital, Hollywood Community Hospital of Hollywood, Hollywood Presbyterian MC, Kaiser Foundation Hospital - Sunset - Los Angeles, Kaiser Permanente Los Angeles Medical Center, Keck Hospital of USC, LAC+USC Medical Center, Los Angeles Metropolitan Medical Center, Miracle Mile Medical Center, Olympia Medical Center, Pacific Alliance MC, Promise Hospital of East LA – East LA Campus, Saint Vincent Medical Center, Shriners Hospital for Children, Silver Lake Medical Center, USC Norris Cancer Hospital, Temple Community Hospital - Los Angeles, White Memorial Medical Center
SPA5	Alta Los Angeles Hospitals, Inc. – Santa Monica, Brotman Medical Center – Culver City, Kaiser Permanente West LA, Kindred Hospital- Los Angeles, Providence Saint John's Health

Table 3 Cont'd

SPA	Hospitals/Medical facilities
	Center, Ronald Reagan UCLA Medical Center, Santa Monica-UCLA MC and Orthopedic Hospital, Saint John's Health Center - Santa Monica, Southern California Hospital at Culver City, VA West LA Medical Center
SPA6	Saint Francis Medical Center
SPA7	Bellflower Medical Center, Beverly Hospital, Coast Plaza Doctors Hospital, Community Hospital of Huntington Park, Downey Regional Medical Center, East Los Angeles Doctors Hospital, Gardens Regional Medical Center, Kaiser Permanente – Downey, Kindred Hospital - La Mirada, Lakewood Regional Medical Center, Los Angeles Community Hospital, Norwalk Community Hospital, PIH Health Hospital – Downey, PIH Health Hospital – Whittier, Promise Hospital of East LA - Suburban Campus, Rancho Los Amigos National Rehabilitation Center, Tri-City Regional Medical Center - Hawaiian Gardens, Whittier Hospital Medical Center
SPA8	Catalina Island Medical Center, Centinela Hospital Medical Center, College Medical Center, Community Hospital of Long Beach, Harbor - UCLA Medical Center, Kaiser Permanente Hospital-South Bay Medical Center, Kindred Hospital South Bay, LAC/Harbor-UCLA Medical Center - Torrance, Long Beach Memorial Medical Center, Marina Del Rey Hospital, Memorial Hospital of Gardena, Miller Children's Hospital, Providence Little Company of Mary Medical Center – Torrance, Providence Little Company of Mary Medical Center-San Pedro, Saint Mary Medical Center, Torrance Memorial Medical Center, Veterans Affair Medical Center- Long Beach

I obtained population data for 2014 for the eight SPAs. The total population for LA County is just over 10 million residents. In SPA1, the total population is 392,730. The majority of residents in SPA1 are Hispanic American (44.6%). The proportion of European American residents in SPA1 is 34.8%. Approximately 16% of the population is African American, and 3.8% is Asian American. Very few residents are classified as American Indian or Alaskan Native (0.4%) or Native Hawaiian/Pacific Islander (0.2%).

In SPA2, most residents are European American (44.8%) or Hispanic American (39.9%). Approximately 11.5% of the population is Asian American. African Americans, American Indians or Alaskan Natives, and Native Hawaiian/Pacific Islanders comprise a relatively small proportion of the population in this SPA (< 4%).

SPA3 is predominantly Hispanic American (46.1%), followed by Asian American (28.6%). European American residents comprise 21.3% of the population, and African

Americans, American Indians or Alaskan Natives, and Native Hawaiian/Pacific Islanders account for less than 4% of the population in SPA3.

More than half of the residents in SPA4 are Hispanic American (51.7%). European American residents made up 24.8% of the population, and Asian American residents account for 17.9%. The African American population in SPA4 is just over 5%, and American Indian or Alaskan Natives and Native Hawaiian/Pacific Islanders account for less than 1% of the population.

In SPA5, the vast majority of residents are European American (64.0%). Hispanic Americans comprise the second largest group at 16.0%, followed by Asian Americans (13.8%) and African Americans (5.8%). American Indians or Alaskan Natives, and Native Hawaiian/Pacific Islanders account for less than 1% of the population in SPA5.

In SPA6, the majority of residents are Hispanic American (67.7%). African American residents account for 27.8% of the population; European American residents comprise only 2.4% of the population. Asian Americans, American Indians or Alaskan Natives, and Native Hawaiian/Pacific Islanders account for less than 2% of the population in SPA6.

Hispanic Americans account for the majority of the population in SPA7 (73.3%). European American residents made up 14.2% of the population, and Asian American residents comprise 9.0% of the population. African American residents account for 3.0% of the population in SPA7, and American Indians or Alaskan Natives and Native Hawaiian/Pacific Islanders account for less than 1% of the population.

In SPA8, 40.1% of the population is Hispanic American, and 28.6% is European American. Asian American residents made up 15.4% of the population, and African American residents comprise 14.9% of the population. American Indians or Alaskan Natives, and Native Hawaiian/Pacific Islanders account for approximately 1% of the population in SPA8. The race/ethnicity of the population by SPA is presented in Table 4.

Table 4

Population in LA County by Ethnicity and SPA

Ethnicity	SPA1		SPA2		SPA3		SPA4		SPA5		SPA6		SPA7		SPA8	
	n	%	*n*	%	*n*	%	*N*	%	*n*	%	*n*	%	*n*	%	*n*	%
European American	136,642	34.79	981,226	44.80	380,072	21.32	285,133	24.80	417,621	64.04	25,295	2.45	185,709	14.15	444,818	28.60
African American	63,624	16.20	78,517	3.58	66,601	3.74	61,667	5.36	37,816	5.80	287,767	27.84	40,153	3.06	231,212	14.87
AIAN	1,639	0.42	4,062	0.19	3,120	0.17	2,164	0.19	1,006	0.15	1,541	0.15	2,819	0.21	3,703	0.24
Asian American	14,974	3.81	251,550	11.48	509,181	28.56	205,478	17.87	90,096	13.82	17,181	1.66	118,385	9.02	238,892	15.36
NHOPI	645	0.16	2,116	0.10	1,849	0.10	851	0.07	987	0.15	1,981	0.19	2,888	0.22	13,316	0.86
Hispanic American	175,206	44.61	872,920	39.85	822,218	46.11	594,398	51.70	104,634	16.04	699,907	67.71	962,061	73.33	623,395	40.08
Total	392,730		2,190,391		1,783,041		1,149,691		652,160		1,033,672		1,312,015		1,555,336	

Note. AIAN = American Indian or Alaskan Native; NHOPI = Native Hawaiian or Other Pacific Islander.

Research Question 1

Is there an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs? To assess RQ1, I conducted a Pearson correlation analysis between the length of hospitalization and infection rate across all facilities in Los Angeles County. The results showed no relationship between the variables, r (271) = .06, p = .314. This finding suggests that an increase in the length of time patients stayed in the hospital did not affect the rate of HA-MRSA infections. The results of this analysis are presented in Table 5.

Table 5

Pearson Correlation Between Length of Hospitalization and Infection Rate

Length of hospitalization	-
HA-MRSA infection rate	.06

*p < .05, **p < .01, ***p < .001

I conducted a second Pearson correlation analysis between length of hospitalization and HA-MRSA infection count across all facilities in Los Angeles County. In this case, the results were statistically significant, r (271) = .73, p < .001, indicating a strong positive relationship between the variables. This finding suggests that as the length of hospitalization increased, the number of HA-MRSA cases also increased. These results are presented in Table 6.

Table 6

Pearson Correlation Between Length of Hospitalization and Infection Count

Length of hospitalization	-
HA-MRSA infection count	.73***

*p < .05, **p < .01, ***p < .001

Research Question 2

Is there a difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs? To assess RQ2, I conducted a one-way ANOVA to test for differences in HA-MRSA infection rate by SPA. In a preliminary analysis, the assumption of normality was assessed with a Shapiro-Wilk test. The results of the test were significant, $p < .001$, violating the assumption. However, Howell (2010) suggested that the ANOVA is robust, despite violations of normality, in cases with large sample sizes (> 50).

The assumption of equality of variance was assessed with Levene's test. Results of the test were not significant, $p = .519$, indicating that the assumption was met. The results of the ANOVA were not significant, $F(7, 250) = 1.22$, $p = .293$, $\eta^2_p = .03$, indicating that there was no difference in MRSA infection rate by SPA. Because there was no statistical significance, I did not conduct post hoc comparisons. Results of the ANOVA are presented in Table 7. Means and standard deviations are presented in Table 8.

Table 7

Results of ANOVA for Infection Rate by SPA

Source	*SS*	*df*	*MS*	*F*	*p*	η^2_p
SPA	5.29	7	0.76	1.22	.293	.03
Error	155.21	250	0.62			

Table 8

Means and Standard Deviations for Infection Rate by SPA

SPA	*M*	*SD*	*n*
1	0.74	0.33	6
2	0.80	0.76	55
3	0.55	0.84	50
4	0.80	0.82	57
5	1.13	0.96	17
6	0.83	0.32	3
7	0.79	0.89	36
8	0.62	0.51	34

I conducted the same analysis with HA-MRSA infection count as the DV. In a preliminary analysis, the assumption of normality was assessed with a Shapiro-Wilk test. The results of the test were significant, $p < .001$, violating the assumption. The assumption of equality of variance was assessed with Levene's test. The results of the test were significant, $p = .018$, also violating this assumption. However, as Howell (2010) and Stevens (2009) suggested, the ANOVA is a robust statistic, despite violations of assumptions.

The results of the ANOVA were significant, $F(7, 263) = 3.75$, $p < .001$, $\eta^2_p = .09$, indicating a difference in HA-MRSA infection count by SPA. The size of the effect ($\eta^2_p = .09$) was moderate. To determine which groups were significantly different from each other, I conducted post hoc comparisons using the Tukey procedure to control for family-wise error rate. The infection count in SPA5 was significantly higher than the infection count in SPA3 ($p = .003$), SPA7 ($p = .008$), and SPA8 ($p = .050$). In addition, the infection count in SPA4 was higher than the infection count in SPA3 ($p = .053$). No other groups were significantly different from each other. The results of the ANOVA are

presented in Table 9. The means and standard deviations for infection count by SPA are presented in Table 10. Figure 1 provides a visual depiction of these means.

Table 9

Results of ANOVA for Infection Count by SPA

Source	*SS*	*df*	*MS*	*F*	*p*	η^2_p
SPA	335.88	7	47.98	3.75	.001	.09
Error	3,361.62	263	12.78			

Table 10

Means and Standard Deviations for Infection Count by SPA

SPA	*M*	*SD*	*n*
1	3.83	2.93	6
2	3.00	2.89	55
3	2.04	2.98	57
4	4.05	5.09	59
5	5.88	4.46	17
6	6.67	5.51	3
7	2.11	2.26	38
8	2.67	2.93	36

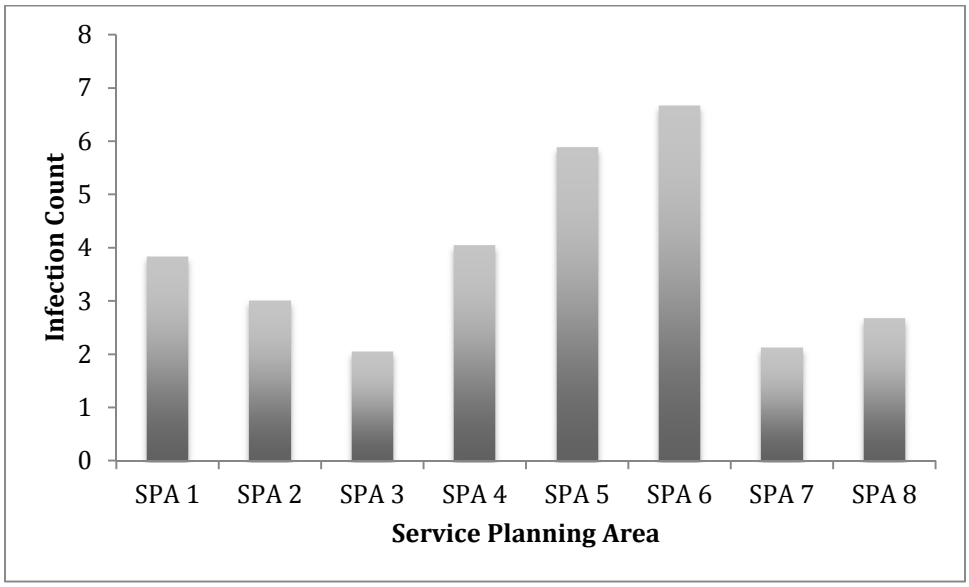

Figure 1. Infection count by service planning area.

Summary and Conclusions

The results of this study underscored several important points. First, although no relationship between length of hospitalization and HA-MRSA infection rate was found, a strong relationship between length of hospitalization and infection count was evident. This finding indicates that an increase in the amount of time that patients spent in the hospital was associated with an increase in the number of patients diagnosed with HA-MRSA.

Second, the results identified possible racial and ethnic disparities in HA-MRSA infection counts. SPA5, which had the highest percentage of European American residents (64%), also had one of the highest number of HA-MRSA infections, when compared to several of the other SPAs. Specifically, SPA5 had significantly more cases of HA-MRSA than SPA7, a predominately Hispanic American SPA (73%). SPA6 had the highest percentage of African American residents (28%) in comparison to the other SPAs, but this area was not significantly different from any other SPA in MRSA infection count. SPA3 had the highest percentage of Asian American residents (29%), but it also had a significantly lower infection count than both SPA4 (52% Hispanic American) and SPA5 (64% European American). SPA5 also had a significantly higher infection count than SPA 2 and SPA8, but given the relatively equal spread of racial and ethnic groups in these areas, it was difficult to draw any conclusions. SPA2 had an approximately even split between European American (44%) and Hispanic American (39%) residents, and SPA8, despite being predominately Hispanic American (40%), had

strong representation from the other major ethnic groups (European American, 29%; African American, 15%; Asian American, 15%).

It is important to note that even though SPA5 had the second smallest populations of the eight SPAs, results showed that it had one of the highest infection counts; SPA3 was the second largest SPA yet had the lowest infection count. These results were unlikely to be the result of population size. However, one key limitation was that because the American Indian/Alaskan Native and Native Hawaiian/Pacific Islander groups comprise such a small proportion of the population (< 1% in each SPA), it was impossible to make any inferences regarding HA-MRSA infection count in this population. These results, including limitations and implications, are discussed in Chapter 5.

Chapter 5: Discussions, Conclusions, and Recommendations

Introduction

The purpose of this quantitative, retrospective study was to examine whether invasive HA-MRSA infections were related to length of hospitalization in each of the eight SPAs in Los Angeles County. I also sought to make inferences about the possible role of race and ethnicity in MRSA infections. I performed a secondary analysis of data from the CADoPH's HAI Program, LACDoPH, and county hospitals for 2011 to 2013.

Results indicated that an increase in the length of time patients stayed in the hospital did not affect the rate of HA-MRSA infections. I conducted a second Pearson correlation analysis to examine the relationship between length of hospitalization and HA-MRSA infection count across all facilities in Los Angeles County. The results suggest that as the length of hospitalization increased, the number of HA-MRSA cases also increased. Elaborate.

In Chapter 5, I present the research findings and my interpretation of the findings. I provide detailed information about the study's limitations, discuss the implications for positive social change, and offer recommendation for further research.

Interpretation of the Findings

Research Question 1

RQ1: Is there an association between invasive HA-MRSA infections and length of hospitalization among Los Angeles County's eight SPAs? The results indicated no relationship between the variables, suggesting that an increase in the length of time patients stayed in the hospital did not affect the rate of HA-MRSA infections. I conducted

a second Pearson correlation analysis between length of hospitalization and HA-MRSA infection count across all facilities in Los Angeles County. In this case, the results were statistically significant; the variables had a strong positive relationship. The results showed that as the length of hospitalization increased, the number of HA-MRSA cases also increased. Per this finding, I rejected my Null Hypothesis 1 in favor of Alternate Hypothesis 1.

Tehrani et al. (2014) conducted a retrospective cohort study in 323 California acute care hospitals for 2009-2010. They found a significant association between HA-MRSA and length of hospitalization. There was a median 16 (range = 0-102) HA-MRSA infections per 10,000 admissions. The median 3- to 4-day hospital stay of the total of 5,530,181 hospitalizations in 323 California hospitals for the 2-year period was 41.8 (range = 38.2- 45.1; Tehrani et al., 2014). The results were significant because Tehrani et al. found a 20-40% increase in the incidence rate of invasive HA-MRSA infections among patients who had been diagnosed with HAP, VAP, and HCAP. Consequently, the number of days that patients spent in the hospital also had increased (Rubenstein et al., 2008). My results were different from those of Tehrani et al. I found no relationship between invasive HA-MRSA infections and length of hospitalization in each of Los Angeles County's eight SPAs. The disparity between Tehrani et al.'s study and my study indicated that further research is needed to confirm or deny the findings of either of these studies.

Research Question 2

RQ2: Is there a difference in the incidence of MRSA infection during hospitalization between Los Angeles County's eight SPAs? To assess RQ2, I conducted a one-way ANOVA to test for differences in HA-MRSA infection rates by SPA. In a preliminary analysis, the assumption of normality was assessed with a Shapiro-Wilk test. The results of the test were significant, thus violating the assumption. However, Howell (2010) suggested that ANOVA is robust despite violations of normality in cases of large sample sizes (e.g., > 50). The assumption of equality of variance was assessed with Levene's test. Results of the test were not significant, indicating that the assumption was met. The results of the ANOVA were not significant, suggesting that MRSA infection rate was not different by SPA. Because I did not find any statistical significance, I did not conduct post hoc comparisons.

I conducted the same analysis with HA-MRSA infection count as the DV. The results of the ANOVA were significant, indicating that HA-MRSA infection count differed by SPA. The size of the effect was moderate. To determine which groups were significantly different from one other, I conducted post hoc comparisons using the Tukey procedure to control for family-wise error rate. The infection count in SPA5 was significantly higher than the infection count in SPA 3, SPA7, and SPA8. In addition, the infection count in SPA4 was higher than the infection count in SPA3. No other groups were significantly different from one other. In this case, the results were statistically significant, indicating a strong positive relationship between the variables and a

difference in HA-MRSA infection count by SPA. As such, I rejected Null Hypothesis 2 in favor of Alternate Hypothesis 2.

Cosgrove et al. (2003) determined that invasive MRSA bacteremia can increase mortality rates, lengthen hospital stays, and increase health care costs. Patients who have been diagnosed with invasive MRSA bacteremia are at high risk of lethality compared to patients who are only suspectible of methicillin. The results of Cosgrove et al.'s (2003) study suggested that the patients who had central line-associated S. aureus infection had a lower mortality rate than patients who had central line-associated infections related to different microbes. Cosgrove et al. (2003) confirmed that MRSA infections are an emerging problem in the hospital setting, making it essential to adhere strictly to infection prevention guidelines and appropriate antibiotic use.

Nelson et al. (2015) stated that hospital-associated MRSA infections increase the risk of death during hospital stays as well as after discharge. The consequences of hospital-associated MRSA colonization and infection are recurrent infections; long-term disabilities (e.g., ventilator dependence); and long-term risk of morbidity. It is essential to implement clinical programs and interventions to reduce the rates of MRSA colonization and spread to improve health outcomes.

Patients with laboratory-confirmed positive nasal cultures are at risk of invasive MRSA infections such as SSTIs, pneumonia, central line-associated bloodstream infections, catheter-associated UTIs, and SSIs (Heyman, 2008; Stenehjem & Rimland, 2013). Squier et al. (2002) stated that positive MRSA nasal and extranasal cultures versus only positive nasal swabs double the risk of the development of severe MRSA infection.

Glick et al. (2014) found that universal MRSA nasal screening can decrease the number of hospital-associated MRSA infections.

In Los Angeles County's eight SPAs, African Americans and European Americans had the highest rates of severe S. aureus infections at 0.5 cases per 100,000 and 0.4 cases per 100,000, respectively, in 2008. Hispanic Americans had the lowest rate of severe S. aureus infections at 0.1 cases per 100,000 (LACDoPH, 2012). Rimawi et al. (2014) identified racial and ethnic disparities in MRSA infections. They found that the African American patients whom they studied had the highest incidence rates of MRSA infections; the lowest rates were among Hispanic Americans. Although Rimawi et al. analyzed demographic data of MRSA infections, they did not offer a viable solution to bridge racial and ethnic disparities in such infections.

Limitations of the Study

One of the major limitations of my study was the use of secondary data collected by infection prevention practitioners in Los Angeles County's eight SPAs. Using laboratory-confirmed cases of secondary data limited the generalization of the concept of culturally specific infection prevention measures in the health care setting in Los Angeles. The limitations also included the unavailability of data on racial and ethnic groups' health-related behaviors due to patient privacy restrictions, which prohibited direct comparison, extraneous data, demographic scope of data, and geographic limitation (data only from one county).

Implications for Social Change

The intent of this quantitative study was to investigate the reasons for the racial and ethnic disparities in MRSA infection rates in Los Angeles County's eight SPAs in an attempt to address areas of culturally sensitive infection prevention and health education programs and protocols so that changes or improvements can be made to programs in hospitals in Los Angeles. The results might be useful in providing information about the clinical problems associated with preventing infection and offering practical ways to decrease the prevalence of infectious diseases among different racial and ethnic groups in the health care setting. The literature has lacked evidence regarding the ways in which infection prevention and health education units address culturally sensitive infection prevention education, thus showing the need for evidence-based practice. This study has the potential to fill this gap in knowledge.

This study also has the potential to advance practice and knowledge by providing public health practitioners with new ideas to design and implement culturally sensitive educational activities, including social marketing; webinars; and presentation programs in community health education centers, churches; and health fairs about infection control and prevention for different racial or ethnic groups that can prevent S. aureus and MRSA infections in the hospital setting in Los Angeles County's eight SPAs. The results can be useful in the development of culturally sensitive infection prevention guidelines, and they can influence policy decisions on ways to improve health outcomes and infection prevention compliance rates among different racial and ethnic groups, thereby promoting positive social change.

Recommendations

This quantitative, retrospective study was essential to investigate the reasons for the racial and ethnic disparities in MRSA infection rates in Los Angeles County's eight SPAs by (a) evaluating a possible association between invasive HA-MRSA infections and length of hospitalization in the eight SPAs, and (b) investigating whether there is an increased incidence rate of MRSA infection during hospitalization among the eight SPAs by performing a demographic comparison. Further qualitative ethnographic studies can use interviews and surveys to obtain primary data identifying racial and ethnic behaviors related to hospitalization, infection prevention, and health education. These studies could help researchers to describe and understand the health behaviors of the people being studies while also critiquing and supporting the transformations of the studied communities.

The results of this study might help to reduce the gap in knowledge directly related to culturally sensitive infection prevention guidelines and the health education of infectious diseases. The limitations of the study can be investigated further by using this conceptual knowledge as a basic of research of infection prevention. Identifying MRSA infection rates, length of hospitalization, and demographic information about patients can help public health professionals and infection prevention practitioners to plan, develop, and design racially and ethnically sensitive infection prevention guidelines, preventive measures, and health education training and materials to improve health outcomes and decrease MRSA infection rates among patients, patients' visitors, and health care professionals.

The formulation and implementation of culturally sensitive infection prevention guidelines and health education training might improve health prevention compliance rates among different racial and ethnic groups. Ethnographic research on different racial and ethnic groups might be useful in identifying ways to prevent and deal with invasive and contagious infectious diseases at home and in various health care settings. Infection prevention practitioners, with the help of hospital health educators, might consider creating an innovative learning tool for health care professionals, patients, and patients' visitors to promote innovative thinking about infection prevention strategies.

The findings might influence policymaking and health education programs to apply the new knowledge to improve health outcomes in the health care setting. Improving the success of newly designed, culturally sensitive infection prevention guidelines requires ongoing evaluations by administrators. MRSA infections are a serious threat in the health care setting, so it is important to address this public health issue quickly.

Conclusion

MRSA infections have emerged as a public health threat to the population. It is essential to develop and design culturally sensitive infection prevention guidelines to ensure that health care professionals, patients, and patients' visitors become competent in preventing the spread of infectious diseases. Infection prevention practitioners and health educators must work to improve the success of culturally sensitive infection prevention programs. By conducting this quantitative study, I sought to find practical clinical solutions to decrease the prevalence of infectious diseases among the different racial and

ethnic groups in the eight SPAs of Los Angeles County. The results will help to fill the gap in the literature on the need for culturally sensitive infection prevention programs. Education, research, and evidence-based practice can improve the health outcomes of the population and prevent the spread of infectious diseases.

References

Antimicrobe. (2014). Methicillin. Retrieved from http://www.antimicrobe.org/

Ardizzone, L. L., Smolowitz, J., Kline, N., Thom, B., & Larson, E. L. (2013). Patient hand hygiene practices in surgical patients. *American Journal of Infection Control, 41*(6), 487-491. http://dx.doi.org/10.1016/j.ajic.2012.05.029

Baddour, L. M., Epstein, A. E., Erickson, C. C., Knight, B. P., Levison, M. E., Lockhart, P. B., … Taubert, K. A. (2010). Update on cardiovascular implantable electronic device infections and their management: A scientific statement from the American Heart Association. *Circulation, 121*(3), 458-477. doi:10.1161/CIRCULATIONAHA.109.192665

Bakullari, A., Metersky, M. L., Wang, Y., Eldridge, N., Eckenrode, S., Pandolfi, M. M., … Moy, E. (2014). Racial and ethnic disparities in healthcare-associated infections in the United States, 2009-2011. *Infection Control and Hospital Epidemiology, 35*(S3), S10-S16. doi:10.1086/677827

Barber, M. (1961). Methicillin-resistant staphylococci. *Journal of Clinical Pathology, 14,* 385-393. doi:10/1136/jcp.14.4.385

Blackpool Teaching Hospitals. (2012). *Methicillin-sensitive Staphylococcus aureus. Patient information leaflet.* Retrieved from http://www.bfwh.nhs.uk/visiting/patleaflets/leaflets/00006955%20Meticillin-%20Sensitive%20Staphylococcus%20aureus.pdf

Brooks, K. (2012). *Ready reference for microbes* (3rd ed.). Washington, DC: Association for Professionals in Infection Control and Epidemiology.

Byrd, K. K., Holman, R. C., Bruce, M. G., Hennessy, T. W., Wenger, J. D., Bruden, D. L., … Cheek, J. E. (2009). Methicillin-resistant Staphylococcus aureus-associated hospitalization among the American Indian and Alaska Native population. *Clinical Infectious Disease, 49*(7), 1009-1005. doi:10.1086/605560

California Department of Public Health. (2009). *Senate Bill No.1058.* Retrieved from http://www.cdph.ca.gov/services/boards/Documents/SB1058chaptered09_25_08.pdf

Calfee, D. P., Salgado, C. D., Milstone, A. M., Harris, A. D., Kuhar, D. T., Moody, J., … Yokoe, D. S. (2014). Strategies to prevent methicillin-resistant staphylococcus aureus transmission and infection in acute care hospitals: 2014 update. *Infection Control and Hospital Epidemiology, 35*(S2), S108-S132. http://dx.doi.org/10.1086/676534

Campos-Murguia, A., Leon-Lara, X., Munoz, J. M., Macias, A. E., & Alvarez, J. A. (2014). Stethoscopes as potential intrahospital carriers of pathogenic microorganisms. *American Journal of Infection Control, 42*(1), 82-83. http://dx.doi.org/10.1016/j.ajic.2013.06.015

Cane, J., O'Connor, D., & Michie, S. (2012). Validation of the theoretical domains framework for use in behaviour change and implementation research. *Implementation Science, 7*(37), 37-53. doi:10.1186/1748-5908-7-37

Centers for Disease Control and Prevention. (2012). *Active bacterial core surveillance (ABCs) report emerging infectious program network methicillin-resistant staphylococcus aureus, 2011.* Retrieved from http://www.cdc.gov/abcs/reports-findings/survreports/mrsa11.pdf

Centers for Disease Control and Prevention. (2013). Antibiotic resistance questions & answers. Retrieved from http://www.cdc.gov/

Centers for Disease Control and Prevention. (2014). Healthcare-associated infections. Retrieved from http://www.cdc.gov/

Chamis, A. L., Peterson, G. E., Cabell, C. H., Corey, G. R., Sorrentino, R. A., Greenfield, R. A., … Fowler, V. G. (2001). Staphylococcus aureus bacteremia in patients with permanent pacemakers or implantable cardiverter-defibrillator. *Circulation, 104*(9), 1029-1033. doi:10.1161/hc3401.095097

Chang, S., Sethi, A. K., Stiefel, U., Candnum, J. L., & Donskey, C. J. (2010). Occurrence of skin and environmental contamination with methicillin-resistant Staphylococcus aureus before results of polymerase chain reaction at hospital admission become available. *Infection Control Hospital Epidemiology, 31,* 607-612. Retrieved from www.shea-online.org

Chen, C. C., & Pass, S. E. (2013). Risk factors for and impact of methicillin-resistant Staphylococcus aureus nasal colonization in patients in a medical intensive care unit. Brief report. *American Journal of Infection Control, 41*(11), 1100-1101.

Copan. (2015). Sample collection: Nasal swab procedure. Retrieved from http://www.copanusa.com/

Cosgrove, S. E., Sakoulas, G., Perencevich, E. N., Schwaber, M. J., Karchmer, A. W., & Carmeli, Y. (2003). Comparison of mortality associated with methicillin-resistant and methicillin-susceptible staphylococcus aureus bacteremia: A meta-analysis. *Clinical Infectious Diseases, 36*(1), 53-59. doi:10.1086/345476. Retrieved from http://cid.oxfordjournals.org/

Custodio, H. T. (2015). Hospital-acquired infections. Retrieved from http://emedicine.medscape.com/

Dantes, R., Yi, M., Bellflower, R., Aragon, D., Dumyati, G., Harrison, L. H. … Fridkin, S. (2013). National burden of invasive methicillin-resistant staphylococcus aureus infections, United States. *Journal of the American Medical Association Internal Medicine, 173*(21), 1970-1978. doi:10.1001/jamainternmed.2013.10423

D'Antonio, N. N., Rihs, J. D., Stout, J. E., & Yu, V. L. (2013). Computer keyboard covers impregnated with a novel antimicrobial polymer significantly reduce microbial contamination. *American Journal of Infection Control, 41*(4), 337-339. http://dx.doi.org/10.1016/j.ajic.2012.03.030

Datta, R., Quan, V., Kim, D., Peterson, E. M., Reynolds, C., Meyers, H., … Huang, S. S. (2014). Protective effects of methicillin-susceptible staphylococcus aureus carriage against methicillin-resistant s. aureus acquisition in nursing homes: A prospective cross-sectional study. *Infection Control and Hospital Epidemiology, 35*(10), 1257-1262. doi:10.1088/678062

DeLeo, F. R., Otto, M., Kreiswirth, B. N., & Chambers, H. F. (2010). Community-associated methicillin-resistant Staphylococcus aureus. *Lancet, 375*(9725), 1557-1568. doi:10.1016/S0140-6736(09)61999-1

Drugs. (2015). Nallpen. Retrieved from http://www.drugs.com/

Eells, S. J., David, M. Z., Taylor, A., Ortiz, N., Kumar, N., Sieth, J., … Miller, R. G. (2014). Persistent environmental contamination with USA300 methicillin-resistant Staphylococcus aureus and other pathogenic strain types in household with S. aureus skin infections. *Infection Control and Hospital Epidemiology, 35*(11), 1373-1382. doi:10.1086/678414

Ellis, M. W., Schlett, C. D., Millar, E. V., Crawford, K. B., Cui, T., Lanier, J. B., … Tribble, D. R. (2014). Prevalence of nasal colonization and strain concordance in patients with community-associated staphylococcus aureus skin and soft-tissue infections. *Infection Control and Hospital Epidemiology, 35*(10), 1251-1256. doi:10.1086/678060

Engelbreacht, K., Ambroso, D., Sifuentes, L., Gerba, C., Weart, I., & Koenig, D. (2013). Decreased activity of commercially available disinfectants containing quaternary Ammonium compounds when exposed to cotton towels. *American Journal of Infection Control, 41*(10), 908-911. http://dx.doi.org/10.1016/j.ajic.2013.01.017

Epocrates. (2014). MRSA. Retrieved from https://online.epocrates.com/

Evans, M. E., Kralovic, S. M., Simbartl, L. A., Freyberg, R. W., Obrosky, D. S., Roselle, G. A., & Jain, R. (2014). Nationwide reduction of health care-associated methicillin-resistant Staphylococcus aureus infections in Veterans Affairs long-term care facilities. *American Journal of Infection Control, 42*(1), 60-62. http://dx.doi.org/10.1016/j.ajic.2013.06.004

Even, S., Charlier, C., Nouaille, S., Zakour, N. L. B., Cretenet, M., Cousin, F. J., … Le Loir, Y. L. (2009). Staphylococcus aureus virulence expression is impaired by Lactococcus lactis in mixed culture. *Applied and Environmental Microbiology, 75*(13), 44-59. doi:10.1128/AEM.02388-08

Francis, J. J., O'Connor, D., & Curran, J. (2012). Theories of behaviour change synthesized into a set of theoretical groupings: Introducing a thematic series on the theoretical domains framework. *Implementation Science, 7*(35). doi:10.1186/1748-5908-7-35

Free Dictionary. (2015). Carrier of infection. Retrieved from http://encyclopedia2.thefreedictionary.com/

Gladwin, M., & Trattler, B. (2007). *Clinical microbiology made ridiculously simple* (4th ed.). Miami, FL: MedMaster.

Glick, S. B., Samson, D. J., Huang, E. S., Vats, V., Aronson, N., & Weber, S. G. (2014). Screening for methicillin-resistant Staphylococcus aureus: A comparative effectiveness review. *American Journal of Infection Control, 42*(2), 148-155. http://dx.doi.org/10.1016/j.ajic.2013.07.020

Gold, K. M., & Hitchins, V. M. (2013). Cleaning assessment of disinfectant cleaning wipes on an external surface of a medical device contaminated with artificial blood or Streptococcus pneumoniae. *American Journal of Infection Control, 41*(10), 901-907. http://dx.doi.org/10.1016/j.ajic.2013.01.029

Gorwitz, R. J. (2008). A review of community-associated methicillin-resistant Staphylococcus aureus infection and soft tissue infections. *Pediatric Infectious Diseases Journal, 27*(1), 1-7. Retrieved from http://www.ncbi.nlm.nih.gov/

Gudnadottir, U., Fritz, J., Zerbel, S., Bernardo, A., Sethi, A. K., & Safdar, N. (2013). Reducing health-care associated infections: Patients want to be engaged and learn about infection prevention. *American Journal of Infection Control, 41*(11), 955-958. http://dx.doi.org/10.1016/j.ajic.2013.03.310

Halpin, H. A., McMenamin, S. B., Simon, L. P., Jacobsen, D., Vanneman, M., Shortell, S., & Milstein, A. (2013). Impact of participation in the California Healthcare-Associated Infection Prevention Initiative on adoption and implementation of evidence-based practices for patient safety and health care-associated infection rates in a cohort of acute care general hospitals. *American Journal of Infection Control, 41*(4), 307-311. http://dx.doi.org/10.1016/j.ajic.2012.04.322

Harbath, S., Sax, H., Fankhauser-Rodriguez, C., Schrenzel, J., Augustino, A., & Pittet, D. (2006). Evaluating the probability of previously unknown carriage of MRSA at hospitals admission. *American Journal of Medicine, 119,* 275. http://dx.doi.org/10.1016/j.amjmed.2005.04.042

Harrison, E. M., Weinert, L. A., Holden, M. T. G., Welch, J. J., Wilson, K., Morgan, F. J., … Holmes, M. A. (2014). A shared population of epidemic methicillin-resistant Staphylococcus aureus 15 circulates in humans and companion animals. *mBio, 5*(3), e00985-13. doi:10.1128/mBio.00985-13

Heimbuch, B. K., Kinney, K., Lumley, A. E., Harnish, D. A., Bergman, M., & Wander, J. D. (2014). Cleaning of filtering facepiece respirators contaminated with mucin and Staphylococcus aureus. *American Journal of Infection Control, 42*(3), 265-270. http://dx.doi.org/10.1016/j.ajic.2013.09.014

Heyman, D. L. (Ed.). (2008). *Control of communicable disease manual* (19th ed.). Washington, DC: American Public Health Association.

Howell, D. C. (2010). *Statistical methods for psychology* (7th ed.). Belmont CA: Wadsworth Cengage Learning.

Huang, S., Gombosev, A., Terpstra, L., Platt, R., Lankiewicz, J., Haffenreffer, K., …. Jernigan, J. (2013). *Universal ICU decolonization toolkit: An enhanced protocol* [Handout AHRQ Publication No. 13-0052-EF]. Prepared for Agency for Healthcare Research and Quality Rockville, MD., Centers for Disease Control and Prevention, Atlanta, GA.

Istenes, N., Bingham, J., Hazelett, S., Fleming, E., & Kirk, J. (2013). Patients' role in the transmission of health care-associated infections: Prevalence of contamination with bacterial pathogens and patients' attitudes toward hand hygiene. *American Journal of Infection Control, 41*(9), 793-798. http://dx.doi.org/10.1016/j.ajic.2012.11.012

Jenkins, T. C., Knepper, B. C., Moore, J., O'Leary, S. T., Caldwell, B., Saveli, C. C., … Burman, W. J. (2014). Antibiotic prescribing practice in a multicenter cohort of patients hospitalized for acute bacterial skin and skin structure infection. *Infection and Hospital Epidemiology, 35*(10), 1241-1250. doi:10.1086/678056

Jessee, M. A., & Mion, L. C. (2013). Is evidence guiding practice? Reported versus observed adherence to contact precautions: A pilot study. *American Journal of Infection Control, 41*(11), 965-970. http://dx.doi.org/10.1016/j.ajic.2013.05.005

Kabbani, D., Weir, S. K., Berg, G., Chien, G. C., Strymish, J., & Gupta, K. (2013). Cohorting based on nasal methicillin-resistant Staphylococcus aureus status: An opportunity to share more than a room. *American Journal of Infection Control, 41*(5), 401-404. http://dx.doi.org/10.1016/j.ajic.2012.10.015

Kiedrowski, L. M., Perisetti, A., Loock, M. H., Kaaitsa, M. L., & Guerrero, D. M. (2013). Disinfection of iPad to reduce contamination with Clostridium difficile and methicillin-resistant Staphylococcus aureus. *American Journal of Infection Control, 41*(11), 1136-1137. http://dx.doi.org/10.1016/j.ajic.2013.01.030

Kjonegaard, R., Fields, W., & Peddecord, K. M. (2013). Universal rapid screening for methicillin-resistant Staphylococcus aureus in the intensive care units in large community hospitals. *American Journal of Infection Control, 41*(1), 45-50. http://dx.doi.org/10.1016/j.ajic.2012.01.038

Klein, E., Smith, D. L., & Laxminarayan, R. (2007). Hospitalizations and deaths caused by methicillin-resistant Staphylococcus aureus, United States, 1999-2005. *Emerging Infectious Disease, 13,* 1840-1846. Retrieved from ww.ncbi.nlm.nih.gov/

Klein, E., Sun, L., Smith, D. L., & Laxminarayan, R. (2013). The changing epidemiology of methicillin-resistant staphylococcus aureus in the United States: A national observational study. *American Journal of Epidemiology, 177*(7), 666-674. doi:10.1093/aje/kws273

Klevens, R. M., Morrison, M. A., Nadle, J., Petit, S., Gershman, K., Ray, S., … Fridkin, S. K. (2007). Invasive methicillin-resistant staphylococcus aureus infections in the United States. *Journal of the American Medical Association, 289*(15), 1763-1771. doi:10.1001/jama.298.15.1763

Kralovic, S. M., Evans, M. A., Simbartl, L. A., Ambrose, M., Jain, R., & Roselle, G. A (2013). Zeroing in on methicillin-resistant Staphylococcus aureus: US Department of Veterans Affairs' MRSA prevention initiative. *American Journal of Infection Control, 41*(5), 456-458. http://dx.doi.org/10.1016/j.ajic.2012.05.017

Kulkarni, R., Antala, S., Wang, A., Amaral, F. E., Rampersaud, R., LaRussa, S. J., … Ratner, A. J. (2012). Cigarette smoke increases Staphylococcus aureus biofilm formation via oxidative stress. *Infection and Immunity, 80*(11), 3804-3811. doi:10.1128/IAI.00689-12

Lewis, S. S., Walker, V. J., Lee, M. S., Chen, L., Moehring, R. W., Cox, C. E., … Anderson, D. J. (2014). Epidemiology of methicillin-resistant staphylococcus aureus pneumonia in community hospitals. *Infection Control and Hospital Epidemiology, 35*(12), 1452-1457. doi:10.1086/678594

Lindberg, C., Downham, G., Buscell, P., Jones, E., Peterson, P., & Krebs, V. (2013). Embracing collaboration: A novel strategy for reducing bloodstream infections in outpatient hemodialysis centers. *American Journal of Infection Control, 41*(6), 513-519. http://dx.doi.org/10.1016/j.ajic.2012.07.015

Longtin, Y., Schneider, A., Tchopp, C., Renzi, G., Gayet-Ageron, A., Schrenzel, J., & Pittet, D. (2014). Contamination of stethoscopes and physicians' hands after a physical examination. *Mayo Clinic Proceedings, 89*(3), 291-299. doi:10.1016/j.mayocp.2013.11.016

Los Angeles County Department of Public Health. (2012). *Annual morbidity report and special studies report.* Retrieved from http://www.ph.lacounty.gov/acd/reports/annual/2012Annual.pdf

Los Angeles County Department of Public Health. (2014). *Los Angeles County population estimates (July 1, 2014).* Retrieved from http://publichealth.lacounty.gov/epi/docs/2014-LAC-Population.pdf

Los Angeles County Department of Public Health. (2015). Service planning areas. Retrieved from http://publichealth.lacounty.gov/

Luick, L., Thompson, P. A., Loock, M. H., Vetter, S. L., Cook, J., & Guerrero, D. M. (2013). Diagnostic assessment of different environmental cleaning monitoring methods. *American Journal of Infection Control, 41*(8), 751-752. http://dx.doi.org/10.1016/j.ajic.2012.09.019

Mayo Clinic. (2012). MRSA infection. Retrieved from http://www.mayoclinic.org/

McCormack, M. G., Smith, A. J., Akram, A. N., Jackson, M., Roberson, D., & Edwards, G. (2015). Staphylococcus aureus and the oral cavity: An overlooked source of carriage and infection. *American Journal of Infection Control, 43*(1), 35-37.

McKenna, M. (2010). *Superbug: The fatal menace of MRSA*. New York, NY: Simon and Schuster.

McKenry, L., Tessie, E., & Hogan, M. (2006). *Mosby's pharmacology in nursing* (22nd ed.). St. Louis: MO: Elsevier-Mosby.

Medeiros, E. A., Grinberg, G., Rosenthal, V. D., Angelieri, D. B., Ferreira, I. B., Cechinel, R. B., … Ferla, S. (2015). Impact of the International Nosocomial Infection Control Consortium (INICC) multidimensional hand hygiene approach in 3 cities in Brazil. *American Journal of Infection Control, 43*(1), 10-15. doi:10.1016/j.ajic.2014.10.001

MedicineNet. (2012a). Definition of infection. Retrieved from http://www.medicinenet.com/

MedicineNet. (2012b). Definition of methicillin. Retrieved from http://www.medicinenet.com/

MedicineNet. (2012c). What is methicillin-resistant staphylococcus aureus (MRSA)? Retrieved from http://www.medicinenet.com/

Medina, G., Egea, A. L., Otth, C., Otth, L., Fernandez, H., Bocco, J. L., … Sola, C. (2013). Molecular epidemiology of hospital-onset methicillin-resistant Staphylococcus aureus infections in South Chile. *European Journal of Clinical Microbiology & Infectious Disease, 32*(12), 1533-1540. doi:10.1007/s10096-013-1907-8

Miller, L. G., & Diep, B.A. (2008). Clinical practice: colonization, fomites, and virulence: Rethinking the pathogenesis for community-associated methicillin-resistant Staphylococcus aureus infection. *Clinical Infectious Diseases, 46*(5), 750-760. Retrieved from http://www.rtjournalonline.com/Colonization,%20Fomites,%20and%20Virulence.%20Rethinking%20the%20Pathogenesis%20of%20Community-Associated%20Methicillin-Resistant%20Staphylococcus%20aureus%20Infection%202008.pdf

Moore, G., Dunnill, C. W., & Wilson, A. P. R. (2013). The effect of glove material upon the transfer of methicillin-resistant staphylococcus aureus to and from a gloved hand. *American Journal of Infection Control, 41*(1), 19-23. http://dx.doi.org/10.1016/j.ajic.2012.03.017

Murphy, C. R., Hudson, L. O., Spratt, B. G., Quan, V., Kim, D., Peterson, E., … Huang, S. (2013). Predicting high prevalence of community methicillin-resistant staphylococcus aureus strains in nursing homes. *Infection Control and Hospital Epidemiology, 34*(3), 325-326. doi:10.1086/669519

Naimi, T. S., LeDell, K. H., Como-Sabetti, K., Borchardt, S. M., Boxrud, D. J., Etienne, J., … Lynfield, R. (2003). Comparison of community- and health care-associated methicillin-resistant Staphylococcus aureus infection. *Journal of the American Medical Association, 290*(22), 2976-2984. doi:10.1001/jama.290.22.2976

Neely, A. N., & Maley, M. P. (2000). Survival of enterococci and staphylococci on hospital fabrics and plastic. *Journal of Clinical Microbiology, 38*(2), 724-726. Retrieved from http://jcm.asm.org/

Nelson, R. E., Stevens, V. W., Jones, M., Samore, M. H., & Rubin, M. A. (2015). Health care associated methicillin-resistant Staphylococcus aureus infections increases the risk of postdischarge mortality. *American Journal of Infection Control, 43*(1), 38-43.

New York State Department of Health. (2007). Community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA): Fact sheet. Retrieved from http://www.health.ny.gov/

Ng, W., George, K., Muhammed, N., Tomassi, J. & Katz, K. C. (2012). Too close for comfort: Screening strategy to detect methicillin-resistant Staphylococcus aureus conversion in exposed roommates. *American Journal of Infection Control, 40*(9), 883-885. http://dx.doi.org/10.1016/j.ajic.2011.11.007

Oller, A. R., & Michell, A. (2008). Staphylococcus aureus recovery from cotton towels. *Journal of Infection in Develop Countries, 3*(3), 224-228. doi:10.3855/jidc.40

Othman, H., Fishbain, J. T., & Khatib, R. (2013). The role of intravenous catheters in cardiovascular implantable electronic device infections: identifying potential targets for prevention. *American Journal of Infection Control, 41*(4), 376-377. http://dx.doi.org/10.1016/j.ajic. 2012.05.008

Ottum, A., Sethi, A. K., Jacobs, E., Zerbel, S., Gaines, M. E., & Safdar, N. (2013). Engaging patients in the prevention of health care-associated infections: A survey of patients' awareness, knowledge, and perceptions regarding the risks and consequences of infection with methicillin-resistant Staphylococcus and Clostridium difficile. *American Journal of Infection Control, 41*(4), 322-326. http://dx.doi.org/10.1016/j.ajic.2012.04.334

Planet, P. J., LaRussa, S. J., Dana, A., Smith, H., Xu, A., Ryan, C., … Prince, A. (2013). Emergence of the epidemic methicillin-resistant Staphylococcus strain USA300 coincides with horizontal transfer of arginine catabolic mobile element and speG-medicated adaptations for survival on skin. *mBio, 4*(6), e00889-13. doi:10.1128/mBio.00889-13

Pope, S. D., Dellit, T. H., Owens, R. C., & Hooton. T. M. (2009). Results of the survey on implementation of Infectious Diseases Society of America and Society for Healthcare Epidemiology of America guidelines for developing an institutional program to enhance antimicrobial stewardship. *Infection Control & Hospital Epidemiology, 30,* 97-98.

Popovich, K. J., Aroutcheva, A., Hota, B., Beavis, K. G., Hayden, M. K., & Weinstein, R. A. (2014). Anatomic sites of colonization with community-associated methicillin-resistant staphylococcus aureus. *Infection Control and Hospital Epidemiology, 35*(9), 1192-1193. doi:10.1086/677627

Prince, L. B., Stegger, M., Hasman, H., Aziz, M., Larsen, J., Andersen, P. S., … Aarestrup, F. M. (2012). Staphylococcus aureus CC398: Host adaptation and emergence of methicillin resistance in livestock. *mBio, 3*(1), e00305-11. doi:10.1128/mBio.00305-11

Reyes-Robles, T., Alonzo, T., III, & Torres, V. J. (2014). S. aureus virulence factors thwart host immune responses. *Microbe, 9*(6), 240-244. Retrieved from http://www.microbemagazine.org/images/June2014/znw00614000240.pdf

Rimawi, R. H., Ramsey, K. M., Shah, K. B., & Cook, P. P. (2014). Correlation between methicillin-resistant Staphylococcus aureus nasal sampling and S. aureus pneumonia in the medical intensive care unit. *Infection Control & Hospital Epidemiology, 35*(5), 590-592.

Robicsek, A., Suseno, M., Beumont, J. L., Thomson, R. B., & Peterson, L. R. (2008). Prediction of methicillin-resistant staphylococcus aureus involvement in disease sites by concomitant nasal sampling. *Journal of Clinical Microbiology, 46*(2), 588-592. doi:10.1128/JCM.01746-07

Roidad, N., & Khakoo, R. (2014). Knowledge and attitudes of visitors to patients in contact isolation. *American Journal of Infection Control, 42*(2), 198-199. http://dx.doi.org/10.1016/j.ajic.2013.09.004

Rubenstein, E., Kollef, M. H., & Nathwani, D. (2008). Pneumonia caused by methicillin-resistant staphylococcus aureus. *Clinical Infectious Diseases, 46*(Suppl. 5), S378-S385. doi:10.1086/533594

Schultz, L., Lowe, T. J., Srinivasan, A., Neilson, D., & Pugliese, G. (2014). Economic impact of redundant antimicrobial therapy in US hospitals. *Infection Control and Hospital Epidemiology, 35*(10), 1229-1235. doi:10.1086/678066

Shenoy, E. S., Hsu, H., Noubary, F., Hooper, D. C., & Walensky, R. P. (2012). National Survey of infection preventionists: policies for discontinuation of contact precautions for methicillin-resistant staphylococcus aureus and vancomycin-resistant enterococcus. *Infection Control and Hospital Epidemiology, 33*(8), 849-852. doi:10.1086/668427

Seibert, D. J., Speroni, K. G., Oh, K. M., DeVoe, M. C., & Jacobson, K. H. (2014). Knowledge, perceptions, and practices of methicillin-resistant Staphylococcus aureus transmission prevention among health care workers in acute-care settings. *American Journal of Infection Control, 42*(3), 254-259. http://dx.doi.org/10.1016/j.ajic.2013.09.005

Sifuentes, L. Y., Gerba, C. P., Weart, I., Engelbrecht, K., & Koenig, D. W. (2013). Microbial contamination of hospital reusable cleaning towels. *American Journal of Infection Control, 41*(10), 912-915. http://dx.doi.org/10.1016/j.ajic.2013.01.015

Spoor, L. E., McAdam, P. R., Weinert, L. A., Rambaut, A., Hasman, H., Aarestrup, F. M., … Fitzgerald, J. R. (2013). Livestock origin for a human pandemic clone of community-associated methicillin-resistant Staphylococcus aureus. *mBio, 4*(4), e00356-13. doi:10.1128/mBio.00356-13

Squier, C., Rihs, J. D., Risa, K. J., Sagnimeni, A., Wagener, M. M., Stout, J., … Singh, N. (2002). Staphylococcus aureus rectal carriage and its association with infections in patients in a surgical intensive care unit and a liver transplant unit. *Infection Control Hospital Epidemiology, 23*(9), 495-501. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12269445

Stenehjem, E., & Rimland, D. (2013). MRSA nasal colonization burden and risk of MRSA infection. *American Journal of Infection Control, 41*(5), 405-410. http://dx.doi.org/10.1016/j.ajic.2012.07.017

Stevens, J. P. (2009). *Applied multivariate statistics for the social sciences* (5th ed.). Mahwah, NJ: Routledge Academic.

Syed, A. K., Ghosh, S., Love, N. G. & Boles, R. B. (2014). Triclosan promotes Staphylococcus aureus nasal colonization. *mBio, 5*(2), e01015-13. doi:10.1128/mBio.01015-13

Talan, D. A., Krishnadasan, A., Gorwitz, R. J., Fosheim, G. E., Limbago, B., Albrecht, V., … Emergency ID Net Study Group. (2011). Comparison of staphylococcus aureus from skin and soft-tissue infections in US emergency departments, 2004 and 2008. *Clinical Infectious Diseases, 53*(2), 144-149. doi:10.1093/cid/cir308

Tehrani, D. M., Phelan, M. J., Cao, C., Billimek, J., Datta, R., Nguyen, H., … Huang, S. S. (2014). Substantial shifts in ranking of California hospitals by hospital-associated methicillin-resistant staphylococcus aureus infection following adjustment for hospital characteristics and case mix. *Infection Control and Hospital Epidemiology, 35*(10), 1263-1270. doi:10.1086/678069

Tenover, F. C., & Goering, R. V. (2009). Methicillin-resistant Staphylococcus aureus strain USA300: Origin and epidemiology. *Journal of Antimicrobial Chemotherapy, 64,* 441-446. doi:10.1093/jac/dkp241

Todar, K. (2012a). Colonization and invasion by bacterial pathogens. Retrieved from http://textbookofbacteriology.net/

Todar, K. (2012b). Staphylococcus aureus and Staphylococcal disease. Retrieved from http://www.textbookofbacteriology.net/

Torres, K., & Sampathkumar, P. (2013). Predictors of methicillin- resistant staphylococcus aureus colonization at hospital admission. *American Journal of Infection Control, 41*(11), 1043-1047. http://dx.doi.org/10.1016/j.ajic.2013.02.013

University of California San Francisco Medical Center. (2015). *Contact isolation precautions patient information.* Retrieved from infectioncontrol.ucsfmedical center.org/assets/factsheets/Contact%20Precautions%20Patient%20Information _UC.pdf

University of Chicago. (2010). MRSA history timeline: 1959-2012. Retrieved from http://mrsa-research-center.bsd.uchicago.edu/

U.S. Department of Health and Human Services. (2013). Health care-associated infections. Retrieved from http://www.healthypeople.gov/

Valencia-Rey, P. A., Strymish, J., Robillard, E., Evans, M., Weinberg, J., & Gupta, K. (2014). Survival time of methicillin-resistant staphylococcus aureus-free status after institutional clearance. *Infection Control and Hospital Epidemiology, 35*(10), 1271-1276. doi:10.1086/678065

Wagner, B., Filice, G. A., Drekonja, D., Greer, N., McDonald, R., Rutks, I., … Timothy, J. W. (2014). Antimicrobial stewardship programs in inpatient hospital settings: A systematic review. *Infection Control and Hospital Epidemiology, 35*(10), 1209-1228. doi:10.1086/678057

Weber, S. G., Huang, S. S., Oriola, S., Huskins, W. C., Noskin, A., Harriman, K., … Karchmer, T. B. (2007). Legislative mandates for use of active surveillance cultures to screen for methicillin-resistant Staphylococcus aureus and vancomycin-resistant enterococci: Position statement from the Joint SHEA and APIC Task Force. *American Journal of Infection Control, 35*(2), 75-85. http://dx.doi.org/10.1016/j.ajic.2007.01.001

WebMD. (2014). Health A-Z. Retrieved from http://www.webmd.com/

Werthein, H. F. L., Melles, D. C., Vos, M. C., van Leeuwen, W., van Belkum, A., Verbrugh, H. A., & Nouwen, J. L. (2005). The role of nasal carriage in Staphylococcus aureus infections. *Lancet Infectious Disease, 5*(12), 751-762. doi:10.1016/S1473-3099(05)70295-4

Wright, M-O., Tropp, J., Schora, D. M., Dillon-Grant, M., Peterson, K., Boehm, S., … Peterson, L. R. (2013). Continuous passive disinfection of catheter hubs prevents contamination and bloodstream infection. *American Journal of Infection Control, 41*(1), 33-38. doi:10.1016/j.ajic.2012.05.030